

MOORING SYSTEMS AND METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of United States Provisional Patent Application No. 63/312,728, filed on February 22, 2022, and entitled “Mooring Systems and Methods,” the entirety of which is incorporated herein by reference and made a part of the present disclosure.

FIELD

[0002] The present disclosure relates to methods, systems, and apparatus for mooring vessels and tensioning mooring lines.

BACKGROUND

[0003] In many applications, floating vessels or structures require mooring, such as in offshore drilling platform applications. Mooring typically includes transport of the vessel and mooring structures to a site and tensioning, securing, cutting, and storing mooring lines.

BRIEF SUMMARY

[0004] The present disclosure includes a fairlead stopper. The fairlead stopper includes a housing assembly, latches movably coupled with the housing assembly, a chainwheel rotatably coupled with the housing assembly, and at least one chain retaining arm coupled with the housing assembly. The at least one chain retaining arm is movable between an open position and a closed position. In the closed position, the at least one chain retaining arm is positioned to secure mooring line passing through the fairlead stopper.

[0005] The present disclosure includes a method of handling a mooring line coupled with a fairlead stopper. The method includes providing a fairlead stopper having a housing assembly, latches coupled with the housing assembly, a chainwheel coupled with the housing assembly, and at least one chain retaining arm coupled with the housing assembly. The method includes latching a mooring line with the latches. The mooring line extends from the latches to the chainwheel and over the chainwheel. The method includes moving the at least one chain retaining arm into a closed position such that the mooring line is secured between the at least one chain retaining arm and another portion of the fairlead stopper.

[0006] The present disclosure includes a vessel. The vessel includes a hull and a sea-fastening brace coupled with the hull. A fairlead stopper is coupled with the sea-fastening brace. The sea-fastening brace extends from the hull to position the fairlead at an angle relative to the hull.

[0007] The present disclosure includes a method of positioning a fairlead stopper relative to a vessel. The method includes coupling a sea-fastening brace with a vessel and coupling a fairlead stopper with the sea-fastening brace. The sea-fastening brace extends from the vessel to position the fairlead at an angle relative to the vessel.

[0008] The present disclosure includes a vessel. The vessel includes a hull and a wave-reaction bar coupled with the hull. A fairlead stopper is coupled with the wave-reaction bar. The wave-reaction bar reacts to forces imparted onto the fairlead stopper.

[0009] The present disclosure includes a method of dampening forces on a vessel from a fairlead stopper. The method includes coupling a wave-reaction bar with a vessel, and coupling a fairlead stopper with the wave-reaction bar. The method includes reacting forces imparted onto the fairlead stopper with the wave-reaction bar.

[0010] The present disclosure includes a method of mooring a floating vessel. The method includes reeving a pre-messenger line through a fairlead stopper coupled with a vessel. The method includes retrieving a pre-laid mooring line off a sea bed with an AHV and securing the pre-laid mooring line on deck of the AHV. The method includes connecting a hold back line between a winch on the AHV and a tri-plate connector coupled with a top chain of the pre-laid mooring line. The method includes transferring two ends of the pre-messenger line from the vessel to the AHV. The two ends include an outer end and an inner end. The method includes connecting the outer end to a first end of a messenger line on the AHV, and over-boarding the connected end of the pre-messenger line and the messenger line with a second end of the messenger line secured on the deck of the AHV. The method includes hauling in on the inner end of the pre-messenger line to pull the pre-messenger line and the messenger line through the fairlead stopper until the messenger line passes through the fairlead stopper and is pulled onto the deck of the AHV. The method includes disconnecting the pre-messenger line from the messenger line. The method includes connecting the top chain of the mooring line to the second end of the messenger line that extends from the AHV into a chain guide of the fairlead. A winch on the AHV is connected to the first end of the messenger line that extends from a chainwheel of the fairlead stopper to the AHV. The method includes over-boarding the connected top chain and messenger line and hauling in the messenger line until the top chain of the mooring line enters the fairlead stopper and until a first tension is on the mooring line. The method includes disconnecting the messenger line from the top chain.

[0011] The present disclosure includes a method of mooring a floating vessel having fairlead stoppers coupled thereto. The method includes securing a plurality of mooring lines to a plurality of fairlead stoppers on the floating vessel. The method includes, after securing

the plurality of mooring lines, cutting lengths of tail chain from the plurality of mooring lines. The method includes connecting at least one of the cut lengths of the tail chain to one of the plurality of mooring lines and then hauling in that mooring line.

BRIEF DESCRIPTION OF THE DRAWINGS

[00012] So that the manner in which the features and advantages of the system, apparatus, products, and/or methods so of the present disclosure may be understood in more detail, a more particular description briefly summarized above may be had by reference to the embodiments thereof which are illustrated in the appended drawings that form a part of this specification. It is to be noted, however, that the drawings illustrate only various exemplary embodiments and are therefore not to be considered limiting of the disclosed concepts as it may include other effective embodiments as well.

[00013] FIG. 1A is a side view of a work site where a floating vessel is positioned, prior to being moored using an AHV.

[00014] FIG. 1B is a detail view of a fairlead stopper of the floating vessel of FIG. 1A.

[00015] FIG. 1C is a detail view of a tension coupler of the mooring line of FIG. 1A.

[00016] FIG. 1D is a side view the AHV of FIG. 1A retrieving a messenger line from the fairlead stopper on the vessel.

[00017] FIG. 1E is a side view of the AHV of FIG. 1D with the mooring line and messenger line secured to the AHV.

[00018] FIG. 1F is a top view of a portion of the AHV with the mooring line and messenger line secured to the AHV.

[00019] FIG. 1G is a side view of the AHV with the connected mooring line and messenger line being lowered into the water.

[00020] FIG. 1H is a side view of the AHV retrieving the other end of the messenger line.

[00021] FIG. 1I is a side view of the AHV lowering a hold line to secure with the mooring line in the water.

[00022] FIG. 1J is a side view of the AHV hauling in the mooring line and the hold line.

[00023] FIG. 1K is a side view showing an ROV monitoring the hauling in of the mooring line.

[00024] FIG. 1L is a detail view of the fairlead stopper of FIG. 1K during hauling in of the mooring line.

- [00025] FIG. 1M is a side view of the vessel and AHV showing an ROV monitoring the provision of slack to the top chain of the mooring line.
- [00026] FIG. 1N is a detail view of the fairlead stopper of FIG. 1M.
- [00027] FIG. 1O is a top view of the AHV of FIG. 1N.
- [00028] FIG. 1P is a side view showing the AHV releasing the mooring line after tensioning is completed.
- [00029] FIG. 1Q is a detail view of the fairlead stopper of FIG. 1P.
- [00030] FIG. 1R is a side view showing the AHV performing stretching of a mooring line of a vessel.
- [00031] FIG. 2A depicts a detail view of a fairlead stopper, including a pre-reeved messenger line that is coupled, at both ends, to pad eyes on the floating structure.
- [00032] FIG. 2B depicts the fairlead stopper of FIG. 2A, with a first end of the messenger line decoupled from a pad eye on the floating structure.
- [00033] FIG. 2C depicts the fairlead stopper of FIG. 2B with a second end of the messenger line decoupled from a pad eye on the floating structure.
- [00034] FIG. 2D depicts a detail view of the fairlead stopper of FIG. 2A, with a mooring line being hauled-in.
- [00035] FIG. 2E depicts the fairlead stopper of FIG. 2D, with the mooring line further hauled-in relative to FIG. 2D, with the mooring line engaged with latches of the fairlead stopper.
- [00036] FIG. 2F depicts the fairlead stopper of FIG. 2E, with the mooring line further hauled-in relative to FIG. 2E, with the mooring line engaged with latches and a chainwheel of the fairlead stopper.
- [00037] FIG. 2G depicts the fairlead stopper of FIG. 2F, after the mooring line is fully hauled-in, including a guide shoe and chain slack holder upon which a bitter end of the mooring line may be laid.
- [00038] FIG. 2H depicts the fairlead stopper of FIG. 2F, after the mooring line is fully hauled-in, with the bitter end of the mooring line coupled with a pad eye on the floating structure.
- [00039] FIG. 2I depicts the fairlead stopper of FIG. 2F, after the mooring line is fully hauled-in, including a deflector plate on the fairlead stopper upon which the bitter end may be routed and cut.
- [00040] FIG. 3 depicts a tension coupler for coupling lengths of mooring line together and providing a load point for application of tension to the mooring line for stretching.

- [00041] FIG. 4 is an at least partially moored floating structure.
- [00042] FIG. 5 is a graph of one exemplary mooring system pattern.
- [00043] FIG. 6A is a perspective view of a fairlead stopper, including a chain and wheel locking pin.
- [00044] FIG. 6B is another perspective view of the fairlead stopper of FIG. 6A.
- [00045] FIG. 6C is a front view of the fairlead stopper of FIG. 6A.
- [00046] FIG. 6D is a side view of the fairlead stopper of FIG. 6A.
- [00047] FIG. 6E is a top view of the fairlead stopper of FIG. 6A.
- [00048] FIG. 7 is a perspective view of a fairlead stopper having chain retaining arms.
- [00049] FIG. 8 is another view of the fairlead stopper of FIG. 7.
- [00050] FIG. 9 is a side view of the fairlead stopper of FIG. 7 showing a range of motion.
- [00051] FIGS. 10A-10B depict the fairlead stopper of FIG. 7 with a bitter end of a mooring line handing therefrom.
- [00052] FIG. 11 depicts the fairlead stopper of FIG. 7 fastened to a vessel.
- [00053] FIGS. 12 and 13 depict multiple fairleads in a sea-fastened position and a deployed position, respectively.
- [00054] FIGS. 14 and 15 depict a fairlead stopper having a sea-fastening brace and a wave-reaction bar.
- [00055] Systems, apparatus, and methods according to present disclosure will now be described more fully with reference to the accompanying drawings, which illustrate various exemplary embodiments. Concepts according to the present disclosure may, however, be embodied in many different forms and should not be construed as being limited by the illustrated embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough as well as complete and will fully convey the scope of the various concepts to those skilled in the art and the best and preferred modes of practice. #

DETAILED DESCRIPTION

[00056] Certain aspects of the present disclosure include methods and systems for mooring vessels and tensioning mooring lines, cutting and securing tail chain, and securing fairlead stoppers to floating vessels.

Mooring with a Fairlead Stopper

[00057] Certain aspects of the present disclosure include methods, systems, and apparatus for mooring vessels and tensioning mooring lines using a fairlead chain stopper (also referred to as a fairlead or fairlead stopper) and an anchor handling vessel (AHV), such as an

anchor handling tug supply (AHTS) vessel. In some such aspects, the vessels are moored and the mooring lines are tensioned without use of chain jacks, such as chain jacks positioned on the deck of the vessel, and without use of other dedicated on-vessel or off-vessel tensioning equipment. For example, and without limitation, the fairlead stoppers used herein may be fairleads in accordance with those disclosed in U.S. Patent Nos. 5,845,893; 8,915,205; or 9,126,659; or may be fairleads in accordance with those disclosed in U.S. Patent Publication No. 2018/0086421; the entireties of each these patents and patent application are incorporated herein by reference. One exemplary fairlead suitable for use herein is the BARLATCH™ Fairlead Stopper by Bardex Corporation.

Exemplary Mooring Line Hook Up, Tensioning, and Stretching Procedure

[00058] Certain aspects of the present disclosure include a mooring hook-up and tensioning procedure using a fairlead stopper. FIGS. 1A-1R depict a floating structure being moored in accordance with certain aspects of the present disclosure, and FIGS. 2A-2I depict detail views of fairlead stoppers used during the mooring of the floating structure. Steps of mooring the floating structure will now be described with reference to FIGS. 1A-1R and FIGS. 2A-2I. The order of steps presented is just one possible sequence, and the order of steps may be determined depending on the particular mooring installation, conditions, and other variables. The elements throughout the Figures provided herein are not necessarily to scale, but are representative thereof. Also, throughout the Figures provided herein, like reference numerals refer to like elements.

[00059] Generally, some embodiments of the method disclosed herein include: (1) coupling a pre-reeved messenger line of a fairlead stopper on a vessel with a pre-laid mooring line and with a winch on an AHV; (2) hauling in the mooring line to a first pre-tension value (e.g., 250 metric tons) while maintaining the position of the AHV using a hold-back line that is coupled between the AHV and the mooring line, ensuring that the polyester segments of the mooring line, if used, are raised above the seafloor during the tensioning steps; (3) optionally proof loading the mooring line to, for example, 40% of the MBL of the stretchable (e.g., polyester) segments of the mooring line by applying tension using a tensioning line coupled between the AHV and the mooring line; and (4) tensioning the mooring line to a second pre-tension value (e.g., 300 metric tons).

Floating Vessel

[00060] With reference to FIG. 1A, the mooring method disclosed herein includes towing vessel 200 to a desired site. Vessel 200 may be any of various types of floating structures requiring mooring, such as an oil drilling or production platform, a floating

production storage offloading (FPSO) vessel, an offshore floating wind power foundation, a floating fish farm, or any other offshore floating structure. The site may be the location at which vessel 200 is to be moored, such as the offshore location at which vessel 200 is to be used in oil drilling or production operations.

Anchor Handling Vessel

[00061] Also positioned at the site is anchor handling vessel, AHV 700. AHV 700 may be a ship including one or more winches, cranes, shark jaws, stern rollers, ROVs, and other devices that may be used in the mooring of a vessel.

Fairlead Stopper

[00062] Vessel 200 includes fairlead stopper 100 coupled therewith (*e.g.*, coupled with the hull). Vessel 200 may include a plurality of fairlead stoppers 100. Fairlead stoppers 100 may be positioned along each side of vessel 200. The fairlead stoppers 100 may be positioned on vessel 200 above waterline 716, below waterline 716, or combinations thereof.

[00063] With reference to FIG. 2A, fairlead stopper 100 is shown positioned and arranged in a manner suitable for transport of vessel 200. For example, fairlead stopper 100 may be in the position and arrangement shown in FIG. 2A from a time at which vessel 200 is at a dock, throughout transport of vessel 200 from the dock to the site, and while positioned at the site prior to beginning the mooring of vessel 200 (*e.g.*, as shown in FIG. 1A).

[00064] Fairlead stopper 100 includes fairlead housing 112 coupled with vessel 200 via brackets 114 and 116. Fairlead housing 112 may be movably (*e.g.*, pivotably) coupled with brackets 114 and 116, such as via pins. Fairlead stopper 100 includes latch housing 120, which may be movably (*e.g.*, pivotably) coupled with fairlead housing 112, such as via pin 122. Latch housing 120 may include guide member 124 for guiding lines (*e.g.*, ropes, chains, and other such lines) into and out of latch housing 120. Latches 130 may be positioned within latch housing 120, and arranged for engagement with chains or other lines passing through latch housing 120. Fairlead stopper 100 includes chainwheel 110, which may be movably (*e.g.*, pivotably) coupled with fairlead housing 112, such as via axle 126. Chainwheel 110 may be positioned to engage with lines (*e.g.*, ropes, chains, and other such lines) for moving, guiding, or otherwise facilitating movement of such lines through fairlead housing 112 and latch housing 120. In some aspects, latch housing 120 or another portion of fairlead stopper 100 may be temporarily secured to vessel 200 during transport, such as to bracket 117 on vessel 200 (as shown in FIG. 2D). The fairlead stoppers disclosed herein are not limited to the particular structures shown in FIGS. 2A-2I, and may be any of various structures capable of moving or

facilitating movement of mooring lines and securing a position of mooring lines for tensioning thereof and for mooring a floating vessel.

[00065] As shown in FIG. 2A, fairlead stopper 100 may be pre-reeved with messenger line 300. That is, fairlead stopper 100 may have messenger line 300 that is at least partially engaged therewith. Pre-reeving of fairlead stopper 100 with messenger line 300 may be performed at port, prior to vessel 200 departing the port for site. A lower end of messenger line 300 is looped up from below fairlead stopper 100 to pad eye 202a on the hull of vessel 200. As shown in FIG. 2A, messenger line 300 is run through fairlead housing 112 adjacent chainwheel 110, and is run through latch housing 120, passing between latches 130 and adjacent guide member 124. Messenger line 300 may be a chain, rope, polymer line, wire, or another type of line. First end 300a and second end 300b of messenger line 300 may each be coupled with vessel 200 during transport. As shown, first end 300a and second end 300b include shackles 302a and 302b, respectively, for coupling with pad eyes 202a and 202b via pins 201, respectively. Pad eyes 202a and 202b may be positioned on vessel 200 (*e.g.*, welded thereto). However, messenger line 300 is not limited to being coupled to vessel 200 via shackles and pad eyes, and may be coupled to vessel 200 via other structures. Furthermore, messenger line 300 may be, instead, coupled with a portion of fairlead stopper 100 or another structure rather than being coupled with vessel 200. Regardless of the particular structure which messenger line 300 is coupled with, one or both ends of messenger line 300 may be secured during transport of vessel 200. While shown as positioned below waterline 716, in some aspects, fairlead stopper 100 is located above waterline 716. Fairlead stopper 100 may be an underwater chain stopper fairlead (UCSF). In some such aspects, pad eyes 202a and 202b may be located below fairlead stopper 100 such that a remotely operated vehicle (ROV) or diver may access messenger line 300 for coupling thereof with lines and/or winches of AHV 700. In other aspects, one end of messenger line 300 may be coupled to a counterweight, securing the counterweight to the hull of vessel 200 or to fairlead stopper 100.

[00066] With reference to FIGS. 1A-1C, the method includes releasing the sea-fastening of fairlead stopper 100, such as by disconnecting fairlead stopper 100 from bracket 117 (shown in FIG. 2D) such that fairlead stopper 100 is positioned for operation. As shown in FIG. 1B, messenger line 300 includes first end 300a and second end 300b, each of which may be at least partially composed of metal or polymer wire or rope, or another material. As discussed with reference to FIG. 2A, each of first end 300a and second end 300b may be coupled with a hull of vessel 200. Messenger line 300 also includes intermediate segment 300c, which may be at least partially composed of a chain (*e.g.*, a steel chain). With first end 300a and second end

300b coupled with the hull of vessel 200, intermediate segment 300c is reeved through latch housing 120 and adjacent chainwheel 110. First and second ends (or segments) 300a and 300b of messenger line 300 may be wires of a non-rotating construction, mitigating the introduction of twists into top chain 310.

[00067] AHV 700 is moved into position relative to floating vessel 200 (*e.g.*, by moving in direction 500a). As shown in FIG. 1A, AHV 700 includes work-line 311, which is coupled with a winch on AHV 700. As AHV 700 moves into position relative to floating vessel 200, AHV 700 pays out work-line 311 as needed. The method includes paying out work-line 311 to retrieve mooring line 701 from seafloor 718. While paying out work-line 311, AHV 700 maintains station using minimal thrust and maintains proper rudder clearances from vessel 200. Work-line 311 is then coupled with top chain 310, such as via a shackle. This operation may be facilitated by a diver or ROV. After work-line 311 is coupled with top chain 310, work-line 311 may be hauled-in toward AHV 700, such that mooring line 701 is at least partially lifted off of seafloor 718 towards AHV 700. While shown and described as using a work line, 311, in some aspects a work line is not used, such as in shallow water operations. In some such aspects, a winch wire is paid to retrieve mooring line 701.

Mooring Line

[00068] Mooring line 701 may include one or more sections of line, each of which may be composed of the same material or of different materials. The various segments of mooring line 701 may be coupled together via shackles, H-Links or other connectors. Mooring line 701 includes bottom chain 722, which may be a pile forerunner, coupled with anchor 714 at seafloor 718. Anchor 714 may be a suction pile, driven pile, drag embedment anchor, gravity anchor, torpedo anchor, or another type of anchor positioned at seafloor 718. Mooring line 701 includes a midspan mooring line coupled with bottom chain 722. In FIG. 1A, the midspan mooring line includes two individual segments of polyester line, 724a and 724b. Midspan line 724a is coupled with bottom chain 722, such as via a shackle. Midspan line 724b is coupled with midspan line 724a via tension coupler 712a. Midspan lines 724a and 724b may be rope, chain, or polymer lines. Mooring line 701 may be pre-laid and wet stored on seafloor 718 at the site, prior to towing vessel 200 to the site, or may be laid on seafloor 718 after towing vessel 200 to the site.

[00069] In some aspects, midspan lines 724a and 724b may include, at least partially, polyester, metal, composite material, or another material. As described in more detail below, in some aspects, materials, such as polyester or other polymers, are subjected to a stretching step in the mooring process. The stretching step may be performed after mooring line 701 has

been connected to vessel 200 and pre-tensioned. The mooring lines disclosed herein are not limited to the particular, exemplary structure shown in FIG. 1A, and may include different numbers of line segments and/or be composed of different materials.

Tension Couplers

[00070] As shown in FIG. 1C, tension coupler 712 includes a plate 713 coupled with connection chains 719 for coupling with both midspan lines 724a and 724b together. Also, shackle 717 is coupled with plate 713 for coupling with a tensioning line (not shown). Midspan line 724b is coupled with top chain 310 (e.g., steel chain) via tension coupler 712b, which may be identical to tension coupler 712a. In operation, tension coupler 712b may be used to couple with a winch line of AHV 700 for holding a position of AHV 700 during mooring line 701 tensioning, and tension coupler 712a may be used to couple with a winch line of AHV 700 for stretching of mooring line 701.

[00071] Tension couplers 712a and 712b are coupled at positions along the length of mooring line 701. As shown in FIG. 1A, tension coupler 712b is coupled between midspan 724a and top chain 310, and tension coupler 712a is coupled between midspan lines 724a and 724b. However, the tension couplers disclosed herein may be coupled at other locations along mooring line 701, such as in bottom chain 722, in midspans 724a and 724b, between bottom chain 722 and midspan 724a, between midspan 724b and top chain 310, or another location along mooring line 701. Tension couplers 712a and 712b may be a structure capable of coupling two, three, or more lines, ropes, wires, or chains together, as well as providing a point along the length of mooring line 701 at which tension may be applied to mooring line 701 (as shown and described in more detail below). In some aspects, if midspans 724a and 724b are or includes rope, tension coupler 712a may be used to stretch the rope, as needed, by pulling upwards on tension coupler 712a in a manner similar to the plucking of a “bow string” after pre-tensioning mooring line 701 is completed. In some aspects, tension couplers 712a and 712b include a steel plate with through-holes positioned therethrough.

Coupling the Messenger Line with the Mooring Line

[00072] Turning now to FIG. 1D, after AHV 700 is moved into position relative to vessel 200, the method includes retrieving first end 300a of the messenger line from vessel 200, and securing first end 300a of the messenger line on AHV 700 (e.g., securing first end 300a of the messenger line in shark jaws of AHV 700). For example, with reference to FIG. 2B, first end 300a may be removed from pad eye 202a by removing the associated pin 201. This may be performed by a diver, ROV, from the deck, or in another manner.

[00073] Once first end 300a of the messenger line is secured on AHV 700 (e.g., in shark jaws), the method includes moving AHV 700 away from vessel 200 (e.g., along direction 500b) to a location suitable for connecting first end 300a with top chain 310. In some such aspects, while AHV 700 is moving away from vessel 200, the method includes hauling-in mooring line 701 by hauling-in work-line 311 (e.g., along direction 501a).

[00074] Turning now to FIGS. 1E and 1F, the method includes hauling in mooring line 701 over stern roller 721 until top chain 310 is secured on deck of AHV 700, such as in a shark jaw 727. The method also includes hauling in first end 300a over another stern roller 721 and securing first end 300a on the deck of AHV 700, such as in another shark jaw 727. With first end 300a of the messenger line and top chain 310 secured in shark jaws 727, rigging 313 (e.g., A & R rigging) is coupled with top chain 310 and first end 300a for the over-boarding of mooring line 701. Rigging 313 is coupled with first end 300a and top chain 310 via ROV shackle 314. In some aspects, AHV 700 maintains position, with minimal thruster assistance, during connection of top chain 310 with first end 300a.

[00075] Turning now to FIG. 1G, the method includes lowering first end 300a and top chain 310, coupled together via rigging 313, overboard (e.g., along direction 503a) into the water. After lowering first end 300a and top chain 310 into water, rigging 313 is disconnected therefrom, such as via use of an ROV or by a diver. Rigging 313 may then be recovered to the deck of AHV 700. Once first end 300a and top chain 310 and rigging 313 is disconnected therefrom, fairlead stopper 100 bears the load of mooring line 701 (via the latches of fairlead stopper 100).

Coupling the Messenger Line with the AHV

[00076] Turning now to FIG. 1H, with the fairlead stopper 100 bearing the load of mooring line 701, the method then includes moving AHV 700 into position to receive second end 300b of the messenger line, such as via moving AHV 700 towards vessel 200 along direction 500a. Once AHV 700 is in position, the method includes passing second end 300b to AHV 700 and securing second end 300b to a winch on AHV 700. For example, as shown in FIG. 2C, second end 300b may be removed from pad eye 202b by removing the associated pin 201. Second end 300b of messenger wire 300 may then be coupled with a winch on AHV 700.

Coupling the AHV with the Mooring Line

[00077] Turning now to FIG. 1I, with second end 300b secured to a winch on AHV 700 via winch line 729 and/or secured in a shark jaw on AHV 700, the method includes moving AHV 700 to a position above tension coupler 712b (e.g., moving along direction 500b), while paying out a winch line, tension line 720 (also referred to as a hold line or hold-back line), from

a winch on AHV 700 (*e.g.*, moving along direction 503a). The method includes lowering tensioning line 720 towards tension coupler 712b. Tensioning line 720 may include a hook or other coupler for connecting with shack 717 of tension coupler 712b. ROV 800, deployed from AHV 700, may observe and/or facilitate the coupling of tensioning line 720 with tension coupler 712b.

[00078] Turning now to FIG. 1J, with tensioning line 720 coupled to tension coupler 712b, the method includes hauling in tensioning line 720 to a desired degree of payout using a winch on AHV 700. Also, second end 300b is hauled in via another winch on AHV 700. Hauling in second end 300b ultimately pulls in top chain 310 through fairlead stopper 100 and into engagement with the latches thereof. Hauling in tensioning line 720 facilitates holding AHV 700 in position while AHV 700 hauls in mooring line 701. In some such aspects, tension coupler 712b is positioned far enough away from vessel 200 that there is a significant horizontal load exerted on AHV 700 pulling it away from vessel 200 when tensioning line 720 is hauled in, counteracting an opposite horizontal load exerted on AHV 700 from pulling on messenger line 300 and/or top chain 310. In some such aspects, the tension applied to tensioning line 720 causes a force on AHV 700 directed away from vessel 200 that is sufficient to counteract force on AHV 700 directed toward vessel 200 (caused by hauling in mooring line 701), such that these forces on AHV 700 are equilibrated and AHV 700 maintains station without use of thrusters or with minimal use of thrusters.

Tensioning Mooring Line

[00079] Turning now to FIGS. 1K and 1L, the method includes continuing to haul in top chain 310 until the desired link of top chain 310 is secured via latches of fairlead stopper 100. Securing the desired link of top chain 310 with latches of fairlead stopper 100 may be indicative of the desired pretension on mooring line 701 being attained. In some such aspects, ROV 800 monitors top chain 310 as top chain 310 passes through fairlead stopper 100. In certain aspects, the desired link of top chain 310 is marked (*e.g.*, painted), such that ROV 800 may visually observe when the desired link of top chain 310 is secured via latches of fairlead stopper 100. Upon observation that the desired link of top chain 310 is secured via latches of fairlead stopper 100, the method may include ceasing the hauling in of mooring line 701.

[00080] AHV 700 is capable of maintaining position with minimal thruster assist during hauling in of mooring line 701. AHV 700 maintains an equilibrium position, where horizontal load components from tensioned top chain 310 are counteracted by horizontal load components provided by line 720.

[00081] Messenger line 300 and top chain 310 are hauled in through fairlead stopper 100, via pulling on messenger line 300 using a winch on AHV 700. As shown in FIG. 2D, messenger line 300 progresses through fairlead stopper 100 as top chain 310 approaches engagement with fairlead stopper 100 until links of top chain 310 are pulled into and through fairlead stopper 100. As top chain 310 passes through fairlead stopper 100, links of top chain ratchetedly engage with latches 130 of fairlead stopper, as shown in FIG. 2E. In some aspects, while hauling in mooring line 701 using a winch, AHV 700 also hauls in tensioning line 720 using a second winch on AHV 700 to provide a restoring force such that use of thrusters to provide a restoring force is not required, or such that the thrusters are at least assisted by the horizontal force component tending to pull AHV 700 away from vessel 200.

[00082] AHV 700 continues to pull top chain 310 through fairlead stopper 100 and over chainwheel 110, as shown in FIG. 2F, until a proper, desired pretension is achieved on mooring line 701. In some aspects, latches 130 on fairlead stopper 100 may be configured to automatically ratchet, closing on every link or every other link that passes through such that there is no need to manually operate latches 130. In some aspects, latches 130 may be configured to remain open while top chain 310 passes through fairlead stopper 100, and then to close when top chain 310 is tensioned to the desired level. Thus, the mooring method includes continuing to pull top chain 310 until mooring line 701 is tightened to the desired level. Depending on how much tail chain is present upon reaching the desired level of tension, the top chain-to-messenger line connection may be disconnected on AHV 700 or on vessel 200 deck. Once tensioned, latches 130 remain closed about at least one link of top chain 310 (sometimes referred to as the “golden link”) to secure and maintain tension on mooring line 701.

[00083] In some aspects, during tensioning by pulling on messenger line 300, the method includes simultaneously pulling on tensioning line 720, thus pulling on tension coupler 712b and mooring line 701, which hauls in catenary weight, holding AHV 700 in a position away from vessel 200 and reduces load on messenger line 300 being pulled by winch. In some aspects, the simultaneous hauling in of mooring line 701 while pulling on mooring line 701 with line 720 provides equalized or substantially equalized horizontal force on AHV 700, allowing AHV 700 to maintain station. In some such aspects, propulsion using thrusters of the AHV 700 is used for station keeping of AHV 700.

[00084] Turning now to FIGS. 1M-1O, the method includes providing slack to top chain 310 by releasing tension applied thereto from AHV 700, allowing fairlead stopper 100 to bear the load of mooring line 701, with the desired link of top chain 310 secured via latches of

fairlead stopper 100. ROV 800 may be used to monitor the slacking of top chain 310. The method then includes moving first end 300a (platform hang-off rigging) to vessel 200 and securing it thereto, such as is shown in FIG. 2H.

[00085] Turning now to FIGS. 1P and 1Q, the method includes, after top chain 310 is disconnected from AHV 700, moving AHV 700 away from vessel 200 to a position above tension coupler 712b, and disconnecting tensioning line 720 therefrom, which may be facilitated via ROV 800. AHV 700 may then recover all lines and ROV 800 in preparation for the next mooring hook up and tensioning procedure. In some aspects, the end of top chain 310 is cut to remove excess chain. The length of the remaining excess, loose top chain 310 may be sufficient to allow for connection thereof to the hull of vessel 200, and/or connection of additional chain or wire for slackening operations for replacement or repair operations.

Stretching the Mooring Line

[00086] Once pretension is complete, AHV 700 may release load on top chain 310 bitter end and haul-in on the tensioning line 720 using a winch to pull on tension coupler 712b; thereby, stretching any stretchable portions of mooring line 701 (e.g., mooring line rope of midspans 724a and 724b), if needed or desired. For example, polyester ropes or the like undergo elongation and an increase in stiffness from the initial purchased length, and may require stretching, where 40-60% of minimum break load (MBL) may be achieved by stretching. AHV 700 may be moved to relocate more vertically above tension coupler 712b prior to pulling on tensioning line 720 to stretch mooring line 701. An exemplary polyester line having an initial MBL of 1,750 metric tons, has an MBL of 700 metric tons at the 40% MBL proof load. In some aspects, stretching of a polyester segment of the mooring line may increase the stiffness of that segment, such as from 11 times MBL to 15 times MBL. In some aspects, stretching is performed by pulling on the same tension coupler that tensioning line was coupled to during mooring line tensioning. In other aspects, stretching is performed by pulling on a different tension coupler than tensioning line was coupled to during mooring line tensioning.

[00087] Turning now to FIG. 1R, after tensioning and releasing mooring line 701, the method includes stretching at least portions of mooring line 701. The method may include positioning AHV 700 above tension coupler 712a, lowering line 720 to tension coupler 712a, and coupling line 720 to shackle 717 of tension coupler 712a. With line 720 and tension coupler 712a coupled, the method may include hauling in line 720 towards AHV 700 along direction 505a to impart a force on mooring line 701. This imparted force may result in a stretching of at least some portions of mooring line 701, such as polyester midspan lines 724a and 724b.

[00088] In some aspects each polyester segment (or other stretchable segment) of mooring line 701, such as midspan lines 724a and 724b, is stretched to at least 40% of that segments MBL. Such stretching may be performed to remove construction stretch from the line, and to minimize the need for further re-tensioning of the line.

[00089] As an example, Table 1 presents vessel and AHV loading data associated with proof tensioning a first mooring line (*i.e.*, the first of all of the mooring lines of the vessel to be stretched) of a vessel to 40% MBL of the polyester, and Table 2 presents line loading data associated with proof tensioning the first mooring line to 40% MBL.

Table 1

AHV Bollard Pull (mT)	Tensioning Line Tension @ stern (mT)	Mooring Line Tension @ Fairlead Stopper (mT)	Vessel Offset (m)
259	483	735	46

Table 2

Tensioning Line Tension @ Tension Coupler (mT)	Tension in Upper Polyester Segment (mT)	% MBL of Upper Polyester Segment	Tension in Lower Polyester Segment (mT)	% MBL of Lower Polyester Segment
467	700	40	700	40

[00090] Table 3 presents vessel and AHV loading data associated with proof tensioning a last mooring line (*i.e.*, the last of all of the mooring lines of the vessel to be stretched) of the vessel to 40% MBL of the polyester, and Table 4 presents line loading data associated with proof tensioning the last mooring line to 40% MBL.

Table 3

AHV Bollard Pull (mT)	Tensioning Line Tension @ stern (mT)	Mooring Line Tension @ Fairlead Stopper (mT)	Vessel Offset (m)
276	510	733	69

Table 4

Tensioning Line Tension @ Tension Coupler (mT)	Tension in Upper Polyester Segment (mT)	% MBL of Upper Polyester Segment	Tension in Lower Polyester Segment (mT)	% MBL of Lower Polyester Segment
494	700	40	700	40

[00091] In some aspects, the ratio of the lengths of the polyester segments 724a and 724b is optimized for proof loading to 40% while reducing tension and bollard pull. Table 5 presents some exemplary data of different length ratios between the polyester segments 724a and 724b. The bollard pull data in Table 5 does not account for vessel motion or offset.

Table 5

Upper Polyester Segment Length (% of total length of both upper and lower polyester segments)	Lower Polyester Segment Length (% of total length of both upper and lower polyester segments)	AHV Bollard Pull Required (mT)	Tension @ Stern (mT)
25	75	194	448
50	50	219	421
75	25	281	469

[00092] In view of the data in Table 5, in at least some embodiments the optimal polyester segment ratio is for the upper polyester segment (724b) to constitute 25% of a length of the total midspan (*i.e.*, the combined length of 724a and 724b), and for the lower polyester segment (724a) to constitute 75% of a length of the total midspan. With such asymmetric polyester segments, the bollard pull required for stretching is reduced, while the utilization of line 720 increases.

[00093] In some aspects, after stretching is performed, the mooring line is again tensioned (*e.g.*, in accordance with FIG. 1K). For example, top chain 310 may be reconnected with a shark jaw of AHV 700, line 720 may be reconnected with tension coupler 712b, and mooring line 701 may be pulled to a second tension. In certain aspects, each mooring line of a vessel is tensioned to a first tension, followed by stretching of each mooring line, followed by further tensioning of each mooring line to a second tension that is greater than the first tension.

Mooring Line Bitter End

[00094] The bitter end of top chain 310 may be secured, stored, and/or cut. With reference to FIG. 2G, in some aspects, after pretension is complete, the bitter end of top chain 310 is laid over the side of fairlead stopper 100 on a guide shoe 124, including chain slack holder 125. Chain slack holder 125 may be a structure on or of fairlead coupler 100 configured to retain top chain 310. In other aspects, the bitter end of top chain 310 is secured to the hull of vessel for permanent or long-term mooring. For example, with reference to FIG. 2H, the bitter end of top chain 310 may be coupled with pad eye 202a on vessel 200 via pin 201 and shackle 302c. In other aspects, the bitter end of top chain 310 is routed over a deflector plate 119 positioned over latch housing 120 and is thereon cut, as shown in FIG. 2I.

[00095] FIGS. 6A-6E depict another embodiment of fairlead stopper 100, illustrating one method of handling the bitter end of mooring lines in accordance with the present disclosure. Fairlead stopper 100 includes chain and wheel locking pin 600. In operation, when hauling in or paying out the mooring line along hauling direction (as indicated in FIG. 6D), pin 600 may be removed from chain wheel 110, such that the mooring chain enters fairlead stopper 100, as indicated via chain 310a, and travels on chain wheel 110 as indicated via 310b. After tensioning is complete, the mooring chain may be pinned to fairlead stopper 100, with excess mooring chain cut off or disconnected. While 310a indicates the position of the mooring chain during tensioning, 310c indicates the position of mooring chain after tensioning, with the mooring chain pinned off. Mooring chain 310c is engaged about chain wheel 110, and pin 600 is engaged with fairlead stopper 100 to maintain chain 310c held on chain wheel 110. As shown in FIGS. 6A-6E, pin 600 is engaged through chain guide 612, such that pin 600 holds chain 310c in engagement with chain wheel 110, preventing chain 310c from disengaging from chain wheel 110. Fairlead stopper 100 may engage with upper bracket 114 via upper retainer 616. Fairlead stopper 100 also includes linear transducer 610 for actuating latches, latch locker and cover 618, and linkage cover 614. While not shown, fairlead stopper 100 also includes, within latch housing 120, latches, synchronizing linkage between latches, and latch tension springs for operation of at least one embodiment of the fairlead stopper.

[00096] In some aspects, a connecting link is included in the mooring line. The connecting link may be disconnected from the mooring line after tensioning is completed to remove excess tail chain.

[00097] After tensioning, and optionally stretching, is completed, AHV 700 may then move onto the next mooring line of vessel 200 or another vessel for tensioning and/or stretching operations.

Tri-Plate Connector

[00098] One exemplary tension coupler 712 is depicted in FIG. 3. Tension coupler 712 shown in FIG. 3, also referred to as a tri-plate connector, includes body 713 with through-holes 715 positioned therethrough. Body 713 may be or include steel. Each through-hole 715 may be positioned and configured to connect with a rope, chain, wire, or other tensioning or mooring line, such as via shackles. In some aspects, tension coupler 712 is configured to couple with segments of mooring line 701 such that the segments of mooring line 701 may be tensioned and may extend in substantial linear alignment with one another. For example, midspans 724a and 724b and top chain 310 may be coupled with through-holes 715 such that top chain 310 and midspans 724a and 724b extend in linear alignment along a direction (or at least parallel) when mooring line 701 is tensioned. Also, through-holes 715 may be arranged such that tensioning line 720 may be coupled therewith to apply a tensioning or pulling force along another direction that is perpendicular to, or at least not parallel to, the direction of extension of mooring line 701.

Moored Vessel

[00099] FIG. 4 depicts vessel 200, which is moored via plurality of mooring lines 701, each including an anchor 714, bottom chain 722, midspans 724a and 724b, top chain 310, and tension couplers 712a and 712b. For simplicity, the details of only one of mooring lines 701 are shown. Also shown is AHV 700 with two winches 710a and 710b. FIG. 5 is a graph of one exemplary mooring system pattern with vessel 200, a plurality of mooring lines 701, and a plurality of anchors 714.

[000100] Table 6, below, shows component lengths of one exemplary mooring line during different stages of the presently disclosed mooring and tensioning procedure. The polyester segment lengths account for the estimated elongation from being loaded.

TABLE 6

Mooring Line Segment	Initial Connection	Pre-Tension to 250 mT	Proof Loading to 40% Polyester MBL	Pre-Tension to 300 mT
Top Chain	350 m	276 m	276 m	229 m
Upper Polyester Segment	1,045 m	1,059 m	1,075 m	1,075 m
Lower Polyester Segment	1,045 m	1,059 m	1,075 m	1,075 m

Bottom Chain	250 m	250 m	250 m	250 m
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Installation and Maintenance

[000101] As disclosed herein, the fairlead stoppers used in the mooring method may be mounted on the hull, either below or above the waterline. If the fairlead stopper is located below the water line, then the fairlead stopper may be positioned outside of the splash zone. The fairlead stopper, which may be installed at port, may be mounted relatively high-up on the hull, above the waterline, such as to provide for access for inspection or installation quayside at the shipyard instead of in the dry dock. As such, the fairlead stoppers may be available for power washing and inspection prior to leaving for the installation site, making it easier for ROV and diver operations offshore and reeving chain, and also mitigating risk prior to arriving on site for mooring hook up.

[000102] Instrumentation on the fairlead stopper may be designed and configured for a relative long-duty life and, in some applicants, may not require replacement for substantial periods of time. In some aspects of the mooring method, the fairlead stoppers require no long-term maintenance other than visual inspections. For example, cleaning and visual inspection once every 5 years may be sufficient for maintenance of the fairlead stoppers. Bearing wear inspection and measurement may also be performed on the fairlead stoppers. If replacement or maintenance of the fairlead stoppers is required, load instrumentation on the fairlead stoppers may be removed and replaced by diver or ROV without disturbing the mooring load thereon. That is, in some aspects, such instrumentation on the fairlead stopper does not include a load cell located in the load path. Strain in the housing of the fairlead stopper may be measured to determine load, such that removal and replacement may occur without requiring removal of the mooring load. In some such aspects, the method includes avoiding the use of acoustic systems for monitoring load on the fairlead stoppers. As such, maintenance of the equipment may be reduced or eliminated, as the present fairlead stoppers are, in at least some aspects, maintenance free or substantially maintenance free. The methods may also be used to reduce mooring line installation time and costs.

Reduction in Weight

[000103] In certain aspects, the present method reduces the weight on the moored vessel and/or the mooring line in comparison to methods using an inline tensioner (ILT). For example, in methods that use an ILT, the ILT and tail chain (adjustment chain of the mooring line) are left hanging, midspan, from the top chain. The weight of the ILT on the top chain has long-term effects on fatigue and life of the chain. Furthermore, the weight of the ILT on the top

chain affects the shape of the catenary of the top chain, which causes other risks and effects on mooring performance. Also, the weight of the ILT on the top chain increases the buoyancy requirements, or reduces topsides weight capacity of the vessel.

[000104] In some aspects, the mooring methods disclosed herein provide for reduced weight of deck equipment on the moored vessels by eliminating some or all tensioning devices thereon. Thus, the methods disclosed herein provide for freeing of space on deck of the moored vessel for other uses by eliminating some or all tensioning devices and associated hydraulic power units, controls and piping. The methods disclosed herein may also eliminate the need to store tail chain on board in chain lockers, further reducing weight on board the vessel. In some aspects, the cost of mooring equipment is reduced when the present method is utilized in comparison to methods that use ILTs.

Motion Control

[000105] In certain aspects, the present method eliminates problems associated with controlling the motion of the ILT during tensioning operations. As an ILT does not run freely on the mooring line when lifting, the AHV lifts the entire mooring line catenary upwards until enough load is achieved to overcome friction, at which point the ILT runs down the chain, falling until the friction takes over again and stops the ILTs motion. Thus, when using an ILT, it is difficult to control how much chain is pulled in as the ILT typically moves past the “golden” link, such that chain must be paid out to get back to the “golden” link. Paying out chain can be difficult, sometimes requiring the use of stopping devices attached to a chain link so that the “golden” link is forced to stop when it reaches the latching device. The use of such stopping devices causes an impact load on the chain and ILT when the ILT is moving down the chain and suddenly clashes with the stopping device.

[000106] In some aspects of the present method, when the AHV pulls the top chain, the top chain passes relatively smoothly through the fairlead stopper, as the method does not depend on weight of a chain tensioner device to overcome resistance to movement in the fairlead stopper. Thus, in some such aspects, the method disclosed herein avoids sudden, uncontrolled movements of the mooring line; reduces the possibility of damage to the mooring line or the tensioner assembly relative to in-line tensioners; increases safety relative to in-line tensioners; and reduces the occurrence of stretch in the mooring line and stalling of the winches relative to in-line tensioners.

Paying Out Mooring Line

[000107] In certain aspects, the present method does not exhibit at least some of the problems exhibited by methods that use ILTs during pay out of mooring line. ILTs require an

ROV to control the latch actuation to allow chain to be paid out. Locking the latches open is a risky operation, as the locking mechanism may fail. Also, the ILT may be positioned too deep for divers to repair. Furthermore, ILTs are suspended in the catenary of the mooring line, and not attached to a rigid structure, such as the vessel hull. If the latch mechanism of an ILT cannot be held open, extraction of the chain from the ILT for retrieval and/or repair is prevented.

[000108] In some aspects of the present method, the method includes paying out additional mooring line. The bitter end of the top chain may be retrieved (*e.g.*, by unpinning the bitter end from the hull of the vessel). The bitter end of the top chain may then be coupled with one of the winches of the AHV, which may then pull the mooring line taut, such that the latches of the fairlead coupler are free to open. An ROV or diver may open the stopper latches, which may also be operable by wire rope from the hull above, and lock the latches in the open position. The AHV may then pay out mooring line until the desired tension is achieved, or may pay out all the mooring line if disconnection from the mooring line is required.

Simplification of Tail Chain Handling

[000109] In certain aspects, the present method simplifies tail chain handling, relative to methods that use ILTs. Handling of the tail chain after tensioning using an ILT can be difficult, and requires cutting of the tail chain by an ROV or diver. When cut, the tail chain includes two loose half-links, and the remainder of the tail chain must be retained and handled. Also, special handling tools are required to ensure that no parts fall, uncontrolled, after cutting of the tail chain. The tail chain is laid over one side of the ILT and, depending on the tail chain weight, a twist in the mooring line could be induced by the tail chain hanging over the one side. Twisting load on the links in the ILT that may have long term effects on chain wear.

[000110] In some aspects of the present method, after the mooring line is hauled through the fairlead stopper and pretensioned, the bitter end of the mooring line may be positioned over to the hull of the vessel and pinned off to an eye using a standard shackle. In some such aspects, this allows the mooring line to be easily accessed at a later time for re-tensioning, if required. In some aspects, the mooring line is not subjected to twisting (*e.g.*, 180-degree twists) during mooring operations, thus, reducing the occurrence of interlink wear and increasing the life of the chain relative to in-line tensioners. In certain aspects of the present method, after tensioning the mooring line, the tail chain (bitter end) does not require cutting, which can save time, money, increase safety, and increase available deck space on the vessel in comparison to methods that use in-line tensioners.

[000111] In some aspects, operations of the hook up and tensioning procedures disclosed herein may be facilitated via use of simulation and analysis software, such as OrcaFlex 10.0d.

Fairlead with Chain-Retaining Arms

[000112] Embodiments disclosed herein include methods and systems for cutting, storing, and securing the tail chain of a mooring line. FIGS. 7-11 depict fairlead stopper 700. Fairlead stopper 700 includes a housing assembly that includes fairlead housing 712, a chainwheel housing 711, and a latch housing 720. Fairlead housing 712 is movably coupled with brackets 714 and 716 such that fairlead housing 712 is rotatable relative to the brackets 714 and 716, and such that fairlead housing 712 is pivotable about pivot point 715. The brackets 714 and 716 can be attached to, or be a portion of, a floating vessel 793 (shown in FIG. 9).

[000113] Fairlead stopper 700 includes chainwheel housing 711 coupled with fairlead housing 712 and chainwheel 710 coupled with chainwheel housing 711. Chainwheel 710 is rotatably coupled with chainwheel housing 711 at axle 713 such that chainwheel 710 is rotatable relative to chainwheel housing 711.

[000114] Fairlead stopper 700 includes latch housing 720 coupled with chainwheel housing 711. Latch housing 720 is pivotably coupled with chainwheel housing 711 such that latch housing 720 is pivotable about pin 721. A range of motion of the latch housing 720 is shown in FIG. 9. Latches 730 (shown in FIG. 9) are positioned within latch housing 720 and configured to latch chain links of a mooring line 790.

[000115] Fairleads stopper 700 includes chain guide 724 positioned to guide mooring line 790 as mooring line 790 passes through fairlead stopper 700.

[000116] Fairlead stopper 700 is configured for the cutting, storage, and securing of the tail chain of mooring line. Components of fairlead stopper 700 that facilitate the cutting, storage, and securing of tail chain include, but are not limited to, tail chain deflector 725, tail chain retaining plate 726, tail chain retaining arm 727, and chain retaining arm 728. During mooring, the mooring line 790 passes through fairlead stopper 700, through latch housing 720, and over chainwheel 710. Within the latch housing 720, the latches 730 are positioned to latch a chain link of the mooring line 790 to secure the tension on the mooring line 790. Once the desired tension on the mooring line 790 is achieved and the latches 730 are latched onto the mooring line 790, the bitter end 792 (shown in FIGS. 10A and 10B) of the mooring line 790 is positioned to hang down from the chain deflector 725. With the desired tension on the mooring line 790 achieved, the chain retaining arm 728 is engaged over the chainwheel 710 and over the portion of the mooring line 790 that is engaged with the chainwheel 710. Also, with the desired tension on the mooring line 790 achieved, the bitter end 792 is positioned on the chain table 726 and extends over the chain deflector 725, which deflects the position of the bitter end

792 away from the position of the mooring line 790 (as shown in FIG. 9). With the bitter end 792 positioned on the chain table 726, the tail chain retaining arm 727 is engaged over the bitter end 792 such that the bitter end 792 is secured between the tail chain retaining arm 727 and the chain table 726. An ROV or diver may swing the chain retaining arm 728 and tail chain retaining arm 727 into the closed positions. In some embodiments, the chain table 726 and chain deflector 725 are different portions of the same component. In other embodiments, the chain table 726 and chain deflector 725 are different components.

[000117] Chain table 726 includes two angled wings or plates 705a and 705b. Where the plates 705a and 705b meet, chain table 726 includes or defines a trough 795. Trough 795 is configured (e.g., shaped and positioned) to receive the mooring line 790.

[000118] If the length of the bitter end 792 extending from the chain guide 724 is greater than a maximum excess chain length, then the portion of the bitter end 792 greater than a maximum excess chain length is cut. For example, an ROV or diver may cut the bitter end 792. The maximum excess chain length can be based on, for example, the weight of the bitter end 792 and/or the length of the bitter end 792. Thus, by cutting the bitter end 792 the weight exerted by the bitter end 792 on the fairlead stopper 700 is reduced. Also, by cutting the bitter end 792 the length of the bitter end is reduced. Reducing the length of the bitter end 792 can reduce the risk of, and dangers associated with, the bitter end 792 becoming entangled with other portions of the fairlead stopper 700 or other components of the floating vessel. When the bitter end 792 is cut, the reduction in the weight of the bitter end 792 can cause a tension to be exerted onto the mooring line such that the bitter end 792 is pulled towards the chainwheel 710 and such that the chainwheel 710 rotates to draw in the bitter end 792. The chain retaining arm 728 and the tail chain retaining arm 727 secure the position of the mooring line 790. Therefore, the chain retaining arm 728 and tail chain retaining arm 727 prevent, or at least resist, the pulling of the bitter end 792 towards the chainwheel 710 that would otherwise occur upon cutting of the bitter end 792.

[000119] The chain retaining arm 728 and tail chain retaining arm 727 can be bars that, when closed, lock the position of the mooring line. The chain retaining arms 727 and 728 are shown in a closed position in FIG. 7, and the chain retaining arm 728 is shown in an open position in FIG. 11. Securing the bitter end 792 reduces the movement (e.g., swinging) of bitter end 792, such as during storms or rough sea conditions; thereby, reducing the risk of damage to the fairlead stopper 700 and/or floating vessel.

[000120] With the bitter end 792 secured to the chain table 726, a portion of the bitter end 792 is engaged over the chain deflector 725. The chain deflector 725 provides a surface for a

portion of the bitter end 792 to rest without interfering with other components of the fairlead stopper 700, such as the latches 730. As shown in FIGS. 10A and 10B, the chain deflector 725 deflects the bitter end 792 such that the bitter end 792 does not hang down from the fairlead stopper 700 in alignment with the mooring line 790, but to one side of the mooring line 790. Thus, the chain deflector 725 protects portions of the fairlead stopper 700 from the bitter end 792. Chain deflector 725 includes a baffle 799. Baffle 799 includes or defines troughs 797. Baffle 799 is positioned to deflect mooring line to either trough 797. The troughs 797 deflect the mooring line to either side of the fairlead stopper 700.

[000121] As shown in FIG. 8, tail chain retaining arm 727 and chain retaining arm 728 each include a handle 729a and 729b. Additionally, the fairlead stopper 700 includes a third handle 729c. The handles 729a-729c can be configured for engagement by an ROV or diver. For example, an ROV or diver can engage handle 729c to brace a position of the ROV or diver relative to the fairlead stopper 700. With the position of the ROV or diver braced, the ROV or diver can engage the handle 729a to open or close the chain retaining arm 728. With the position of the ROV or diver braced, the ROV or diver can engage the handle 729b to open or close the tail chain retaining arm 727. Each of the handles 729a-729c can be locked into position. Chain retaining arm 728 is pivotably coupled with arm housing 703a (which is coupled with or a portion of chainwheel housing 711) such that the ROV or diver can swing the chain retaining arm 728 about pivot pin 731 between an open position and a closed position. In the closed position, chain retaining arm 728 can be locked onto arm housing 703b. In the same manner, tail chain retaining arm 727 is pivotably coupled with the chain plate 705a such that the ROV or diver can swing the tail chain retaining arm 727 about the pivot pin 735 between an open position and a closed position as shown. In the closed position, the tail chain retaining arm can be locked onto the chain plate 705b.

[000122] Fairlead stopper 700 also includes a latch actuation lever 740 that can be actuated by an ROV or diver for controlling the opening and closing of the latches. Actuation of the latches 730 can be performed to pay out additional mooring line. In some embodiments, actuation of the latches 730 can be performed from above the fairlead and/or remotely by an ROV or diver. In some embodiments, an ROV or diver can connect a wire from the deck of the vessel, at a point above the fairlead, rather than from a position on the latch housing between fairleads.

[000123] Fairlead stopper 700 includes a sea-fastening clevis 780 and a sea-fastening bracket 782. The sea-fastening bracket 782 is configured to couple with the floating vessel at a first end 784 and to couple with the sea-fastening clevis 780 at a second end 786. The sea-

fastening clevis 780 and sea-fastening bracket 782 are used to secure the fairlead stopper 700 to the floating vessel, such as during transport of the floating vessel.

[000124] In some embodiments, the tail chain retaining arm is used in place of one or more pins (*e.g.*, three pins) to pin the bitter end of the chain to a chain table. The use of the tail chain retaining arm has, in some embodiments, advantages relative to the use of pins to secure the bitter end to a chain table. For example, pins are typically required to be installed during transport, then removed prior to mooring, and then reinstalled after mooring, which each of these steps requiring the use of an ROV or diver and sea conditions that are suitable for the use of the ROV or diver. The tail chain retaining arm can be placed in the open position during transport of the vessel and left in the open position until completion of the mooring. Thus, the tail chain retaining arm can be used without requiring use of an ROV or diver to open or close the arm prior to mooring operations. Additionally, pins are at a greater risk of being dropped during installation or removal, whereas, the tail chain retaining arm, in some embodiments, remains pivotably coupled to the fairlead stopper at all times before, during, and after mooring operations. Both the chain retaining arm and the tail chain retaining arm can be locked in the open position (*e.g.*, during transport) and locked in the closed position (*e.g.*, after mooring is complete). The ability to lock and unlock the position of the chain retaining arm and the tail chain retaining allows the chain retaining arms to be positioned out of the way during mooring operations, and to be swung into the locked position by an ROV or diver after the mooring is complete. For example, the chain retaining arm and the tail chain retaining arm can be locked into the closed position after mooring tensioning and poly stretch is complete.

[000125] With the bitter end 792 deflected by the chain deflector 725 and hanging down to a position below the fairlead stopper 700, the bitter end 792 is accessible by an ROV or diver for cutting operations. The chain deflector 725 has a shape and size such that the bitter end 792 will move into the desired location via the action of gravity upon lowering of the bitter end 792 (*e.g.*, from an AHTS). By hanging the bitter end 792 from the chain deflector 725 to a position below the fairlead 700, the bitter end 792 is more accessible for cutting as well as for re-connecting additional chain to extend the length of the mooring line. In some embodiments, the chain deflector 725 has a relatively large bell mouth, without protruding features, and has a shape and size that deflects the bitter end over to one side or the other side of the latch housing 720.

[000126] Eliminating the use of pins for cutting the tail chain allows the fairlead to swing through a larger range in the vertical direction without the risk of the chain getting bunched-up

in-between the pins. In some embodiments, pins can only be inserted when the fairlead has sufficient tension to achieve a sufficient vertical angle.

Sea-Fastening Brace and Wave-Reaction Bar

[000127] Some floating vessels are designed in such a way that the fairlead, if allowed to hang vertically, would hang vertically below the keel (e.g., a floating production storage having relatively small pontoons). In such embodiments, the fairlead may be sea fastened in a position where the latch housing of the fairlead is suspended at an angle, such as a 45-degree angle. A sea-fastening brace can be used to support this attachment of the fairlead to the vessel. With reference to FIGS. 14-15, fairlead stopper 800 is depicted. Fairlead stopper 800 includes sea-fastening brace 889. Sea-fastening brace 889 is coupled between the fairlead housing 812 and the latch housing 820 (or another portion of the fairlead stopper). Sea-fastening brace 889 can be a rigid bar or other structure configured to position the fairlead stopper 800 at the desired angle relative to the vessel (not shown). The length of the sea-fastening brace 889 can be adjusted (and adjustable) to vary the angle at which the fairlead stopper 800 is relative to the fairlead housing 812 and/or the vessel to which the fairlead stopper 800 is coupled.

[000128] Fairlead stopper 800 also includes wave-reaction bar 879. Wave-reaction bar 879 is coupled between the vessel (not shown) and the latch housing 820. The wave-reaction bar 879 can be, for example, a strut or another device capable of reacting to force (e.g., a spring). The wave-reaction bar 879 is configured to react to and dampen forces that are imparted onto the fairlead stopper 800. The wave-reaction bar 879 can reduce the amount of force that is transferred from the fairlead stopper 800 to the vessel. While referred to as a “wave-reaction” bar, the wave-reaction bar 879 can react to forces that are not caused by waves. The wave-reaction bar 879 can be coupled between the vessel and the fairlead stopper 800 during, for example, transport.

Pre-Messenger Line

[000129] Some embodiments include a pre-messenger line for use during mooring operations. The pre-messenger line can be sea-fastened to the fairlead stopper and/or vessel prior to sail away, such as in a manner the same as or similar to that shown in FIG. 2A. The pre-messenger line can be used offshore to reave through a heavier messenger line. With reference to FIG. 2A, the pre-messenger line 300 has two LLC links 302a and 302b. In other embodiments, the pre-messenger line has only one link. In other embodiments, the pre-messenger line has no links. In some embodiments, the pre-messenger line and the messenger line has no standard chain links.

[000130] Use of a pre-messenger line avoids the need to move a heavier messenger line to an AHV for connection to winches and to the mooring line. In some embodiments, each fairlead stopper on a vessel has a pre-messenger line installed thereon. The pre-messenger lines can be installed at the shipyard prior to transport of the vessel. A relatively heavier and stronger messenger line can be hauled through the fairlead stopper once the vessel is at the offshore site during the mooring operations. This same heavier and stronger messenger line can be re-used with each fairlead stopper of the vessel during the mooring operations. This method has the advantage that as little as one messenger line is needed during the mooring operations rather than one messenger line for each mooring line.

[000131] With reference to FIGS. 1A-1R, in some embodiments the outer messenger line (first end 300a) is connected to the top chain 310 on the AHV 700 (as shown in FIG. 1F) and is then placed overboard (as shown in FIG. 1G) prior to picking up the inner messenger line (second end 300b) as shown in FIG. 1H. At this point in the process, the catenary is held by the fairlead stopper 100 while the AHV 700 approaches the vessel 200 to retrieve the inner messenger (second end 300b), as shown in FIG. 1H. This process scenario provides the ability to avoid the need to have both the inner and outer messenger lines (first and second ends 300a and 300b) as well as the top chain 310 and holdback line (tension line 720) all on the deck of the AHV 700 at the same time. Additionally, at least some embodiments of this process scenario require no more than two chain links to be in the pre-messenger line such that the pre-messenger line can be hung off in the fairlead stopper.

[000132] Reducing ROV or diver operations provides for the ability to complete mooring operations more quickly, and allows mooring operations to be performed in poor conditions that ROVs and divers cannot operate within, such as strong currents or significant wave heights (Hs). In some embodiments, all four lines (the inner messenger line, outer messenger line, top chain, and holdback line) are taken on the deck of the AHV at the same time. Chain links within a messenger line result in additional weight that needs to be retained (*e.g.*, from falling into or below the fairlead stopper). Thus, a pre-messenger line without any chain links can be used to reduce the weight on the AHV.

[000133] The pre-messenger line can be a relatively small line that is relatively easy to handle. Examples of such pre-messenger lines include a rope (*e.g.*, ~25mm Dyneema) or wire. In some such embodiments, steel wire is used as the pre-messenger line, as steel wire does not float in typical sea conditions and is generally less flexible than other ropes and, therefore, less likely to be snagged during hand over operations. Both the first and second ends of the pre-messenger line can be handed over relatively easily onto the AHV, connected to a larger

messenger line on the deck of the AHV, and then be run through the fairlead in preparation for connecting to the top chain. Such embodiments allow for work to be performed further away from the floating vessel being moored, avoiding the need for the AHV to have to hold station close by the floating vessel for long periods of time.

Exemplary Pre-Messenger Line Method

[000134] One exemplary method of using the pre-messenger line includes reeving the pre-messenger line through the fairlead stopper at a shipyard, prior to sail-away of the vessel. Both ends of the pre-messenger line are secured at a column top of the vessel.

[000135] After weaving the pre-messenger line through the fairlead stopper and securing the pre-messenger line to the vessel, the vessel is transported to the desired site. At the desired site, an AHV is used to retrieve a pre-laid mooring line off the sea bed. The pre-laid mooring line is locked in shark jaws on deck of the AHV.

[000136] After locking the pre-laid mooring line, a hold back line is connected between a winch on the AHV and a tri-plate connector located in the top chain of the mooring line (e.g., at the top chain-to-poly connection).

[000137] After connecting to the tri-plate connector, the AHV is positioned close to a hull of the vessel (e.g., within about 25m from the vessel).

[000138] With the AHV positioned close to the hull of the vessel, both ends of the pre-messenger line are transferred from the vessel to the AHV. An outer end of the pre-messenger line is connected to a messenger line (e.g., wire or rope) on the AHV. The connected end of the pre-messenger line and messenger line are then over-boarded while the loose end of the messenger line is secured on the deck of the AHV.

[000139] The AHV then hauls in on the inner pre-messenger line to pull the connected pre-messenger line and messenger line through the fairlead stopper until the messenger line passes through the fairlead stopper and then is pulled back onto the AHV.

[000140] With the messenger line, connected to pre-messenger, having passed through the fairlead stopper and back onto the AHV, the pre-messenger line is disconnected and can be discarded. At this point in the method, both ends of the messenger line on the deck of the AHV.

[000141] The top chain of the mooring line is then connected to the end of the messenger line that extends from the AHV into the chain guide of the fairlead (e.g., 724), i.e., the outer messenger line end.

[000142] A winch on the AHV is connected to the end of the messenger line that extends from the fairlead stopper chainwheel to the AHV (i.e., the inner messenger line end).

[000143] The connected top chain and outer messenger line are then over-boarded.

[000144] The AHV hauls in the messenger line until the chain of the mooring line enters the fairlead stopper.

[000145] The AHV continues to haul in the mooring line until the top chain is hauled through to the golden link of the mooring line. The messenger line can be disconnected from the top chain when convenient during the process (e.g., when the connection point of the messenger line reaches the deck of the AHV or when enough chain is pulled through the fairlead and is lowered down to hang off of the fairlead stopper. In some embodiments, the messenger line is disconnected from the mooring line by an ROV or diver.

[000146] The exemplary pre-messenger line method is not limited to performing each of the above steps and is not limited to the above described order of steps. Some of the steps may be eliminated, some steps may be added, and the order of some of the steps may be rearranged. For example, connection of the winch on the AHV to the tri-plate connector can be performed after passing the messenger line through the fairlead stopper, such as if tension is low enough to allow the pre-messenger line to be pulled through the fairlead stopper. Also, the messenger line may be pulled through the fairlead stopper prior to over-boarding of the top chain. The exact steps and ordering thereof can be made based on line lengths, loads, vessel characteristics and installation contractor preferences.

Additional Features

[000147] For traditional mooring systems using chain jacks, it is beneficial to limit the amount of chain that needs to be hauled in because the hauled in chain results in an inefficient use of deck space and in additional weight in the chain locker that does not provide a benefit. If there is not a sufficient amount of extra chain to pull through, then the AHV is required to be positioned in close proximity to the floating vessel being moored, which requires additional energy and difficult maintenance of station. Typically, the first mooring lines can be installed relatively easily because the tugs can move the floating vessel off position, closer to the mooring line to facilitate ease of operations. Once the floating vessel is storm safe and the tugs are cut loose, the floating vessel remains in place. Using the mooring methods disclosed herein, the remnants of the first cut chain lengths (e.g., the first four cut chain lengths) with LLLC connectors can be used to increase the amount of chain on the end of the mooring line for hauling through the fairlead. This provides an essentially unlimited access to chain (“an unlimited chain locker”) that can be disconnected after hauling in. Adding additional tail chain prior to hauling in reduces the bollard pull requirements by the AHV performing the hauling in operation (e.g., allowing for smaller, lower cost AHVs to be used).

[000148] While specific embodiments and equipment are shown and described herein, one skilled in the art would understand that the methods, systems, and apparatus disclosed herein are not limited to these particular embodiments described.

[000149] Although the present embodiments and advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the disclosure. Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the disclosure, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present disclosure. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

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CLAIMS

What is claimed is:

1. A fairlead stopper, the fairlead stopper comprising:
a housing assembly;
latches movably coupled with the housing assembly;
a chainwheel rotatably coupled with the housing assembly;
at least one chain retaining arm coupled with the housing assembly, wherein the at least one chain retaining arm is movable between an open position and a closed position, wherein in the closed position the at least one chain retaining arm is positioned to secure mooring line passing through the fairlead stopper.
2. The fairlead stopper of claim 1, further comprising:
a chain table coupled with the housing assembly, wherein the chainwheel is positioned to direct mooring line to the chain table; and
a chain deflector coupled with the housing assembly, wherein the chain table is positioned to direct mooring line to the chain deflector, and wherein the chain deflector is configured to deflect mooring line to one side of the fairlead stopper.
3. The fairlead stopper of claim 2, wherein the chain table comprises a first chain plate coupled with a second chain plate, wherein the first and second chain plates define a trough that is positioned to receive mooring line from the chainwheel.
4. The fairlead stopper of claim 2, wherein the chain deflector comprises a baffle, wherein the baffle defines at least one chain deflector trough, and wherein the at least one chain deflector trough is positioned to deflect mooring line to one side of the fairlead stopper.
5. The fairlead stopper of claim 4, wherein the at least one chain deflector trough comprises a first chain deflector trough positioned to deflect mooring line to a first side of the fairlead stopper and a second chain deflector trough positioned to deflect mooring line to a second side of the fairlead stopper.
6. The fairlead stopper of claim 2, further comprising a mooring line, wherein the mooring line extends from the latches to the chainwheel, from the chainwheel to the chain table, and from the chain table to the chain deflector, and wherein the chain deflector deflects the mooring line to one side of the fairlead stopper.

7. The fairlead stopper of claim 2, wherein the at least one chain retaining arm comprises:

a first chain retaining arm coupled with the housing assembly, wherein the first chain retaining arm is movable between an open position and a closed position, wherein in the closed position the first chain retaining arm is engaged over the chainwheel to secure mooring line passing over the chainwheel; and

a second chain retaining arm coupled with the chain table, wherein the second chain retaining arm is movable between an open position and a closed position, wherein in the closed position the second chain retaining arm is engaged over the chain table to secure mooring line positioned on the chain table.

8. The fairlead stopper of claim 1, wherein the at least one chain retaining arm is pivotably coupled with the housing assembly, and is pivotably movable relative to the housing assembly between the open and the closed positions.

9. The fairlead stopper of claim 1, wherein the at least one chain retaining arm is lockable into the open and the closed positions.

10. The fairlead stopper of claim 1, wherein the at least one chain retaining arm comprises a handle configured for opening and closing the at least one chain retaining arm.

11. The fairlead stopper of claim 1, wherein the housing assembly comprises a fairlead housing, a chainwheel housing coupled with the fairlead housing, and a latch housing pivotably coupled with the chainwheel housing, wherein the chainwheel is rotatably coupled with the chainwheel housing.

12. The fairlead stopper of claim 1, further comprising a sea-fastening bracket, wherein the sea-fastening bracket is selectively couplable with the housing assembly to secure the fairlead stopper to a vessel.

13. A method of handling a mooring line coupled with a fairlead stopper, the method comprising:

providing a fairlead stopper comprising a housing assembly, latches coupled with the housing assembly, a chainwheel coupled with the housing assembly, and at least one chain retaining arm coupled with the housing assembly;

latching a mooring line with the latches, wherein the mooring line extends from the latches to the chainwheel and over the chainwheel, and wherein the mooring line extends from the chainwheel; and

moving the at least one chain retaining arm into a closed position such that the mooring line is secured between the at least one chain retaining arm and another portion of the fairlead stopper.

14. The method of claim 13, further comprising:

directing the mooring line from the chainwheel to a chain table that is coupled with the housing assembly;

directing the mooring line from the chain table to a chain deflector that is coupled with the housing assembly; and

deflecting the mooring line to one side of the fairlead stopper with the chain deflector.

15. The method of claim 14, wherein the mooring line is deflected with a baffle and a chain deflector trough of the chain deflector.

16. The method of claim 14, wherein moving the at least one chain retaining arm comprises:

moving a first chain retaining arm coupled with the housing assembly into the closed position such that the first chain retaining arm is engaged over the chainwheel to secure mooring line passing over the chainwheel; and

moving a second chain retaining arm coupled with the chain table into the closed position such that the second chain retaining arm is engaged over the chain table to secure mooring line positioned on the chain table.

17. The method of claim 13, further comprising locking the at least one chain retaining arm into the closed position.

18. The method of claim 13, wherein moving the at least one chain retaining arm comprises manipulating a handle of the at least one chain retaining arm.

19. The method of claim 16, wherein the bitter end of the mooring line extends from the chain deflector to a position below and to one side of the fairlead stopper.

20. The method of claim 19, further comprising cutting a portion of the bitter end below the fairlead stopper.

21. The method of claim 13, further comprising, prior to latching the mooring line, transporting a vessel including the fairlead stopper to a site, wherein during transport of the vessel, the at least one chain retaining arm is locked in the open position.

22. The method of claim 21, wherein during the transport of the vessel, the fairlead stopper is secured to the vessel with a sea-fastening bracket.

23. A vessel, the vessel comprising:
a hull;
a fairlead stopper coupled with the hull; and
a sea-fastening brace coupled between the fairlead stopper and the hull, or between a first portion of the fairlead stopper and a second portion of the fairlead stopper;
wherein the sea-fastening brace extends to position the fairlead stopper at an angle relative to the hull.

24. The vessel of claim 23, wherein the angle is a 45-degree angle.

25. A method of positioning a fairlead stopper relative to a vessel, the method comprising:
coupling a fairlead stopper with a vessel;
coupling a sea-fastening brace between the fairlead stopper and the vessel or between the a first portion of the fairlead stopper and a second portion of the fairlead stopper;
wherein the sea-fastening brace extends to position the fairlead at an angle relative to the vessel.

26. A vessel, the vessel comprising:
a hull;
a wave-reaction bar coupled with the hull;
a fairlead stopper coupled with the wave-reaction bar;
wherein the wave-reaction bar reacts to forces imparted onto the fairlead stopper.

27. The vessel of claim 26, wherein the wave-reaction bar comprises a strut.

28. A method of dampening forces on a vessel from a fairlead stopper, the method comprising:
coupling a wave-reaction bar with a vessel;
coupling a fairlead stopper with the wave-reaction bar; and
reacting forces imparted onto the fairlead stopper with the wave-reaction bar.

29. The method of claim 28, wherein the wave-reaction bar comprises a strut.

30. The method of claim 28, wherein the fairlead stopper is coupled with the wave-reaction bar during transport of the vessel.

31. A method of mooring a floating vessel, the method comprising:

reeving a pre-messenger line through a fairlead stopper coupled with a vessel;

retrieving a pre-laid mooring line off a sea bed with an AHV and securing the pre-laid mooring line on deck of the AHV;

connecting a hold back line between a winch on the AHV and a tri-plate connector coupled with a top chain of the pre-laid mooring line;

transferring two ends of the pre-messenger line from the vessel to the AHV, wherein the two ends include an outer end and an inner end;

connecting the outer end to a first end of a messenger line on the AHV;

over-boarding the connected end of the pre-messenger line and the messenger line, wherein a second end of the messenger line is secured on the deck of the AHV;

hauling in on the inner end of the pre-messenger line to pull the pre-messenger line and the messenger line through the fairlead stopper until the messenger line passes through the fairlead stopper and is pulled onto the deck of the AHV;

disconnecting the pre-messenger line from the messenger line;

connecting the top chain of the mooring line to the second end of the messenger line that extends from the AHV into a chain guide of the fairlead, wherein a winch on the AHV is connected to the first end of the messenger line that extends from a chainwheel of the fairlead stopper to the AHV;

over-boarding the connected top chain and messenger line;

hauling in the messenger line until the top chain of the mooring line enters the fairlead stopper and until a first tension is on the mooring line; and

disconnecting the messenger line from the top chain.

32. The method of claim 31, wherein the pre-messenger line has at most two LLLC links.

33. The method of claim 31, wherein the pre-messenger line is reeved through the fairlead stopper at a shipyard, prior to transport of the vessel to a mooring site.

34. The method of claim 31, further comprising using the messenger line to moor multiple different mooring lines of the vessel.

35. The method of claim 31, wherein the pre-messenger line comprises rope or wire.

36. The method of claim 35, wherein the pre-messenger line comprises steel wire.

37. The method of claim 31, further comprising cutting a length of a bitter end of the mooring line.

38. The method of claim 37, further comprising reconnecting the cut length of the bitter end to the mooring line to lengthen the mooring line.

39. The method of claim 38, wherein the cut length of the bitter end is reconnected to the mooring line with an LLLC link.

40. The method of claim 31, wherein the pre-messenger line, the messenger line, the top chain of the mooring line, and the hold back line are simultaneously positioned on the AHV for at least a discrete period of time.

41. The method of claim 31, further comprising, while hauling in the mooring line, hauling in the hold back line.

42. The method of claim 31, wherein the pre-messenger line comprises a Dyneema.

43. A method of mooring a floating vessel having fairlead stoppers coupled thereto, the method comprising:

securing a plurality of mooring lines to a plurality of fairlead stoppers on the floating vessel;

after securing the plurality of mooring lines, cutting lengths of tail chain from the plurality of mooring lines; and

connecting at least one of the cut lengths of the tail chain to one of the plurality of mooring lines and then hauling in that mooring line.

44. A method of mooring a floating vessel, the method comprising:

reeving a pre-messenger line through a fairlead stopper coupled with a vessel;

connecting a first end of the pre-messenger line with a first end of a messenger line on an AHV;

over-boarding the connected ends of the pre-messenger line and the messenger line, wherein a second end of the messenger line is secured on the deck of the AHV;

hauling in on a second end the pre-messenger line onto the AHV to pull the connected pre-messenger line and the messenger line through the fairlead stopper until the first end of the messenger line passes through the fairlead stopper and is pulled onto the deck of the AHV;

disconnecting the pre-messenger line from the messenger line;

connecting a mooring line to the second end of the messenger line that extends from the AHV into a chain guide of the fairlead, wherein a winch on the AHV is connected to the first end of the messenger line that extends from a chainwheel of the fairlead stopper to the AHV;

over-boarding the connected mooring line and messenger line;

hauling in the messenger line until the mooring line enters the fairlead stopper and until a first tension is on the mooring line; and

disconnecting the messenger line from the mooring line.

45. A method of connecting a messenger line to a fairlead stopper, the method comprising:

reeving a pre-messenger line through a fairlead stopper coupled with a vessel;

connecting a first end of the pre-messenger line with a first end of a messenger line on an AHV;

over-boarding the connected ends of the pre-messenger line and the messenger line, wherein a second end of the messenger line is secured on the deck of the AHV;

hauling in on a second end the pre-messenger line onto the AHV to pull the connected pre-messenger line and the messenger line through the fairlead stopper until the first end of the messenger line passes through the fairlead stopper and is pulled onto the deck of the AHV;

disconnecting the pre-messenger line from the messenger line.

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