(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 January 2024 (25.01.2024)

WIPO | PCT

(10) International Publication Number
WO 2024/018189 A1

(51) International Patent Classification:
B63B 21/26 (2006.01) *E02D 27/52* (2006.01) *E02D 5/80* (2006.01) *E02D 15/08* (2006.01) *E02D 27/50* (2006.01)

(21) International Application Number: PCT/GB2023/051875

(22) International Filing Date: 17 July 2023 (17.07.2023)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2210696.7 21 July 2022 (21.07.2022) GB

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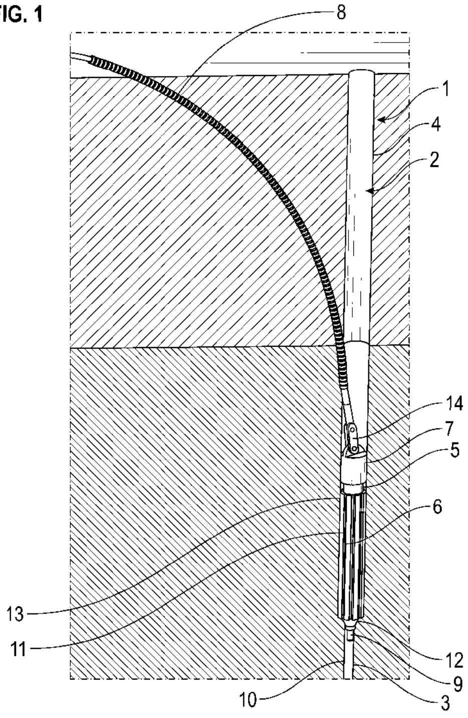
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(54) **Title:** ANCHORING SYSTEM

FIG. 1



(57) **Abstract:** The present invention relates to an anchoring system comprising an anchor pile configured to be embedded in a first lower portion of a borehole. The anchor pile comprises a first elongate body having an upper end and a lower end. The anchoring system further comprises a lateral load transition member configured in use to be spaced apart from the upper end of the first elongate body of the anchor pile and embedded in a second upper portion of the borehole. The lateral load transition member comprises a second elongate body having an upper end configured in use to be in communication with a laterally loaded mooring tether, and an opposed lower end. The anchoring system further comprises an intermediate portion connecting the lower end of the second elongate body of the lateral load transition member to the upper end of the first elongate body of the anchor pile. The second elongate body of the lateral load transition member comprises side portions, extending between the upper and lower ends thereof, configured in use to abut surrounding

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[Continued on next page]

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

wall portions of the second upper portion of the borehole to create hoop stress within the second upper portion of the borehole wall without penetration thereof.

ANCHORING SYSTEM

The present invention relates to an anchoring system for securing an anchor pile within a borehole. In particular, the present invention relates to an anchoring system for securing an anchor pile within a borehole, with improved lateral resistance to prevent or reduce penetration of the walls of the borehole by a tether in communication with the anchor pile. The anchoring system is suitable for use in subsea applications. The present invention further relates to a method of installing such an anchoring system.

BACKGROUND OF INVENTION

A variety of anchoring systems are known in the art, such as driven piles, suction piles, and drag embedment. Such systems have however been found to suffer from several disadvantages. Commonly used anchoring systems are, typically, limited for use with specific seabed soil types, and/or have high associated cost and time implications.

For Floating Offshore Wind (FOW) projects, the geological conditions can vary greatly across a single site. As a result, conventional anchoring systems may not be suitable for use across the whole of the site. Furthermore, FOW projects require a large number of anchor foundations and as such there are high associated costs for using conventional anchoring systems.

Conventional anchoring systems include a tether, for example mooring line, extending from the anchor pile. Once embedded within a borehole, the tether is subjected to significant lateral loading. As a result, over time, the tether cuts through the soil structure adjacent to the upper end of the anchor. This cutting action can cause damage to the tether and can also cause the tether to slacken resulting in a less reliable anchoring system over time.

It is among the objectives of embodiments of the present invention to obviate or alleviate these and other disadvantages of known anchor piling systems.

SUMMARY OF INVENTION

According to a first aspect of the present invention, there is provided an anchoring system comprising:

an anchor pile configured to be embedded in a first lower portion of a borehole, the anchor pile comprising a first elongate body having an upper end and a lower end;

a lateral load transition member configured in use to be spaced apart from the upper end of the first elongate body of the anchor pile and embedded in a second upper portion of the borehole, in which the lateral load transition member comprises a second elongate body having an upper end configured in use to be in communication with a laterally loaded mooring tether, and an opposed lower end; and

an intermediate portion connecting the lower end of the second elongate body of the lateral load transition member to the upper end of the first elongate body of the anchor pile,

in which the second elongate body of the lateral load transition member comprises side portions, extending between the upper and lower ends thereof, configured in use to abut surrounding wall portions of the second upper portion of the borehole to create hoop stress within the second upper portion of the borehole wall without penetration thereof.

The anchoring system of the present invention can be used to reliably and effectively anchor a tether, for example mooring line, to provide a taut mooring solution with reduced risk of damage and/or failure of the tether over time. The anchoring system of the present invention may be compatible with a wide range of geological formations.

The anchoring system of the present invention may be capable of resisting high loads, for example in excess of 1000 tonnes.

The anchoring system of the present invention may be used for resisting high angle mooring through to vertically loaded tension leg systems.

The anchoring system is preferably an onshore or offshore anchoring system. Preferably, the anchoring system is an offshore anchoring system. The borehole is preferably provided in a seabed.

The borehole is preferably a stepped profiled. The first lower portion preferably has cross-sectional dimensions less than the second upper portion. The first lower portion may for example be drilled quickly and efficiently due to having reduced cross-sectional dimensions. The second upper portion, preferably having greater cross-sectional dimensions than the first lower portion, preferably provides for a larger contact surface area (compared to the first lower portion) to improve the transmission of lateral loads from the lateral load transition member into the surrounding borehole wall portions and thereby creating improved lateral resistance to penetration of the borehole wall portions. The second upper portion is preferably configured to have greater cross-sectional dimensions in order to facilitate receiving of additional mechanical equipment, for example to connect mooring lines to the lateral load transition member.

The first lower portion of the borehole may have a cross-sectional dimension of at least 300 mm, preferably about 310 mm. The first lower portion of the borehole may have a cross-sectional dimension of no more than 500 mm, preferably no more than 450 mm. The first lower portion of the borehole may have a cross-sectional dimension of between 300 mm and 500 mm, and preferably between 310 mm and 450 mm.

The second upper portion of the borehole may have a cross-sectional dimension which is at least 10%, preferably at least 20%, preferably at least 30% greater than the cross-sectional dimension of the first lower portion. The second upper portion may for example have a cross-sectional dimension which is 100% greater than the cross-sectional dimension of the first lower portion.

The anchor pile is preferably located at a depth within the bore hole adjacent high strength geological formations to provide for increased resistance. For example, the anchor pile may be located at at least 50 m below the surface (for example below the seabed). Preferably, the anchor pile may be located at a depth of between 50 m and 80 m below the surface (for example below the seabed). The anchor pile is configured to receive the vertical loading from a mooring.

Preferably, the cross-sectional dimensions of the second elongate body of the lateral load transition member are greater than the cross-sectional dimensions of the first elongate body of the anchor pile.

In one embodiment, the borehole provides an inwardly protruding abutment surface located between the first lower portion and the second upper portion of the borehole.

In one embodiment, the second lower end of the second elongate body of the lateral load transition member is configured in use to be received on and to abut the inwardly protruding abutment surface.

The lateral load transition member is configured to remove the lateral forces of the loading from a mooring (i.e. to transmit the lateral forces of the loading into the surrounding borehole wall portions). In one embodiment, the lateral load transition member is configured to be positioned within the second upper portion of the borehole at a location which has sufficient lateral resistance to prevent penetration of the borehole wall portions by the lateral load transition member. Preferably, the lateral load transition member is configured to be positioned at the highest point within the borehole at which the lateral load transition member will remain stable (i.e. will not penetrate the borehole wall).

The second elongate body of the lateral load transition member is preferably dimensioned to provide a tight fit within the second upper portion of the borehole in order to provide, in use, increased frictional resistance and/or to effectively transmit lateral forces to create hoop stress within adjacent portions of the borehole.

The side portions of the second elongate body of the lateral load transition member may comprise ribbed portions. The ribbed portions may each define a longitudinal axis. The longitudinal axes of the ribbed portions may be aligned with, and spaced apart from, each other. The ribbed portions preferably extend substantially parallel to a longitudinal axis of the second elongate body of the lateral load transition member.

In one embodiment, the lower end of the second elongate body of the lateral load transition member is tapered. For example, the lower end of the lateral load transition member may be cone shaped.

The lower end of the second elongate body of the lateral load transition member may extend into the first lower portion of the borehole, for example beyond the abutment surface provided between the first and second portions of the borehole.

The lateral load transition member may be rotationally and/or pivotally connected to the laterally loaded mooring tether.

In one embodiment, the lateral load transition member comprises a hinge located at the upper end of the elongate body.

The anchoring system may further comprise an intermediary coupling comprising a first end providing a first hinge for connection to a laterally loaded mooring tether, and a second opposed end providing a second hinge connected to the upper end of the second elongate body of the lateral load transition member.

The first hinge preferably defines a first rotational axis which extends substantially parallel to and spaced apart from a second rotational axis defined by the second hinge.

The intermediate portion is preferably rigid. The intermediate portion is preferably free from contact with the borehole wall portions. The cross-sectional dimensions of the intermediate portion are preferably less than the cross-sectional dimensions of the first and second elongate bodies.

The intermediate portion preferably comprises an elongate tensile member, for example a wire or tubing.

The tether may have a first end connectable to the upper end of the second elongate body of the lateral load transition member, and a second opposed end for connection to a tether termination. The tether termination is preferably configured to be a connection point for a main mooring line. The tether is preferably flexible. The tether may be enclosed within a protective outer layer to protect the tether from frictional forces arising as a result of lateral loading forces from the main mooring line causing the tether to move (or cut) through the surrounding geological formation. The second elongate body of the lateral load transition member is preferably shaped, dimensioned and located within the second upper portion of the borehole to remove the lateral forces from the tether.

The lateral load transition member may further define an open-ended fluid pathway extending between the upper and lower ends of the second elongate body. The open-ended fluid pathway may be configured to supply locking media into the first lower portion of the borehole.

According to a second aspect, the present invention provides a method for installing an anchoring system comprising:

drilling a borehole, the borehole comprising a first lower portion in communication with a second upper portion, in which the cross-sectional dimensions of the first lower portion are smaller than the cross-sectional dimensions of the second upper portion, and in which an inwardly protruding abutment surface is provided at a transition point located therebetween;

obtaining an anchoring system as herein described;

introducing and embedding the anchor pile in the first lower portion of the borehole; and

positioning the lateral load transition member in the second upper portion of the borehole, spaced apart from the anchor pile, and positioned such that side portions of the second elongate body of the lateral load transition member abut surrounding wall portions of the second upper portion of the borehole to create hoop stress within the second upper portion of the borehole wall without penetration thereof.

In one embodiment, the lateral load transition member is positioned within the second upper portion of the borehole such that the lower end of the second elongate body of the lateral load transition member is received on and abuts an inwardly protruding abutment surface provided at the transition point between the first and second portions of the borehole.

The method of the present invention provides a simple, reliable installation methology.

The borehole may be drilled in a seabed. The borehole is preferably a stepped borehole.

The method may further comprise introducing locking media to secure the anchor pile in position within the first lower portion of the borehole. The locking media may for example comprise cement.

The locking media may be introduced into the first lower portion and positioned to not extend beyond the transition point between the first and second portions of the borehole. Such an arrangement provides for free movement of for example at least one connectors and/or mooring tethers in communication with the upper end of the lateral load transition member.

It is however to be understood that the locking media may extend beyond the transition point into the second upper portion of the borehole. For example, in one embodiment, the locking media may be introduced into the borehole to extend from the first lower portion into the second upper portion of the borehole to secure at least a portion of the lateral load transition member in position within the upper portion of the borehole.

Preferably, the locking media is introduced into the borehole to not extend beyond the upper end of the lateral load transition member.

The locking media may be introduced after positioning of the lateral load transition member in the second upper portion of the borehole.

The locking media is preferably introduced through an open-ended fluid pathway extending between the upper and lower ends of the second elongate body of the lateral load transition member.

The method may further comprise attaching the upper end of the second elongate body of the lateral load transition member to a laterally loaded mooring tether.

In one embodiment, the method further comprises abutting (for example embedding) the side portions of the second elongate body of the lateral load transition member against surrounding wall portions of the second upper portion of the borehole.

BRIEF DESCRIPTION OF FIGURES

Figure 1 is a schematic illustration of the anchoring system according to one embodiment of the present invention installed within a borehole; and

Figures 2A and 2B are schematic illustrations of enlarged views of the lateral load transition member of the anchoring system of Figure 1.

DETAILED DESCRIPTION

With reference to the Figures, the anchoring system 1 comprises an anchor pile (not shown) configured to be embedded in a first lower portion 3 of a borehole 2 drilled in the seabed. The anchor pile (not shown) comprises a first elongate body having an upper end and a lower end.

The anchoring system 1 further comprises a lateral load transition member 5 configured in use to be spaced apart from the upper end of the first elongate body of the anchor pile (not shown) and embedded in a second upper portion 4 of the borehole 2.

The lateral load transition member 5 comprises a second elongate body 6 having an upper end 7 configured in use to be in communication with a laterally loaded mooring tether 8, and an opposed lower end 9. The second elongate body 6 is substantially cylindrical in shape.

The tether 8 has a first end connectable to the upper end 9 of the second elongate body 6 of the lateral load transition member 5, and a second opposed end for connection to a tether termination (not shown) which may for example be a connection point for a main mooring line. The tether 8 is flexible and is enclosed within a protective outer layer to protect the tether 8 from frictional forces arising as a result of lateral loading forces from the main mooring line causing the tether to move (or cut) through the surrounding geological formation.

The anchoring system 1 further comprises an intermediate portion 10 connecting the lower end 9 of the second elongate body 6 of the lateral load transition member 5 to the upper end of the first elongate body of the anchor pile. The intermediate portion 10 is rigid and provides the spacing between the upper end of the first elongate body of the anchor pile and lower end 9 of the second elongate body 6 of the lateral load transition member 5.

The second elongate body 6 of the lateral load transition member 5 is configured in use to be received on and to abut an inwardly protruding abutment surface 12 provided at a transition point between the first lower portion 3 and second upper portion 4 of the borehole 2.

The cross-sectional dimensions of the second elongate body 6 of the lateral load transition member 5 are greater than the cross-sectional dimensions of the first elongate body of the anchor pile. The cross-sectional dimensions of the second elongate body 6 are slightly smaller than the cross-section dimensions of the upper portion of the borehole to ensure a tight fit to enable efficient transmission of lateral forces from the lateral load transition member 5 into the surrounding portions of the borehole.

The second elongate body 6 of the lateral load transition member 5 comprises side portions 11 extending between the upper and lower ends 7, 9 thereof, configured in use to abut surrounding wall portions of the second upper portion 4 of the borehole 2 to create, in use, hoop stress within the second upper portion 4 of the borehole wall 2 without penetration thereof.

In the illustrated embodiment, a portion of the lower end 9 of the second elongate body 6 of the lateral load transition member 5 extends into the first lower portion of the bore hole 2. It is however to be understood that the lower end 9 of the second elongate body 6 may be located at or adjacent the transition point between the first lower portion and the second upper portion 4 (for example adjacent the abutment surface 12 provided at the transition point therebetween).

In the illustrated embodiment, the lower end 9 of the second elongate body 6 of the lateral load transition member 5 is tapered, for example cone shaped. It is however to be understood that the lower end 9 of the second elongate body 6 may have any suitable profile.

The side portions 11 of the second elongate body 6 of the lateral load transition member 5 comprises a plurality of spaced apart ribbed portions 14. The ribbed portions 14 each define a longitudinal axis. The longitudinal axes of the ribbed portions 14 are substantially with, and spaced apart from, each other. The longitudinal axes of the ribbed portions 14 extend substantially parallel to a longitudinal axis of the second elongate body 6 of the lateral load transition member 5.

The intermediate portion 10 is free from contact with the borehole 2 wall portions. The cross-sectional dimensions of the intermediate portion 10 are significantly less than the cross-sectional dimensions of the first and second 6 elongate bodies. This arrangement reduces frictional forces encountered during installation of the anchoring system whilst providing the desired rigidity between the bodies.

The lateral load transition member 5 is pivotally connected to the laterally loaded mooring tether 8. The lateral load transition member 5 comprises a hinge 14 located at the upper end 7 of the elongate body 6.

As shown in Figures 2A and 2B, the anchoring system 1 further comprises an intermediary coupling 15 comprising a first end 16 providing a first hinge 15a for connection to a laterally loaded mooring tether 8, and a second opposed end 18 providing a second hinge 14b connected to the upper end 7 of the second elongate body 6 of the lateral load transition member. The first hinge 14a defines a first rotational axis which extends substantially parallel to and spaced apart from a second rotational axis defined by the second hinge 14b. This arrangement enables the tether 8 to be offset from the central longitudinal axis defined between the opposing ends 7, 9 of the elongate body 6 of the lateral load transition member 5.

The lateral load transition member 5 further defines an open-ended fluid pathway 18 extending between the upper and lower ends 7, 9 of the second elongate body 6. In the illustrated embodiment, the pathway 18 is substantially centrally located. It is however to be understood that the pathway 18 may be located at any suitable location and may for example be offset from the centre of the body 6. The open-ended fluid pathway 19 is configured to supply locking media into the first lower portion of the borehole.

In use, the anchoring system 1 is installed by first drilling a borehole 2 in the seabed. The borehole 2 comprises a first lower portion 3 having a cross-sectional dimension between 300 mm and 500 mm. It is however to be understood that the lower portion 3 may have any suitable dimensions. The borehole 2 further comprises a second upper portion 4 in communication with a first lower portion 3. The cross-sectional dimensions of the first lower portion 3 are smaller than the cross-sectional dimensions of the second upper portion 4 and define an inwardly protruding abutment surface 12 at a transition point located therebetween.

The upper end 9 of the second elongate body 6 of the lateral load transition member 5 is connected to the laterally loaded mooring tether 8.

The anchor pile is introduced into the first lower portion of the borehole 2.

The anchor pile is located at a depth within the lower portion 3 of the bore hole adjacent high strength geological formations to provide for increased resistance. For example, the anchor pile may be located at at least 50 m below the surface (for example below the seabed) within the lower portion 3 of the borehole. Preferably, the anchor pile may be located at a depth of between 50 m and 80 m below the surface (for example below the seabed). The anchor pile is configured to receive the vertical loading from a mooring.

The lateral load transition member 5 is positioned within the second upper portion 4 of the borehole 2, spaced apart from the anchor pile and positioned such that the lower end 9 of the second elongate body 6 of the lateral load transition member 5 is received on and abuts the inwardly protruding abutment surface 12 provided at the transition point.

The method further comprises abutting (for example embedding) the side portions 11 of the second elongate body 6 of lateral load transition member 5 against surrounding wall portions of the second upper portion 4 of the borehole 2.

As shown in the Figures, a portion of the lower end 9 of the second elongate body 6 of the lateral load transition member 5 is positioned so as to extend into the first lower portion 3 of the bore hole 2.

Locking media, for example cement, is then introduced through the fluid pathway 19 to secure the anchor pile in position within the first lower portion 3 of the borehole 2. The locking media may for example comprise cement. The locking media may be introduced into the first lower portion 3 and does not extend beyond the transition point between the first and second portions of the borehole 2.

The locking media may be introduced after positioning of the lateral load transition member in the second upper portion of the borehole.

The method of the present invention provides a simple, reliable installation methology.
The anchoring system of the present invention can be used to effectively and reliably anchor a tether, for example mooring line, to provide a taut mooring solution over time. The anchoring system of the present invention may be compatible with a wide range of geological formations.

The lateral load transition member is located to resist the lateral forces of the loading from a mooring and to transmit the lateral forces of the loading into the surrounding borehole wall portions. In one embodiment, the lateral load transition member is configured to be positioned within the second upper portion of the borehole at a location which has sufficient lateral resistance to prevent penetration of the borehole wall portions by the lateral load transition member. Preferably, the lateral load transition member is configured to be positioned at the highest point within the borehole at which the lateral load transition member will remain stable (i.e. will not penetrate the borehole wall).

The anchoring system of the present invention may be capable of resisting high loads, for example in excess of 1000 tonnes.

The anchoring system of the present invention may be used for resisting high angle mooring through to vertically loaded tension leg systems.

The anchoring system of the present invention enables the lateral forces exerted by the tether to be resisted and transmitted directly into the geological surfaces surrounding the borehole. As a result, the anchoring system of the present invention reduces the forces exerted on the tether, thereby reducing the cutting motion of the tether through the geological surfaces which occurs with conventional anchoring systems. The anchoring system of the present invention therefore reduces the length of tether required and thereby reduces the cost of materials, reduces the potential for damage to occur to the tether as a result of the cutting motion and therefore reduces labour and costs associated with repair and/or replacement of the tether over time. The anchoring system of the present invention reduces the risk of failure of the anchor pile as a result of damage to the tether and thereby provides a more reliable anchoring system.

CLAIMS

1. An anchoring system comprising:

an anchor pile configured to be embedded in a first lower portion of a borehole, the anchor pile comprising a first elongate body having an upper end and a lower end;

a lateral load transition member configured in use to be spaced apart from the upper end of the first elongate body of the anchor pile and embedded in a second upper portion of the borehole, in which the lateral load transition member comprises a second elongate body having an upper end configured in use to be in communication with a laterally loaded mooring tether, and an opposed lower end; and

an intermediate portion connecting the lower end of the second elongate body of the lateral load transition member to the upper end of the first elongate body of the anchor pile,

in which the second elongate body of the lateral load transition member comprises side portions, extending between the upper and lower ends thereof, configured in use to abut surrounding wall portions of the second upper portion of the borehole to create hoop stress within the second upper portion of the borehole wall without penetration thereof.

2. An anchoring system as claimed in claim 1, in which the cross-sectional dimensions of the second elongate body of the lateral load transition member are greater than the cross-sectional dimensions of the first elongate body of the anchor pile.

3. An anchoring system as claimed in either of claims 1 and 2, in which the lower end of the second elongate body of the lateral load transition member is configured in use to be received on and to abut an inwardly protruding abutment surface provided at a transition point between the first and second upper portions of the borehole.

4. An anchoring system as claimed in any one of claims 1 to 3, in which the lateral load transition member is configured to be positioned within the second upper portion of the

borehole at a location which has sufficient lateral resistance to prevent penetration of the borehole wall portions by the lateral load transition member.

5. An anchoring system as claimed in any one of claims 1 to 4, in which the lateral load transition member is rotationally and/or pivotally connected to the laterally loaded mooring tether.

6. An anchoring system as claimed in claim 5, in which the lateral load transition member comprises a hinge located at the upper end of the elongate body of the lateral load transition member.

7. An anchoring system as claimed in claim 6, further comprising an intermediary coupling comprising a first end providing a first hinge for connection to a laterally loaded mooring tether, and a second opposed end providing a second hinge connected to the upper end of the second elongate body of the lateral load transition member.

8. An anchoring system as claimed in claim 7, in which the first hinge defines a first rotational axis which extends substantially parallel to and spaced apart from a second rotational axis defined by the second hinge.

9. An anchoring system as claimed in any preceding claim, in which the side portions of the second elongate body of the lateral load transition member comprise ribbed portions.

10. An anchoring system as claimed in claim 9, in which the ribbed portions extend substantially parallel to a longitudinal axis of the second elongate body of the lateral load transition member.

11. An anchoring system as claimed in any preceding claim, in which the lower end of the second elongate body of the lateral load transition member is tapered.

12. An anchoring system as claimed in claim 11, in which the lower end of the lateral load transition member is cone shaped.

13. An anchoring system as claimed in any preceding claim, in which the intermediate portion is free from contact with the borehole wall portions.

14. An anchoring system as claimed in claim 13, in which the cross-sectional dimensions of the intermediate portion are less than the cross-sectional dimensions of the first and second elongate bodies.

15. An anchoring system as claimed in any preceding claim, further comprising a tether having a first end connectable to the upper end of the first elongate body of the lateral load transition member, and a second opposed end comprising a connector for engagement to a laterally loaded mooring tether.

16. An anchoring system as claimed in any preceding claim, in which the lateral load transition member further defines an open-ended fluid pathway extending between the upper and lower ends of the second elongate body.

17. An anchoring system as claimed in claim 16, in which the fluid pathway is substantially centrally located and extending substantially parallel to the longitudinal axis of the lateral load transition member.

18. A method for installing an anchoring system comprising:

drilling a borehole comprising a first lower portion in communication with a second upper portion, in which the cross-sectional dimensions of the first lower portion are smaller than the cross-sectional dimensions of the second upper portion, and in which an inwardly protruding abutment surface is provided at a transition point located therebetween;

obtaining an anchoring system as claimed in any one of claims 1 to 16;

introducing and embedding the anchor pile in the first lower portion of the borehole; and

positioning the lateral load transition member in the second upper portion of the borehole, spaced apart from the anchor pile and positioned such that side portions of the second elongate body of the lateral load transition member abut surrounding wall portions of the second upper portion of the borehole to create hoop stress within the second upper portion of the borehole wall without penetration thereof.

19. A method as claimed in claim 18, in which at least a portion of the lower end of the second elongate body of the lateral load transition member extends into the first lower portion of the bore hole.

20. A method as claimed in either of claims 18 and 19, further comprising introducing locking media to secure the anchor pile in position within the first lower portion of the borehole.

21. A method as claimed in claim 20, in which the locking media is cement.

22. A method as claimed in either of claims 20 and 21, in which the locking media is introduced into the first lower portion and positioned to not extend beyond the transition point between the first and second portions of the borehole.

23. A method as claimed in any one of claims 20 to 22, in which the locking media is introduced after positioning of the lateral load transition member in the second upper portion of the borehole.

24. A method as claimed in claim 23, in which locking media is introduced through an open-ended fluid pathway extending between the upper and lower ends of the second elongate body of the lateral load transition member.

25. A method as claimed in any one of claims 18 to 24, further comprising attaching the upper end of the second elongate body of the lateral load transition member to a laterally loaded mooring tether.

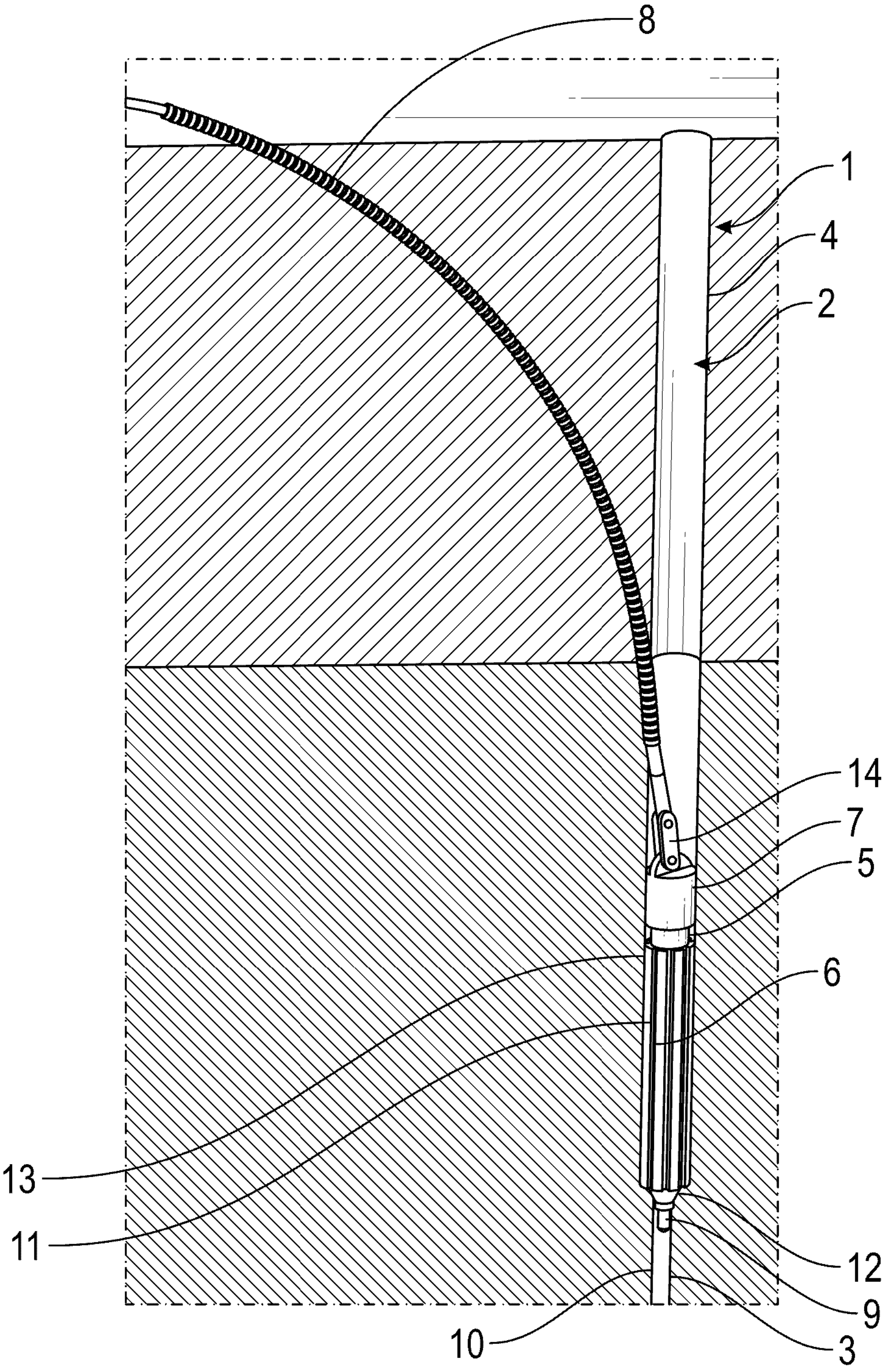

FIG. 1

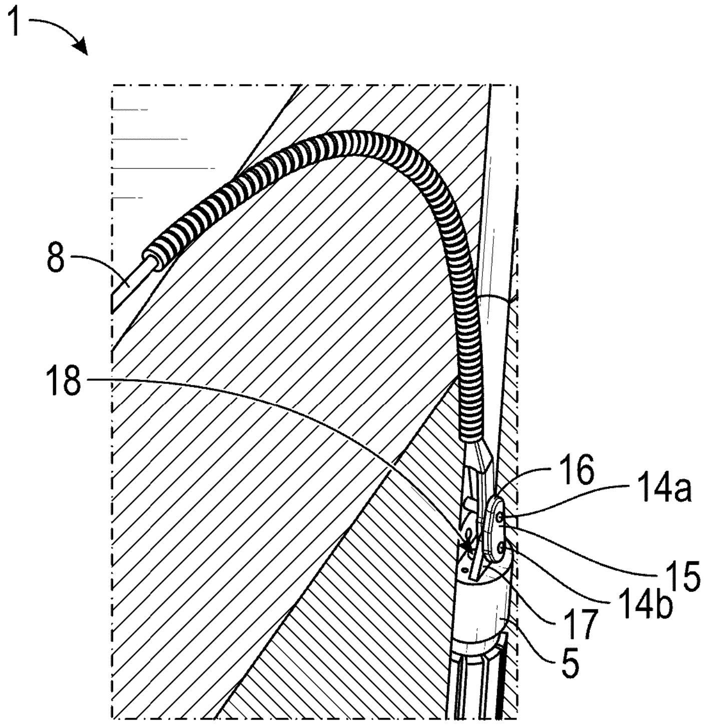

FIG. 2A

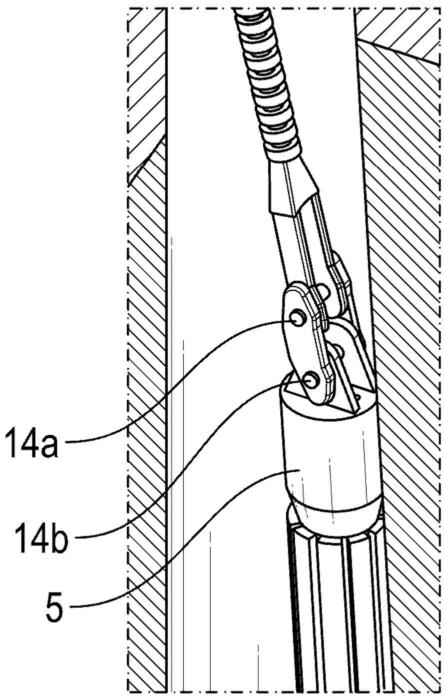

FIG. 2B

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2023/051875

A. CLASSIFICATION OF SUBJECT MATTER
INV. B63B21/26 E02D5/80 E02D27/50 E02D27/52
ADD. E02D15/08

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B63B E02D

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 355 039 A (LIBERTY OFFSHORE LTD [GB]) 11 April 2001 (2001-04-11) page 8, line 18 - page 12, line 20; figures 1-6B	1-25
X A	GB 2 578 948 A (SUSTAINABLE MARINE ENERGY LTD [GB]) 3 June 2020 (2020-06-03) page 1, line 12 - page 3, line 5; figures 1-3D page 14, line 35 - page 24, line 18	1-19,25 20-24
X A	JP S60 108598 U (-) 23 July 1985 (1985-07-23) page 2 - page 14; figure 4	1-17 18-25
A	US 6 368 021 B1 (STRONG PHILIP ANTON [IT] ET AL) 9 April 2002 (2002-04-09) column 3, line 19 - column 5, line 67; figures 1-14	1-25

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

☒ See patent family annex.

* Special categories of cited documents :

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 October 2023	26/10/2023

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Martínez, Felipe

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2023/051875

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
GB 2355039	A	11-04-2001	NONE			
GB 2578948	A	03-06-2020	NONE			
JP S60108598	U	23-07-1985	NONE			
US 6368021	B1	09-04-2002	AU	2816999	A	25-11-1999
			BR	9901545	A	18-01-2000
			CA	2271630	A1	16-11-1999
			EP	0962596	A1	08-12-1999
			GB	2364728	A	06-02-2002
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			US	2002081158	A1	27-06-2002
			ZA	993304	B	15-11-1999