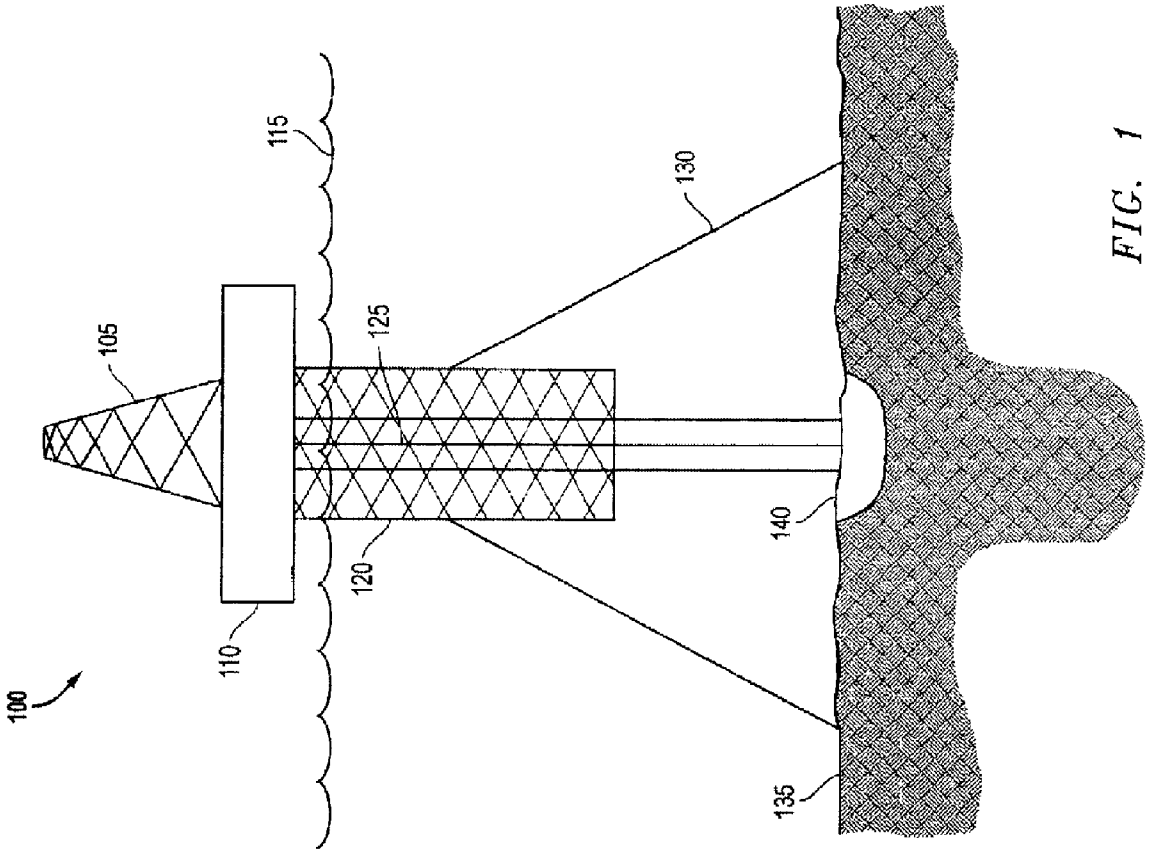




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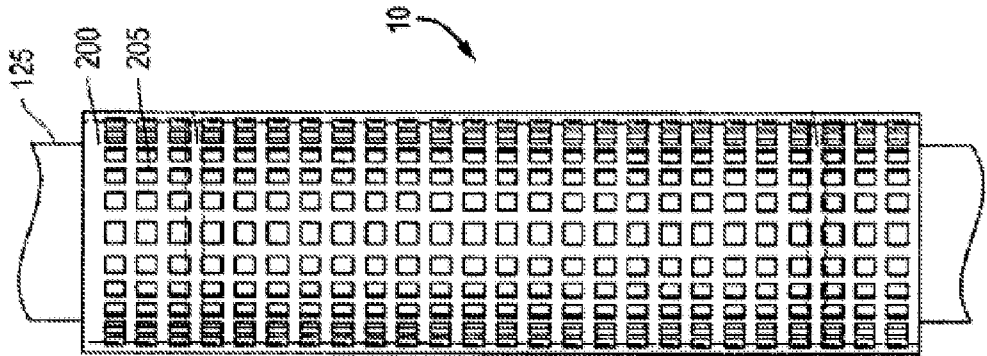


Figure 2

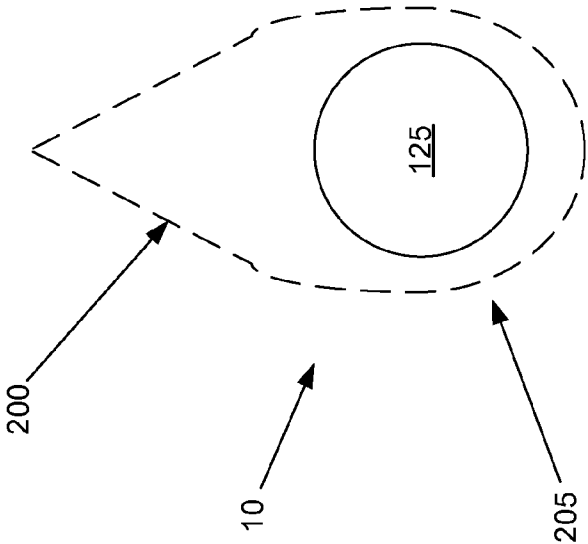


Figure 3

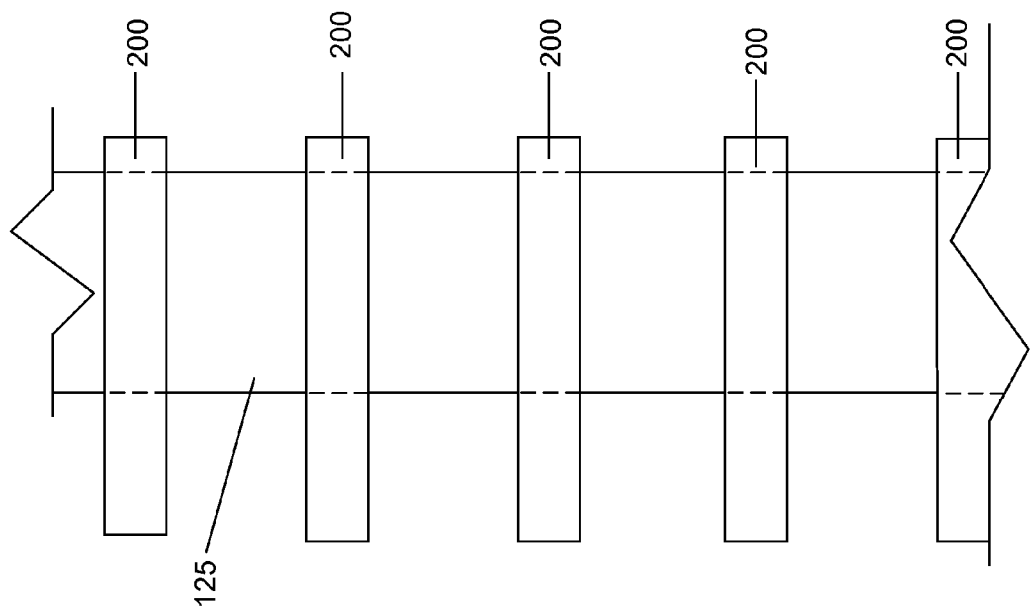


Figure 4

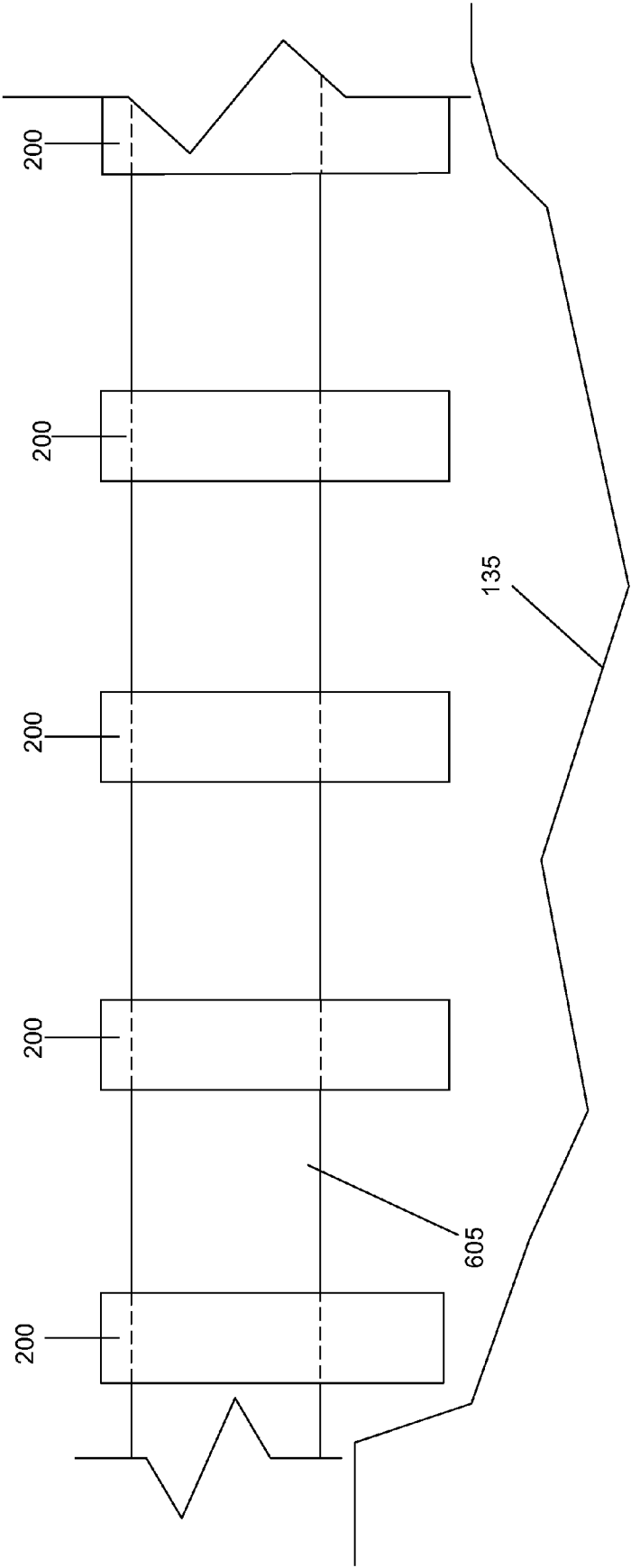


Figure 5

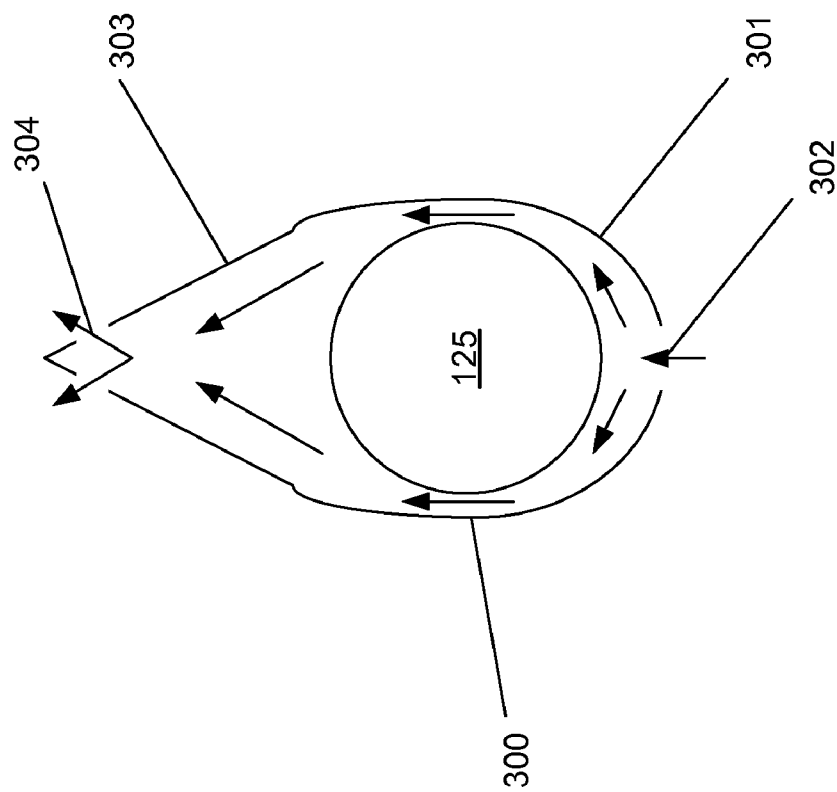


Figure 6

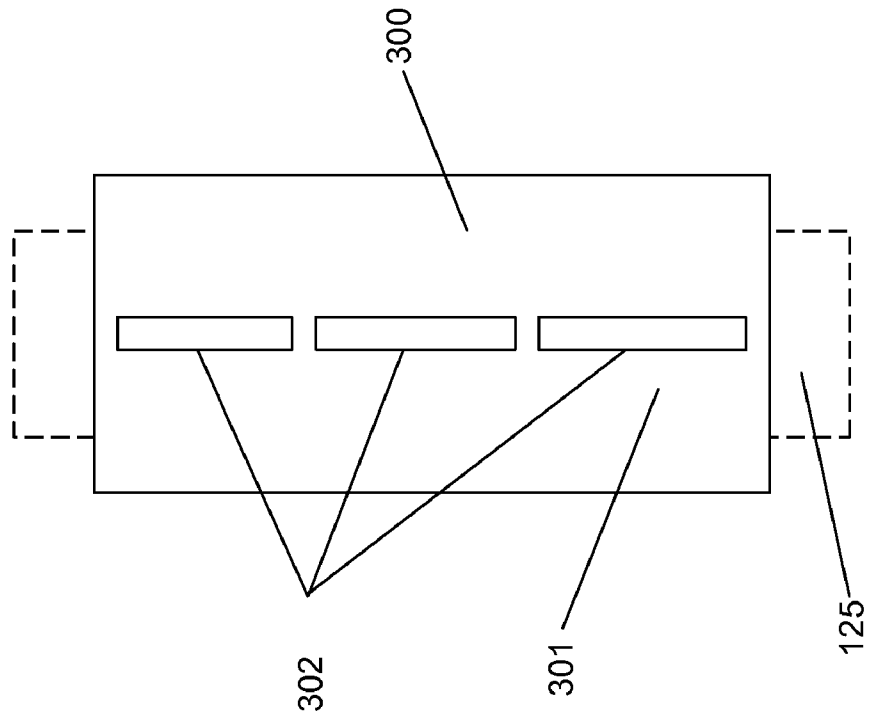


Figure 7

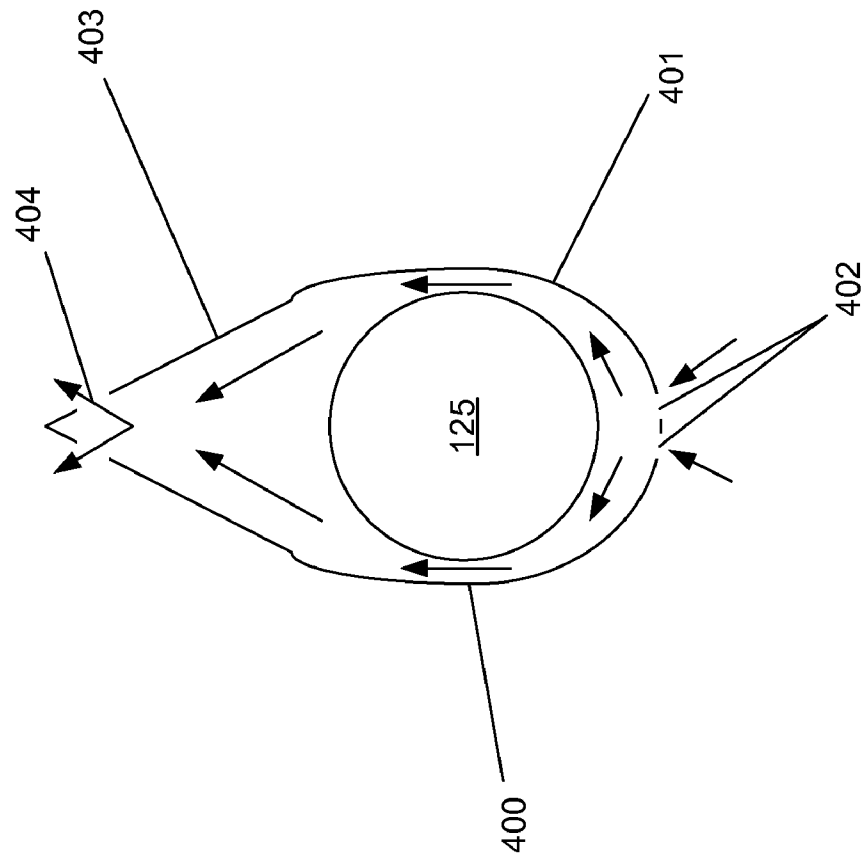


Figure 8

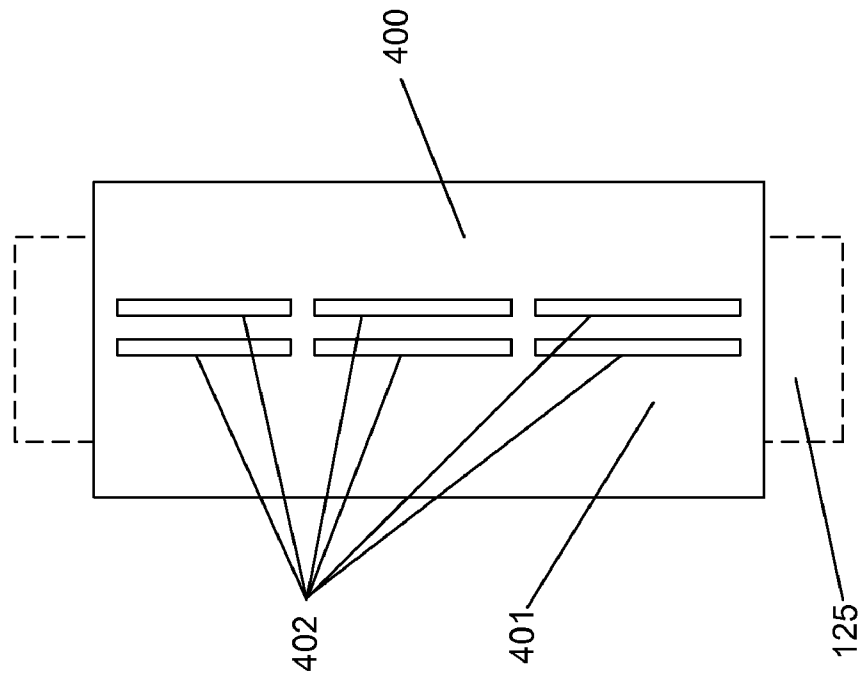


Figure 9

SYSTEMS AND METHODS FOR REDUCING DRAG AND/OR VORTEX INDUCED VIBRATION

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims the benefit of the filing date of U.S. Provisional patent application Ser. No. 60/690,973, filed on Jun. 16, 2005, the disclosure of which is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to systems and methods for reducing drag and/or vortex-induced vibration ("VIV").

DESCRIPTION OF THE RELATED ART

[0003] 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 vibration (VIV). These vibrations may be 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.

[0004] 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").

[0005] Risers are discussed here as a non-exclusive example of an aquatic element subject to VIV.

[0006] Also, newly developed spar production facilities may be used in aquatic environments of great depths. Strong water currents often occur at these greater depths in ocean environments. The hulls of spar production facilities, therefore, can be exposed to excessive vortex-induced vibrations.

[0007] The magnitude of the stresses on the riser pipe, tendons or spars may be generally a function of and increases with the velocity of the water current passing these structures and the length of the structure.

[0008] It is noted that even moderate velocity currents in flowing fluid environments acting on linear structures can cause stresses. Such moderate or higher currents may be readily encountered when drilling for offshore oil and gas at greater depths in the ocean or in an ocean inlet or near a river mouth.

[0009] Drilling in ever deeper water depths requires longer riser pipe strings which, because of their increased length and subsequent greater surface area, may be subject to greater drag forces which must be resisted by more tension. This is believed to occur as the resistance to lateral forces due to the bending stresses in the riser decreases as the depth of the body of water increases.

[0010] Accordingly, the adverse effects of drag forces against a riser or other structure caused by strong and shifting currents in these deeper waters increase and set up

stresses in the structure which can lead to severe fatigue and/or failure of the structure if left unchecked.

[0011] There are generally two kinds of current-induced stresses in flowing fluid environments. The first kind of stress may be 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 may be 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.

[0012] The second type of stress may be 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 vibration 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.

[0013] 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.

[0014] Devices used to reduce vibrations caused by vortex shedding from sub-sea structures may 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.

[0015] 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.

[0016] 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.

[0017] Currently, fairings may cover a tubular, and in order to inspect the tubular, the fairing may have to be removed. In addition, fairings may act as insulation for the tubular, which may act to lower the heat transfer between the tubular and the surrounding environment. In addition, fairings may cause the boundary layer to separate, which may cause increased drag and/or increased VIV. In addition, fairings may hinder the effectiveness of a cathodic protection system of a tubular. In addition, fairings may provide

VIV protection at limited current angles. In addition, fairings may have a large mass, and be difficult to transport and/or install.

[0018] U.S. Pat. No. 6,223,672 discloses an ultrashort fairing for suppressing vortex-induced vibration in substantially cylindrical marine elements. The ultrashort fairing has a leading edge substantially defined by the circular profile of the marine element for a distance following at least about 270 degrees thereabout and a pair of shaped sides departing from the circular profile of the marine riser and converging at a trailing edge. The ultrashort fairing has dimensions of thickness and chord length such that the chord to thickness ratio is between about 1.20 and 1.10. U.S. Pat. No. 6,223,672 is herein incorporated by reference in its entirety.

[0019] There are needs in the art for one or more of the following: apparatus and methods for reducing VIV and/or drag on structures in flowing fluid environments, which do not suffer from certain disadvantages of the prior art apparatus and methods; fairings that do not have to be removed to inspect the tubular; fairings which provide increased heat transfer between the tubular and the surrounding environment; fairings which delay the separation of the boundary layer, which cause decreased drag, and/or decreased VIV; fairings which enable the effectiveness of a cathodic protection system of a tubular; fairings that provide VIV protection at a wide range of current angles; and/or fairings that have a small mass that are easier to transport and/or install.

[0020] 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

[0021] One aspect of invention provides a system for reducing drag and/or vortex induced vibration of a structure, the system comprising a fairing defining a plurality of perforations, wherein the fairing is suitable for placement around the structure, the perforations defining a porosity of the fairing of at least 1%.

[0022] Another aspect of invention provides a method for modifying a structure subject to drag and/or vortex induced vibration, said method comprising positioning at least one fairing around the structure, wherein the at least one fairing defines a plurality of perforations, the perforations defining a porosity of the fairing of at least 1%.

[0023] Advantages of the invention may include one or more of the following: improved VIV and/or drag reduction; VIV and/or drag reduction at a larger range of angles of the fairing orientation to the current flow; enhanced heat transfer; delaying the separation of the boundary layer over the fairing body; improved performance of cathodic protection systems; increased access to inspect coatings on a structure; increased access to inspect welds on a structure; lower cost fairings; and/or lighter weight fairings.

[0024] 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.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] FIG. 1 is an illustration of a typical environment in which the invention may be deployed, showing a spar

drilling and production facility 100, showing surface platform 110 and derrick 105, spar hull 120, risers 125, support tendons 130, wells 140, the surface of ocean 115 and ocean floor 135.

[0026] FIG. 2 shows a fairing 200 of the invention regularly perforated by holes 205 about the structure 125.

[0027] FIG. 3 shows a cross-section of the structures shown in FIG. 2.

[0028] FIG. 4 shows the application of the fairing of the invention to a structure.

[0029] FIG. 5 shows the application of the fairing of the invention to a lateral pipe span 605.

[0030] FIG. 6 shows a cross-sectional view of fairing 200 of the invention with centered perforations about the structure 125.

[0031] FIG. 7 is a side view of the structures of FIG. 6.

[0032] FIG. 8 shows a cross-sectional view of fairing 200 of the invention with off-centered perforations about the structure 125.

[0033] FIG. 9 is a side view of the structures of FIG. 8.

DETAILED DESCRIPTION OF THE INVENTION

[0034] In one embodiment, there is disclosed a system for reducing drag and/or vortex induced vibration of a structure, the system comprising a fairing defining a plurality of perforations, wherein the fairing is suitable for placement around the structure, the perforations defining a porosity of the fairing of at least 1%. In some embodiments, the fairing comprises a porosity from 2% to 80%, or from 5% to 70%, or from 10% to 60 %. In some embodiments, the fairing comprises a front and a tail, wherein the perforations comprise at least one centered perforation at the front, and at least one perforation at the tail. In some embodiments, the fairing comprises a front and a tail, wherein the perforations comprise at least two off-centered perforations at the front, and at least one perforation at the tail. In some embodiments, the fairing comprises a front and a tail, wherein the perforations provide a fluid path within the fairing from the front to the tail and around the structure, when the fairing is placed around the structure, and the structure is placed in a flowing fluid. In some embodiments, at least one of the perforations comprise a shape selected from the group consisting of regular n-sided, irregular n-sided, linear, and curvilinear geometric shapes. In some embodiments, at least one of the perforations comprise a shape selected from the group consisting of square, rectangle, triangle, circle, oval, and ellipsoid. In some embodiments, the perforations are arranged in a regular pattern. In some embodiments, the fairing comprises a teardrop shape.

[0035] In another embodiment, there is disclosed a method for modifying a structure subject to drag and/or vortex induced vibration, said method comprising positioning at least one fairing around the structure, wherein the at least one fairing defines a plurality of perforations, the perforations defining a porosity of the fairing of at least 1%. In some embodiments, the positioning comprises positioning at least two fairings about the structure. In some embodiments, the method also includes positioning a collar, a buoyancy mod-

ule, and/or a clamp around the structure. In some embodiments, the fairing comprises a teardrop shape. In some embodiments, the fairing comprises a porosity from 2% to 80%, or from 5% to 70%, or from 10% to 60%.

[0036] The VIV suppression systems of the invention generally include a fairing member defining a number of perforations, and an element to be protected from VIV in a spatial relationship to each other.

[0037] The VIV systems of the invention may be used in any flowing fluid environment in which the structural integrity of the system can be maintained. The term, "flowing-fluid" is defined here to include but not be limited to any fluid, gas, or any combination of fluids, gases, or mixture of one or more fluids with one or more gases, specific non-limiting examples of which include fresh water, salt water, air, liquid hydrocarbons, a solution, or any combination of one or more of the foregoing. The flowing-fluid may be "aquatic," meaning the flowing-fluid comprises water, and may comprise seawater or fresh water, or may comprise a mixture of fresh water and seawater.

[0038] Referring first to FIG. 1, there is illustrated a typical flowing-fluid environment showing a number of possible structures, such as spar hull 120, risers 125, and tendons 130, which may all individually be subject to VIV caused by water currents, on which the invention may be deployed. FIG. 1 shows offshore platform 100, in particular a spar floating drilling and production system, which includes surface facilities 105 and 110, hull of the spar 120, risers 125, support tendons 130, and wells 140. Numerous other subsea structures are subject to VIV, and may have the fairings of the invention applied to them.

[0039] The perforated fairings of the invention may be used to suppress VIV and/or drag when attached to a structure, for example, hull 120, risers 125 and/or tendons 130. In some embodiments, fairings of the invention may be used with most any type of offshore structure, for example, bottom supported and vertically moored structures, such as for example, fixed platforms, compliant towers, tension leg platforms, and mini-tension leg platforms, and also include floating production and subsea systems, such as for example, spar platforms, floating production systems, floating production storage and offloading, and subsea systems.

[0040] In some embodiments, fairings may be attached to marine structures such as subsea pipelines; drilling, production, import and export risers; tendons for tension leg platforms; legs for traditional fixed and for compliant platforms; space-frame members for platforms; cables; umbilicals; mooring elements for deepwater platforms; and the hull and/or column structure for tension leg platforms (TLPs) and for spar type structures. In some embodiments, fairing may be attached to spars, risers, tethers, and/or mooring lines.

[0041] Referring now to FIGS. 2 and 3, in some embodiments, there is shown a VIV and/or drag suppression system 10 including fairing 200, which fairing 200 may be regularly perforated by a multiplicity of holes 205 and positioned about structure 125.

[0042] In some embodiments, the porosity of the fairing may vary depending upon the operating environment, the structure to which the fairing may be attached, and/or cost. "Porosity" generally means the fraction as a percentage of

the surface area of a fairing penetrated by perforations. In some embodiments, the suitable ranges of porosity may vary from about 1%, or about 2%, or about 5%, or about 10%, or about 15%, or about 25%; to about 99%, or about 80 %, or about 70%, or about 60%, or about 50%. In some embodiments, examples of ranges of porosity include from about 1% to about 99%; from about 10% to about 80%; from about 15% to about 70%; and from about 25% to about 60%. Of course, it is to be understood that other ranges may be formed by selection of other combinations of upper and lower ends. In some embodiments, any suitable size of perforation may be utilized provided that the desired structural integrity of the fairing, and suitable VIV protection may be achieved. In general, the size of the perforations in the fairing may vary depending upon the material of the fairing, the size of the fairing, the operating environment, the structure being encircled and cost, as well as other engineering factors. In some embodiments, the shape of the perforation may be any shape suitable for the purpose of VIV suppression, for example, suitable shapes include any regular or irregular n-sided geometric shape, or any linear or curvilinear geometric shape, such as square, rectangle, triangle, circle, oval, ellipsoid, or the like, and any combinations thereof.

[0043] While fairing 200 may be shown as having a regular pattern of square perforations 205, it should be understood that any suitable regular or irregular pattern, ordering, or random placement of perforations, or any combination of the above, may be utilized. Thus, the pattern of perforations of the fairing may be selected so as to be suitable for the operational environment, the structure to which the fairing may be applied, and cost. Non-limiting examples of patterns of perforations include random, regular, irregular, or ordered.

[0044] Referring now to FIG. 4, in some embodiments, there is shown a plurality of fairings 200 on structure 125. Shown is an example of one spacing method for fairings 200 along a portion of the length of structure 125. It should be understood that more than one fairing may be utilized in the practice of the invention. It should also be understood that the spacings between any adjacent pair of fairings may be the same or different than the spacings between any another adjacent pair of fairings.

[0045] Referring to FIG. 5, in some embodiments, fairings 200 are illustrated on a lateral underwater pipeline span 605, such as across an underwater channel 135. Shown is one example of a spacing arrangement of the attachment of fairings 200 along a portion of lateral pipe span 605.

[0046] Referring now to FIGS. 6 and 7, in some embodiments, fairing 300 is shown about structure 125. Fairing 300 has a teardrop shape with front 301 and tail 303. Centered perforations 302 may be provided in front 301, and perforation 304 may be provided in tail 303. In operation, fluid flow enters centered perforations 302 in front 301, flows around structure 125 as shown by arrows, and exits fairing 300 by perforation 304 in tail 303.

[0047] Referring now to FIGS. 8 and 9, in some embodiments, fairing 400 is shown about structure 125. Fairing 400 has teardrop shape with front 401 and tail 403. Off-centered perforations 402 may be provided in front 401, and perforation 404 may be provided in tail 403. In operation, fluid flow enters off-centered perforations 402 in front 401, flows

around structure **125** as shown by arrows, and exits fairing **400** by perforation **404** in tail **403**.

[0048] In some embodiments, fairing comprises a chord and a thickness as defined in U.S. Pat. No. 6,223,672. The chord may be measured from the front to the tail and defines a major axis, and thickness may be measured from one side to the other. In some embodiments, the chord to thickness ratio may be at least about 1.10. In some embodiments, the chord to thickness ratio may be at least about 1.25. In some embodiments, the chord to thickness ratio may be at least about 1.50. In some embodiments, the chord to thickness ratio may be at least about 1.75. In some embodiments, the chord to thickness ratio may be up to about 10.0. In some embodiments, the chord to thickness ratio may be up to about 5.0. In some embodiments, the chord to thickness ratio may be up to about 3.0. In some embodiments, the chord to thickness ratio may be up to about 2.0. In some embodiments, the fairing may have a cross-sectional shape selected from a teardrop, an airfoil, an ellipse, an oval, and/or a streamlined shape.

[0049] In some embodiments, the fairing may be mounted upon a structure for underwater deployment, the fairing comprising a fairing body which, viewed along its length, may be substantially wedge-shaped or tear-drop shaped, having a relatively broad front tapering to a relatively narrow trailing edge, and optionally at least two collars which may be both secured to the fairing body and may be separated from each other along the length of the fairing body, the collars being positioned and aligned to receive the structure, thereby to pivotally mount the fairing body upon the structure such that it may be able to rotate about the axis of the structure and so align itself with a water current, the fairing body defining, when viewed along the length of the fairing, a teardrop shape. The collar may be shaped to form a respective bearing ring for receiving the structure. Each bearing ring may have a substantially circular interior surface. A bearing surface of the collar, which faces toward the structure and upon which the collar rides, may comprise low friction material. The bearing surface may be self lubricating. The collar may comprise a plastics material with an admixture of a friction reducing agent.

[0050] In some embodiments, the fairing may be seen to be generally wedge shaped. Its front, lying adjacent the structure, may have a lateral dimension similar to that of the structure. Moving toward its rear the fairing tapers to a narrow trailing edge. This tapered shape may be defined by convergent walls, which meet at the trailing edge. The front of the fairing may be shaped to conform to the adjacent surface of the structure, being part cylindrical and convex. The fairing may form a streamlined teardrop shape. In a manner which will be familiar to the skilled person, this shape tends to maintain laminar flow and serves both to reduce drag and/or to prevent or reduce VIV.

[0051] In some embodiments, the fairing may be formed as a hollow plastics moulding whose interior communicates with the exterior to permit equalisation of pressure, for example by perforations provided in the fairing. In some embodiments, the fairing may be formed by a single plastics moulding, such as by rotational moulding, so that it may be hollow. The fairing may be manufactured of polythene, which may be advantageous due to its low specific gravity (similar to that of water), toughness and low cost. Openings

may be provided to allow water to enter the fairing to equalise internal and external pressures. The fairing could also be formed as a solid polyurethane moulding. In some embodiments, the principal material used in constructing the fairing may be fiberglass. Other known materials may also be used which have suitable weight, strength and corrosion-resistant characteristics. In some embodiments, fairings may be formed from a flat sheet of material, wrapped around the structure, and connected at the tail with one or more fasteners, such as rivets, bolts with lock nuts, clips, snaps or welding operations. Alternatively, an edge of the fairing may be folded over and crimped onto the outer edge of the fairing after the fairing has been wrapped around the marine element. In some embodiments, the fairings may be constructed from any non-metallic, low corrosive material such as a multi-layer fiberglass mat, polyurethane, vinyl ester resin, high or low density polyurethane, PVC or other materials with substantially similar flexibility and durability properties. These materials provide the fairings with the strength to stay on the structure, but enough flex to allow it to be snapped in place during installation. The fiberglass may be 140-210 MPa tensile strength (for example determined with ISO 527-4) that may be formed as a bi-directional mat or the fairing can be formed of vinyl ester resin with 7-10% elongation or polyurethane. The use of such materials eliminates the possibility of corrosion, which can cause the fairing shell to seize up around the elongated structure it surrounds.

[0052] Collars may be provided to connect the fairing to the structure and/or to provide spacing between adjacent fairings along the structure. Collars may be formed by a single plastics moulding, such as nylon, or from a metal such as stainless steel, copper, or aluminum. In some embodiments, the internal face of the collar's bearing ring may serve as a rotary bearing allowing the fairing to rotate about the structure's longitudinal axis and so to weathervane to face a current. Only the collar may make contact with the structure, its portion interposed between the fairing and the structure serving to maintain clearance between these parts. This bearing surface may be (a) low friction and even "self lubricating" and/or (b) resistant to marine fouling. These properties can be promoted by incorporation of anti-fouling and/or friction reducing materials into the material of the collar. The material of the collar may contain a mixture of an anti-fouling composition which provides a controlled rate of release of copper ions, and/or also of silicon oil serving to reduce bearing friction.

[0053] In some embodiments, there may not be provided a collar, and the fairing may be mounted to the structure itself. That is, the fairing may be mounted directly upon the structure (or on a cylindrical protective sheath conventionally provided around the structure). A number of such fairings may be placed adjacent one another in a string along the structure. To prevent the fairings from moving along the length of the structure, clamps and/or collars may be secured to the structure at intervals, for example between about every one to five fairings. The clamps and/or collars may be of a type having a pair of half cylindrical clamp shells secured to the structure by a tension band passed around the shells.

[0054] In some embodiments, the fairing may be designed so that it can freely rotate about the structure in order to provide more efficient handling of the wave and current action and VIV bearing on the structure. The fairings may

not be connected, so they can rotate relative to each other. Bands of low-friction plastic rings, for example a molybdenum impregnated nylon, may be connected to the inside surface of the fairing that defines an opening to receive the structure. A low friction material may be provided on the portion of the fairing that surrounds a structure, for example strips of molybdenum impregnated nylon, which may be lubricated by sea water.

[0055] In some embodiments, a first retaining ring, or thrust bearing surface, may be installed above and/or below each fairing or group of fairings. Buoyancy cans may also be installed above and/or below each fairing or group of fairings.

[0056] The methods and systems of the invention may further comprise modifying the buoyancy of the fairing. This may be carried out by attaching a weight or a buoyancy module to the fairing. In some embodiments, the fairing may include filler material that may be either neutrally or partially buoyant. The tail portion of each fairing may be partially filled with a known syntactic foam material for making the fairing partially buoyant in sea water. This foam material can be positively buoyant or neutrally buoyant for achieving the desired results.

[0057] In some embodiments, at least one copper element may be mounted at the structure and/or the fairing to discourage marine growth at the fairing—structure interface so that the fairing remains free to weathervane to orient most effectively with the current, for example a copper bar. In some embodiments, the fairings may be made of copper, or be made of copper and one or more other materials.

[0058] In some embodiments, the fairings may have a maximum ratio of length to width of from 2.0 or greater, or 1.5 to as low as about 1.25, 1.20, or 1.10.

[0059] The height of the fairing can vary considerably depending upon the specific application, the materials of construction, and the method employed to install the fairing. In extended marine structures, numerous fairings may be placed along the length of the marine structure, for example covering from about 15% or 25%, to about 50%, or 75%, or 100% of the length of the marine structure with the fairings.

[0060] In some embodiments, fairings may be placed on a marine structure after it is in place, for example, suspended between a platform and the ocean floor, in which divers or submersible vehicles may be used to fasten the multiple fairings around the structure. Alternatively, fairings may be fastened to the structure as lengths of the structure are assembled. This method of installation may be performed on a specially designed vessel, such as an S-Lay or J-Lay barge, that may have a declining ramp, positioned along a side of the vessel and descending below the ocean's surface, that may be equipped with rollers. As the lengths of the structure are fitted together, fairings may be attached to the connected sections before they are lowered into the ocean.

[0061] The fairings may comprise one or more members. Examples of two-membered fairings suitable herein include a clam-shell type structure wherein the fairing comprises two members that may be hinged to one another to form a hinged edge and two unhinged edges, as well as a fairing comprising two members that may be connected to one another after being positioned around the circumference of

the marine structure. Optionally, friction-reducing devices may be attached to the interior surface of the fairing.

[0062] Clam-shell fairings may be positioned onto the marine structure by opening the clam shell structure, placing the structure around the structure, and closing the clam-shell structure around the circumference of the structure. The step of securing the fairing into position around the structure may comprise connecting the two members to one another. For example, the fairing may be secured around the structure by connecting the two unhinged edges of the clam shell structure to one another. Any connecting or fastening device known in the art may be used to connect the member to one another.

[0063] In some embodiments, clamshell type fairings may have a locking mechanism to secure the fairing about the structure, such as male-female connectors, rivets, screws, adhesives, welds, and/or connectors.

[0064] Of course, it should be understood that the above attachment apparatus and methods are merely illustrative, and any other suitable attachment apparatus may be utilized.

[0065] The methods and systems of the invention may further comprise positioning a second fairing, or a plurality of fairings around the circumference of a structure. In the multi-fairing embodiments, the fairings may be adjacent one another on the structure, or stacked on the structure. The fairings may comprise end flanges, rings or strips to allow the fairings to easily stack onto one another, or collars or clamps may be provided in between fairings or groups of fairings. In addition, the fairings may be added to the structure one at a time, or they may be stacked atop one another prior to being placed around/onto the structure. Further, the fairings of a stack of fairings may be connected to one another, or attached separately.

[0066] While the fairings have been described as being used in aquatic environments, they may also be used for VIV and/or drag reduction on elongated structures in atmospheric environments.

[0067] 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 system for reducing drag and/or vortex induced vibration of a structure, the system comprising:

a fairing defining a plurality of perforations, wherein the fairing is suitable for placement around the structure, the perforations defining a porosity of the fairing of at least 1%.

2. The system of claim 1, wherein the fairing comprises a porosity from 2% to 80%.

3. The system of claim 1, wherein the fairing comprises a front and a tail, wherein the perforations comprise at least one centered perforation at the front, and at least one perforation at the tail.

4. The system of claim 1, wherein the fairing comprises a front and a tail, wherein the perforations comprise at least two off-centered perforations at the front, and at least one perforation at the tail.

5. The system of claim 1, wherein the fairing comprises a front and a tail, wherein the perforations provide a fluid path within the fairing from the front to the tail and around the structure, when the fairing is placed around the structure, and the structure is placed in a flowing-fluid.

6. The system of claim 1, wherein at least one of the perforations comprise a shape selected from the group consisting of regular n-sided, irregular n-sided, linear, and curvilinear geometric shapes.

7. The system of claim 1, wherein at least one of the perforations comprise a shape selected from the group consisting of square, rectangle, triangle, circle, oval, and ellipsoid.

8. The system of claim 1, wherein the perforations are arranged in a regular pattern.

9. The system of claim 1, wherein the fairing comprises a teardrop shape.

10. A method for modifying a structure subject to drag and/or vortex induced vibration, said method comprising:

positioning at least one fairing around the structure, wherein the at least one fairing defines a plurality of perforations, the perforations defining a porosity of the fairing of at least 1%.

11. The method of claim 10, wherein the positioning comprises positioning at least two fairings about the structure.

12. The method of claim 10, further comprising:

positioning a collar, a buoyancy module, and a clamp around the structure.

13. The method of claim 10, wherein the fairing comprises a teardrop shape.

14. The method of claim 10, wherein the fairing comprises a porosity from 2% to 80%.

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