Support structure

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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 June 2020 (11.06.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/115474 A1

(51) International Patent Classification:
E02D 23/00 (2006.01) *E02D 27/42* (2006.01)
E02D 23/08 (2006.01) *E02D 27/52* (2006.01)

(21) International Application Number:
PCT/GB2019/053421

(22) International Filing Date:
04 December 2019 (04.12.2019)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1819844.0 05 December 2018 (05.12.2018) 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, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME,

(54) Title: SUPPORT STRUCTURE

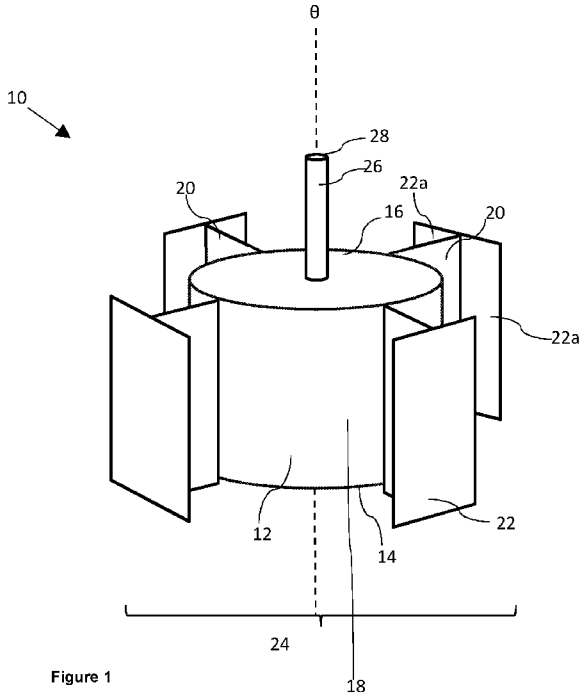

Figure 1

(57) Abstract: This application describes a caisson for insertion into a seabed along an insertion axis, comprising: a body comprising a first end for insertion into the seabed, and an opposing second end, the first end and second end having a wall extending therebetween, wherein the wall is aligned with and defines an insertion axis; a cavity enclosed by the wall, the cavity configured to receive the seabed during insertion; at least one primary blade extending outwardly from an external surface of the wall; and, at least one secondary blade extending laterally from the at least one primary blade, each of the at least one primary blade and at least one secondary blade comprising an insertion edge configured to be inserted into the seabed.

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MG, MK, MN, 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, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, 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, 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))*

Support structure

Field

The invention relates to a caisson for insertion into a seabed. The caisson is particularly useful for providing a foundation to support off-shore structures such as wind turbines.

Background

Caissons are commonly used for anchoring or providing a foundation for off-shore structures such as wind turbines and oil rigs. A caisson is typically a hollow structure with an open end which is inserted into the seabed. Applying suction to the hollow structure draws out water and the caisson is sucked into the seabed. Once embedded in the seabed, the caisson can then act as a foundation for the chosen off-shore structure.

Known caissons have wings which extend from a central body and provide additional surface area which can react with the seabed to help resist rotational and lateral in-service forces which might move the caisson.

The present invention seeks to provide an improved caisson for insertion into a seabed.

Description

According to a first aspect there is provided an caisson for insertion into a seabed along an insertion axis, comprising: a body comprising a first end for insertion into the seabed, and an opposing second end, the first end and second end having a wall extending therebetween, wherein the wall is aligned with and defines an insertion axis; a cavity enclosed by the wall, the cavity configured to receive the seabed during insertion; at least one primary blade extending outwardly from an external surface of the wall; and, at least one secondary blade extending laterally from the at least one primary blade, each of the at least one primary blade and at least one secondary blade comprising an insertion edge configured to be inserted into the seabed.

Typically, the caisson for insertion into a seabed is suitable for anchoring and providing a footing for off-shore structures such as wind turbines. The caisson for insertion acts as

a foundation in the seabed for the off-shore structure. The primary and second blade arrangement helps to reduce lateral movement of the caisson once inserted in the seabed. This improves the stability of the caisson and the associated off-shore structure.

The primary and/or secondary blades may be plate-like members.

The cavity may be enclosed by a cap at the second end. The cap may comprise at least one opening to provide fluid communication between the cavity and the exterior of the caisson. The opening may facilitate suction between the cavity and the exterior of the cassion.

The at least one secondary blade may extend laterally from an edge of the at least one primary blade, at a location which is separated from the external surface of the wall, optionally at an edge distal to the external surface of the wall. A distal edge of the at least one primary blade may be understood to refer to an edge of the blade furthest from the wall. The at least one secondary blade may comprise an upper and lower peripheral edge in which the lower edge may provide a portion of the insertion edge. The secondary blades may be aligned with the insertion axis.

The at least one primary blade may comprise two facing surfaces. The two facing surfaces may be the major surfaces of a plate-like surface which meet at an edge of the primary blade. It will be appreciated that the two facing surfaces are coplanar and extend laterally from the external surface of the wall and optionally radially with respect to the insertion axis.

The caisson may comprise a plurality of primary blades. For example, the caisson may comprise two, three, four, five or six primary blades. In some embodiments the caisson may comprise four primary blades.

The length of the at least one primary blade may be equal to the length of the wall (the length of the wall being defined as the measurement in the direction aligned with the insertion axis). Alternatively, the length of the at least one primary blade may be less than the length of the wall. The width of the at least one primary blade is defined as the dimension of the blade away from the wall and insertion axis. The length of the at least

one primary blade may be defined as the measurement of the blade in the direction aligned with the insertion axis.

The width of the at least one primary blade may form approximately 10, 20, 30, 40, 50 or 60% of the width of the caisson. In embodiments comprising a plurality of primary blades, the width of a primary blade may form approximately 10, 20, 30, 40, 50 or 60% of the width of the caisson. Alternatively, the total combined width of the plurality of primary blades may form approximately 10, 20, 30, 40 or 50% of the width of the caisson. The plurality of primary blades may have a combined width which is twice the width of the body. For example, the total combined width of the plurality of primary blades may form approximately 30 or 40% of the width of the caisson.

A variety of length to width ratios can be used for the caisson. It will be appreciated that in the context of the caisson, length will be understood to be the measurement in line with the insertion axis, and width transverse to the insertion axis. Suitable length to width ratios include, but are not limited to 0.25, 0.5, 0.75, 1.25, 1.5, 2, 2.5,3, 3.5 or 4. In some embodiments the caisson has a length to width ratio of approximately 0.5, 1 or 1.5.

Each of the plurality of primary blades may be angularly offset about the insertion axis from each other. That is, the plurality of primary blades may be distributed about the insertion axis so as to be separated from one another by an angle. The plurality of primary blades may be evenly distributed about the insertion axis.

Each of the plurality of primary blades may be angularly offset about the insertion axis from each other at an angle of 180° or less. For example, each of the plurality of primary blades may be angularly offset about the insertion axis from each other at an angle of approximately 90°. The caisson may comprise four primary blades.

At least two of the plurality of primary blades may be diametrically opposed with respect to one another. For example, where the caisson comprises four primary blades, i.e. two pairs of primary blades, each pair of blades may comprise two diametrically opposed primary blades.

Each of the plurality of the primary blades may be similar to one another. By “similar”, this will be understood to refer to the shape and size rather than the position of each blade.

A plurality of secondary blades may extend laterally from the at least one primary blade. For example, at least two, three, four, five or six secondary blades may extend laterally from the at least one primary blade. Each of the plurality of secondary blades may be similar to one another.

The radial position (with respect to the insertion axis) of the plurality of secondary blades along the primary blade may vary. At least one secondary blade may extend laterally from any edge or surface of the primary blade which is not connected to the wall. For example, each of the secondary blades may extend from the distal edge of the at least one primary blade.

At least one secondary blade may extend laterally from each of the two facing surfaces of the at least one primary blade. In embodiments comprising at least two secondary blades extending laterally from the at least one primary blade, the at least two secondary blades may be coplanar with respect to one another.

The at least one secondary blade may have a smaller surface area, length and/or width than the primary blade from which it extends. In the context of secondary blades, width will be understood to refer to the measurement of the secondary blade in the lateral direction from the primary blade. Length will be understood to refer to measurement of the secondary blade in the direction aligned with the insertion axis.

The at least one secondary blade may extend from the primary blade at an angle of between 45 degrees and 135 degrees. It will be appreciated that the at least one secondary blade may be concave with respect to the wall. The at least one secondary blade may be parallel to and/or concentrically arranged with respect to the wall in the transverse section normal to the insertion axis.

Alternatively, the at least one secondary blade may be angularly offset from the primary blade from which it extends at an angle of 90 degrees. In such embodiments, it will be

appreciated that the at least one secondary blade may be convex with respect to the wall.

The plurality of secondary blades extending from the at least one primary blade may form a secondary blade structure. For example, the plurality of secondary blades may, in transverse section relative to the insertion axis, form a T-shaped-structure, a U-shaped structure, a V shaped structure, an arrow shaped structure or an X shaped structure. The secondary blade structure may be positioned at the distal edge of the at least one primary blade or along a width thereof. The shape of the structure may be in respect to the wall, i.e. it will be understood that the open end of a V or U-shaped structure will be the most distal point of the secondary blade structure to the wall, while the open end of an arrow shaped structure will be the most proximal point of the secondary blade structure to the wall.

The wall may be cylindrical so as to have a round or oval transverse section. However, other cross sectional shapes are envisaged for the wall such as polygonal shapes like square, rectangular, hexagonal, or pentagonal, for example.

The caisson may further comprise a cap on the first and/or the second end. As used herein, “cap” is understood to refer to a cover for an end. The cap may comprise a projecting rim which engages with the boundary of the end to secure the cap to the end. Alternatively, the cap may not comprise a projecting rim.

The boundary of the cavity may be defined by a cap at the second end. The cavity may be in fluid communication with an opening in the cap. The opening may be configured to attach to a suction device, for example, a pump. The application of suction to the opening and into the cavity can draw the caisson into the seabed.

A peripheral edge of the cap may be located radially outwardly of the wall with respect to the insertion axis. The peripheral edge may terminate at the distal edge of the at least one primary blade.

The diameter of the cavity and the opening may be equal. Alternatively, the diameter of the cavity may be greater than the diameter of the opening.

According to a second aspect there is provided a system for insertion into a seabed along an insertion axis, comprising: at least two caissons according to the first aspect and which are interconnected by a coupling.

The coupling may be attached to a portion of the at least two caissons which is exposed after installation. The portion which is exposed after installation may comprise the second end of each of the at least two caissons.

In some embodiments the system comprises three caissons according to the first aspect.

The coupling may comprise a plate, the plate being attached to a portion of each of the at least two caissons. In some embodiments the plate comprises a panel, for example a triangular or square panel.

In embodiments comprising three caissons, the coupling may comprise a triangular panel. The triangular panel may be attached to a portion of each of the three caissons such that the three caissons are evenly distributed across the surface area of the panel. This is believed to aid with weight distribution and resulting stability following insertion into the seabed.

Brief Overview of Figures

The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a perspective view of a caisson;
Figure 2 shows a plan view of the caisson of Figure 1;
Figure 3 shows a plan view of another caisson; and
Figure 4 shows a perspective view of a caisson system.

Detailed description

The caissons described herein each generally comprise: a body 12 comprising a first end 14 for insertion into the seabed, and an opposing second end 16. A wall 18 may extend therebetween, the wall being aligned with and defining an insertion axis θ. The

wall may enclose a cavity for receiving the seabed. Extending outwardly from an external surface of the wall is at least one primary blade 20. At least one secondary blade 22 may extends laterally from the at least one primary blade so as to project away from the primary blade to which it is attached. The at least one primary blade and at least one secondary blade may comprise an insertion edge 24 configured to be inserted into the seabed.

The term blade may refer to a plate-like member having a plurality of edges at its periphery. One of the edges may provide an insertion edge 24 which is configured to be inserted into the seabed. A first, proximal, peripheral edge may be mechanically connected to the external surface of the wall so as to provide a suitable connection from which the blade can extend from the wall 18.

The wall 18 has an internal surface and an external surface. The internal surface may define the cavity into which the seabed is received. The wall 18 can have any suitable cross-sectional shape transverse to the insertion axis θ, for example, polygonal, round, regular or irregular. Polygonal cross-sectional shapes may include square, rectangular, hexagonal, or pentagonal. Figure 1 shows a perspective view of a caisson 10 having a cylindrical wall 18 with a round, e.g. circular, cross section. It will be appreciated that once the cavity is received by the seabed, it may no longer be a cavity (i.e. it may be fully or partially filled by the seabed).

The wall 18 may be coaxially arranged with the insertion axis θ and have a constant cross-section along the axial length of the wall 18 such that a frontal area which is exposed to the seabed during installation is minimised and constant. Thus, when viewing the wall end on along the insertion axis θ, the frontal insertion area may be limited to the insertion edge 24 at least for the extent of the wall which is intended for insertion into the seabed. As will be appreciated, if the wall 18 did not have a constant cross-section, then any changes in cross-section would result in added resistance to the insertion.

A plurality of primary blades 20 may extend outwardly from the external surface of the wall 18. The plurality of primary blades 20 may comprise one, two, three, four, five, six or more primary blades 20, although typically the caisson comprises an even number of primary blades 20 for improved stability, i.e. two, four or six. The example of Figure 1 provides four primary blades 20. The primary blades 20 may be evenly distributed around

the wall 18 so as to be angularly displaced from one another in relation to the insertion axis.

Each primary blade 20 may comprise a plate-like member. The plate-like member may have two facing surfaces which terminate at a peripheral edge of the primary blade 20. A first, proximal, peripheral edge may be mechanically connected to the external surface of the wall 18 so as to provide a suitable connection from which the blade 20 can extend from the wall 18. The connection may be provided by welding, mechanical fasteners, or another other suitable means, as required.

The primary blade 20 has a length which extends from a top edge to a bottom edge. The bottom edge may provide the insertion edge 24 which is received by and driven into the seabed during installation of the caisson. The primary blade 20 extends along the length of the external surface of wall 18. The axial extent along the length of the primary blade 20 may correspond to the axial length of the wall 18, or may be shorter or longer, as required.

The primary blades 20 may extend radially outwards from the external surface of the wall 18, with respect to the insertion axis θ to a second, distal, peripheral edge.

The primary blades 20 may be planar or curved. In the example of Figure 1, the primary blades 20 are planar with the plane extending in the direction of the insertion axis, such that the primary blades are aligned with the insertion axis. Thus, when viewed along the insertion axis, the frontal area of the primary blade 20 is restricted to the insertion edge 24.

In the example shown, each of the plurality of the primary blades 20 have corresponding rectangular shapes. It will, however, be appreciated, that other shapes may be possible.

In the present example, the length of each primary blade 20 is equal to the length of the wall 18 (the length of the wall being defined as the measurement in the direction aligned with the insertion axis). In other embodiments, the length of the at least one primary blade 20 may be less than the length of the wall 18.

The primary blades may be arranged so as to be circumferentially distributed around the wall so as to be angularly offset about the insertion axis θ from each other. The distribution of the primary blades may be even such that the angle between each is similar. Pairs of primary blades may be diametrically opposed to one another. As shown in Figure 1, the angle may be approximately 90°. Thus, the four primary blades 20 form two pairs of primary blades 20, each primary blade 20 in the pair being diametrically opposed to the other primary blade 20 in the pair. Other angular offsets are possible.

The caisson may comprise a plurality of secondary blades 22. The secondary blades 22 may extend from the primary blades 20 to provide additional surface area against which the seabed can react to provide additional resistance to movement. Providing the secondary blades 22 along the primary blades 20 at a distance from the main body of the caisson is advantageous as they are further removed from the central axis of the caisson and may provide additional leverage to resist some in service movements.

The secondary blades 22 may be positioned circumferentially with respect to the insertion axis θ such that the facing surfaces of the secondary blades 22 face away from the insertion axis θ and help resist lateral/sideways movement of the caisson during use. Thus, as shown in Figure 1, the secondary blades 22 may be plate-like structures which are positioned in a plane which is tangential to the insertion axis (i.e., tangential to an imaginary circle which is centred on the insertion axis). The secondary blades may be planar so as to be substantially flat, or may be dished so as to have either a concave of convex relation to the body. The secondary blades may be parallel and/or concentric to the external surface of the body wall 18 when viewed in transverse section or plan.

One or more secondary blades 22 may extend from each or some of the plurality of primary blades 20. The one or more secondary blades 22 may be attached to a primary blade 20 along a single edge with the remaining edges being unattached and free. As shown in Figure 1, the secondary blades 22 may comprise an upper and lower peripheral edge in which the lower edge may provide a portion of the insertion edge 24 which is inserted in to the seabed.

In the example of Figure 1, two secondary blades 22 extend laterally from each of the primary blades 20. As shown, the secondary blades 22 may extend laterally from each of the two facing surfaces of each primary blade 20 at the distal edge of each primary

blade 20. This results in the two secondary blades forming one unitary secondary blade structure 22 extending from each primary blade 20. Thus, the two secondary blades 22 extending from each primary blade 20 are coplanar with respect to each other.

The radial position (with respect to the insertion axis) of the secondary blades 22 along the primary blade 20 may vary. In Figure 1, the secondary blades 22 are provided at the terminal end of the primary blade 20, but this need not be the case and the secondary blades 22 may be positioned between the wall 18 and the distal peripheral edge of the primary blade 20. It may also be desirable to place the secondary blades 22 at different radial locations on either side of a primary blade 20, or have different numbers of secondary blades 22 on either side of a primary blade 20. Thus, at least one secondary blade 22 may extend laterally from any edge or surface of the primary blade 20 which is not connected to the wall 18. Each primary blade 20 may have a series of secondary blades 22 on one or both sides.

Each of the secondary blades 22 may be identical to one another, and have a rectangular shape when viewed face on. It will, however, be appreciated, that in other embodiments the secondary blades 22 may be different from one another and/or may comprise other shapes, such as square, triangular or circular.

The secondary blade 22 may be extend at an angle from the primary blade 20, so as to be angularly offset therefrom. Thus, the facing surface of a secondary blade 22a, may be angularly separated from the opposing facing surface of the primary blade 20 from which it extends. In the example of Figure 1, the angle is approximately 90° but it will be appreciated that other configurations of caisson may benefit from secondary blade structures being angularly offset from the primary blade from which it extends at an angle of more or less than 90°.

In Figure 1, each of the secondary blades 22 has the same length as the primary blade 20 from which it extends. However, each of the secondary blades 22 has a smaller width and surface area than the primary blade 20 from which it extends. In alternative embodiments, each of the secondary blades 22 may have a smaller length than the primary blade 20 from which it extends, and/or may have a larger or equal width and/or surface area than the primary blade 20 from which it extends.

In the embodiment of Figure 1, the thickness of the wall 18 and each of the primary 20 and secondary blades 22 is the same. In other embodiments, the thickness may differ. For example, the thickness of the wall 18 may be greater than thickness of the primary blade(s) 20 and/or the secondary blade(s) 22.

The wall 18 may terminate with a cap 30 which encloses the cavity save for an outlet which can be used to evacuate the seawater to draw the caisson into the seabed. The outlet may be provided by any suitable opening or valve to which suction equipment may be connected as known in the art. Thus, as shown in Figure 1, in the second end 16 of the caisson 10 is an opening which is connected to a suction conduit 26. The opening is in fluid communication with the suction conduit 26 and a cavity (not shown), which is enclosed by the cylindrical wall 18. In this embodiment, the diameter of the opening (and the suction conduit 26) is less than the diameter of the cavity.

While not shown in Figure 1, the cap may comprise a projecting rim which engages with the boundary of the end to secure the cap to the end. Alternatively, the cap may not comprise a projecting rim.

As shown, the peripheral edge of the cap may be coterminous with the wall 18, or may extend radially outwardly of the wall with respect to the insertion axis. The peripheral edge may terminate at the distal edge of the at least one primary blade.

The caisson shown in Figure 1 can comprise metal and/or a composite material, for example a composite material comprising metal and concrete. The metal may comprise steel.

Figure 2 shows a plan view of the caisson of Figure 1. The plan view of the caisson clearly shows that each of the four primary blades 20 is angularly offset about the insertion axis θ from each other at an angle of approximately 90°. Each secondary blade structure 22 is angularly offset from the primary blade from which it extends at an angle of approximately 90°.

The common thickness of each of the primary and secondary blades (20 and 22) is also shown.

In the example shown, the width of one of the primary blades forms approximately 20% of the diameter of the caisson. In other embodiments, the width of one of the primary blades may form 30%, 40%, 50% or 60% of the diameter of the caisson.

In use, the caisson of Figure 1 and Figure 2 can be placed on the surface of a seabed. A suction device (not shown) is attached to the end of the suction conduit 26 distal to the second end 16. Suction is applied from the suction device to the distal end 28 of the suction conduit 26 and through the opening into the cavity (not shown) of the caisson. This suction action draws the insertion edge 24 of the caisson into the seabed, such that the insertion edge 24, including the primary and secondary blades 20 and 22, are inserted into the seabed. Suction can be applied until the desired depth of insertion into the seabed is achieved. Generally, suction is applied until all of the caisson except for the second end 16, or at least a portion of the suction conduit 26, is not inserted into the seabed (i.e. the second end 16 or at least a portion of the suction conduit 26 is above or rests upon the seabed).

By insertion of the portion of the caisson containing the secondary 22 and primary blades 20 into the seabed, these blades secure the caisson in the seabed and reduce or prevent lateral movement of the caisson when in the seabed. The caisson can then act as a foundation for an off-shore structure such as a wind turbine. The off shore structure can be connected to the caisson via the second end 16, the opening if in the second end 16, or the suction conduit 26.

Although suction mechanisms are generally envisaged for insertion of the caisson into the seabed, these are not essential. In alternative embodiments, a downward force along the insertion axis may be applied to the second end 16 to insert the caisson into the seabed.

Figure 3 shows a plan view of another caisson. The caisson of Figure 3 is similar to the caisson of Figure 2 except that the caisson comprises an alternative cap 30 on the second end 16. The peripheral edge of the cap 30 is defined by the dashed line in Figure 3.

As shown in Figure 3, the peripheral edge of the cap 28 is located radially outwardly of the wall 18 with respect to the insertion axis. The peripheral edge may terminate at the

distal edge of the at least one primary blade 20. In the present embodiment, the cap is flat and so does not comprise a flange. However, in other embodiments, it will be appreciated that the cap may comprise a flange and/or may be curved.

The caissons described above may form part of a caisson system, as shown in Figure 4. Generally, the system comprises at least two caissons according to the first aspect which are interconnected by a coupling 230. The coupling 230 may be attached to a portion of the at least two caissons 10 which is exposed after insertion.

In the example shown, the system 210 comprises three caissons10 according to the first aspect. In other examples, the system 210 may comprise two, four, five or six caissons 10 according to the first aspect. In addition to comprising at least two caissons 10 according to the first aspect, the system 210 may comprise at least one further caisson which does not comprises primary and/secondary blades. The coupling 230 is attached to a portion of the three caissons which is exposed after insertion, in this instance the second end 16 of each of the caissons.

In the embodiment shown in Figure 4, the coupling 230 comprises a plate or plurality of connecting members which is attached to a portion of the second end 16 of each of the caissons. The coupling 230 may be affixed to each of the caissons at a point substantially central in the second end 16 and may be the same for each caisson. The distance between the positions of the affixment on the coupling 230 is the same to ensure stability during insertion. In such instances, the caissons are evenly distributed across the coupling. This is thought to aid with weight distribution and resulting stability following insertion into the seabed.

In the example shown in Figure 4, the coupling 230 comprises a unitary structure. However, it is possible for the coupling to comprise a plurality of structures, each structure coupling two caissons. For example, the plurality of structures may form a spoke or a frame arrangement.

In the present embodiment the plate 230 is affixed to each of the caissons by a screw member, however, other attachment members will be known by the skilled person.

It will be appreciated that the insertion axis for the system 210 is the same as the insertion axis for an individual caisson 10.

It will be understood that the invention is not limited to the embodiments above-described and various modifications and improvements can be made without departing from the concepts described herein. Except where mutually exclusive, any of the features may be employed separately or in combination with any other features and the disclosure extends to and includes all combinations and sub-combinations of one or more features described herein.

CLAIMS:

1. A caisson for insertion into a seabed along an insertion axis, comprising:

a body comprising a first end for insertion into the seabed and an opposing second end, the first end and second end having a wall extending therebetween, wherein the wall is aligned with and defines an insertion axis;

a cavity enclosed by the wall, the cavity configured to receive the seabed during insertion;

at least one primary blade extending outwardly from an external surface of the wall; and,

at least one secondary blade extending laterally from the at least one primary blade, wherein each of the at least one primary blade and at least one secondary blade comprise an insertion edge configured to be inserted into the seabed.

2. A caisson according to claim 1, wherein the at least one secondary blade extends laterally from a facing surface of the at least one primary blade at a location which is separated from the external surface of the wall.

3. A caisson according to claim 1 or claim 2, wherein the at least one primary blade comprises two facing surfaces, and wherein at least one secondary blade extends laterally from each of the two facing surfaces of the at least one primary blade.

4. A caisson according to any one of claims 1 to 3, wherein the at least one secondary blade has a smaller surface area than the primary blade from which it extends.

5. A caisson according to any one of the preceding claims, wherein the caisson comprises a plurality of primary blades.

6. A caisson according to claim 5, wherein the plurality of primary blades are distributed about the insertion axis.

7. A caisson according to claim 6, wherein the plurality of primary blades are evenly distributed about the insertion axis.

8. A caisson according to claims 6 or 7, wherein there are four primary blades.

9. A caisson according to any one of the preceding claims, wherein the at least one secondary blade extends from the primary blade at an angle of between 45 degrees and 135 degrees.

10. A caisson according to any one of the preceding claims, wherein the at least one secondary blade extends from a distal edge of the at least one primary blade relative to the external surface of the wall.

11. A caisson according to any preceding claim, wherein an insertion end of the or each primary blade is coterminous with the respective the or each secondary blade.

12. A caisson according to any one of the preceding claims, wherein the wall is cylindrical.

13. A caisson according to any one of the preceding claims, wherein the cavity is enclosed by a cap at the second end, wherein the cap comprises at least one opening to provide fluid communication between the cavity and the exterior of the caisson.

14. A caisson according to claim 13, wherein a peripheral edge of the cap is located radially outwardly of the wall with respect to the insertion axis.

15. A caisson according to claim 14, wherein the peripheral edge terminates at the edge of the at least one primary blade distal to the external surface of the wall.

16. A system for insertion into a seabed along an insertion axis, comprising:
at least two caissons according to any one of claims 1-15 and which are interconnected by a coupling.

17. The system of claim 16, wherein the coupling is attached to a portion of the at least two caissons which is exposed after installation.

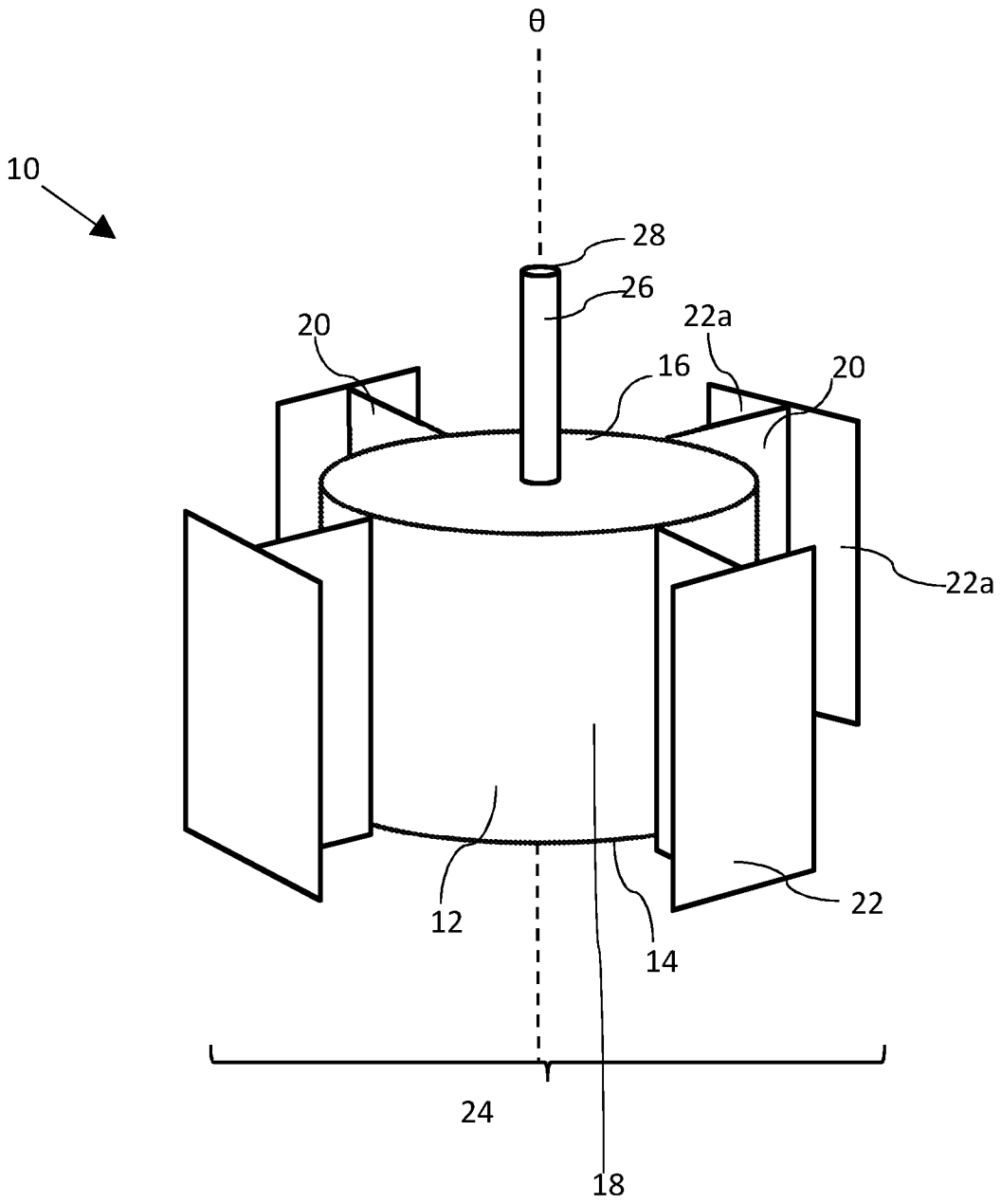

Figure 1

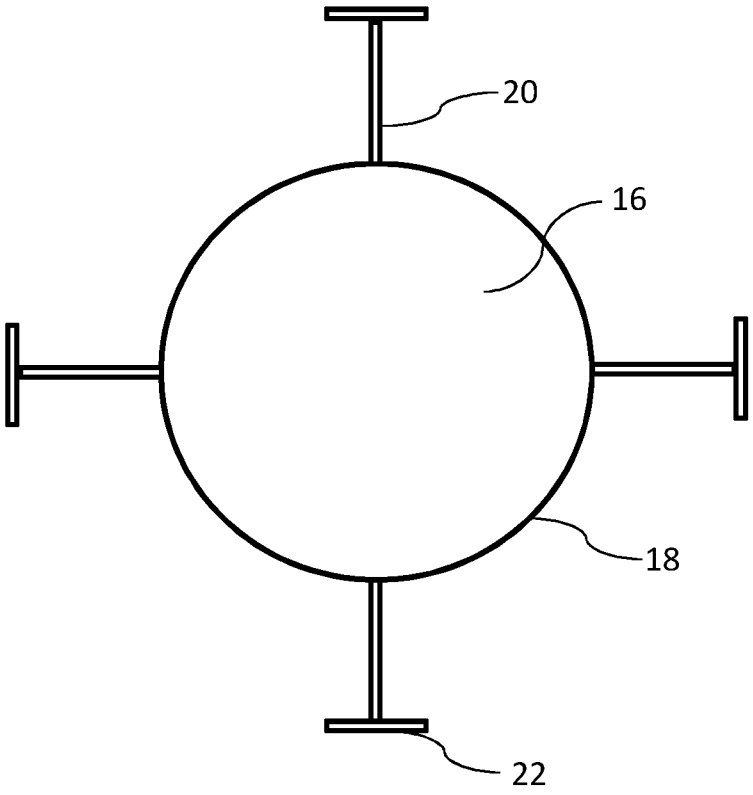

Figure 2

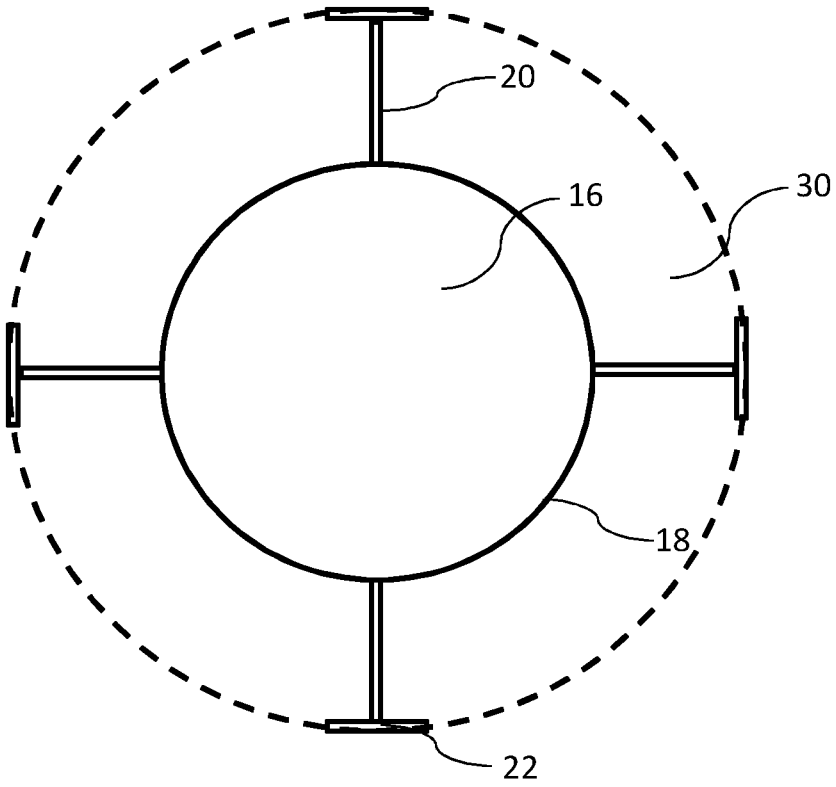

Figure 3

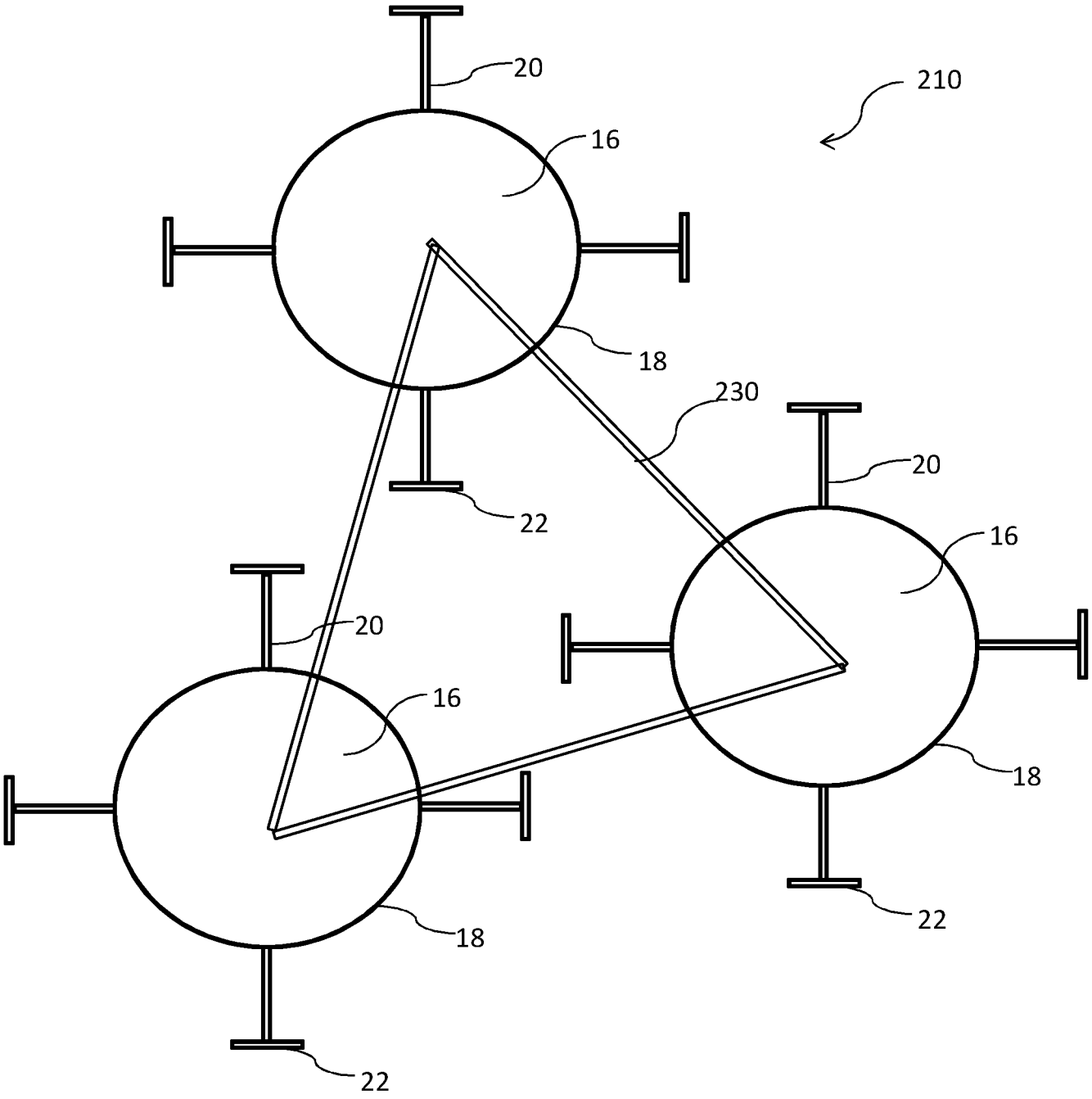

Figure 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2019/053421

A. CLASSIFICATION OF SUBJECT MATTER
INV. E02D23/00 E02D23/08 E02D27/42 E02D27/52
ADD.

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)
E02D E02B

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 616 464 A1 (INST OKEANOLOGIA [BG]) 16 December 1988 (1988-12-16)	1-15
A	page 3, line 12 - page 5, line 17; figures 4,5	16,17

X	KR 2015 0105081 A (KOREA INST OCEAN SCI & TECH [KR]) 16 September 2015 (2015-09-16)	1-3,5-7, 9-15
A	figures 4,5	4,8,16, 17

X	WO 2014/060650 A2 (STX FINLAND OY [FI]) 24 April 2014 (2014-04-24) page 6, line 3 - page 20, line 8; figures 3,7,10,13,18,20	1-17

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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

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"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
6 March 2020	24/03/2020

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	Geiger, Harald

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Form PCT/ISA/210 (second sheet) (April 2005)

International application No
PCT/GB2019/053421

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 86/02966 A1 (OFFSHORE AB J & W [SE]) 22 May 1986 (1986-05-22) page 4, line 23 - page 8, line 29; figures 1,5b,7	1-17

X	US 2016/138239 A1 (ÁLVAREZ GRACÍA-LUBÉN RICARDO [ES] ET AL) 19 May 2016 (2016-05-19)	1-15
A	paragraph [0028] - paragraph [0048]; figures 2,3	16,17

INTERNATIONAL SEARCH REPORT

Information on patent family members

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