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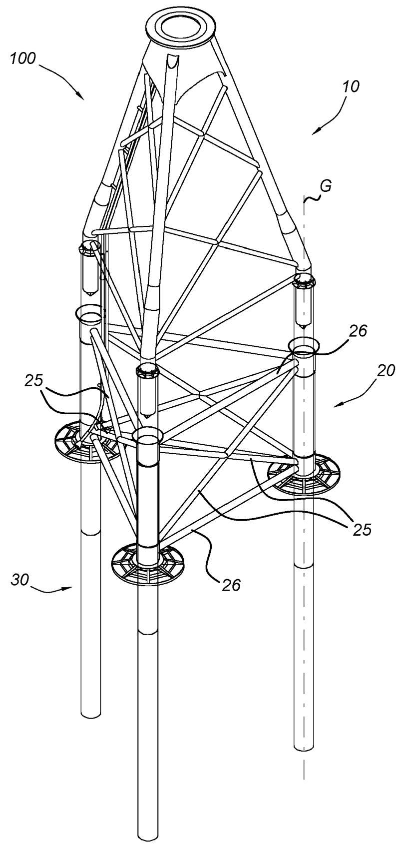
(54) METHOD OF INSTALLING A SUPPORT FOR SUPPORTING A LOAD STRUCTURE, SUCH AS A WIND TURBINE, ON, FOR INSTANCE, A SEA BED

(57) A jacket for supporting a load structure, such as a wind turbine or transformer platform or an oil or gas platform, on a bed, floor or bottom of, for instance a sea, ocean, lake, harbor or river, wherein the jacket is configured to be provided on a jointly rigid structure of a pile guiding frame, that comprises at least three pile holding sections, wherein each pile holding section allows guiding and maintaining a pile along a pile guiding direction in a vertical orientation, wherein neighbouring and/or opposing pile holding sections are interconnected by mutually crossing diagonal cross beams; wherein said piles are driven through each pile holding section of the pile guiding frame in the bed, floor or bottom such that each pile projects in an upward direction out of the bed, floor or bottom and out of associated pile holding sections over a projection length from each pile holding section.

Fig. 2A



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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a jacket for supporting a load structure, such as a wind turbine or transformer platform or an oil or gas platform, thereon on bed, floor or bottom of, for instance, a sea, ocean, lake, harbor or river.

BACKGROUND OF THE INVENTION

[0002] With the increasing demand for energy, a considerable interest arose in the last years around the installation of offshore structures supporting wind turbines and transformer platforms alongside oil and gas platforms. A commonly used form of offshore support structure consists of a stand-alone multi-legged unit, the offshore jacket, made of steel which is stabbed onto predriven or otherwise embedded piles or having post-driven piles and then grouted to fixate it to the sea bed.

[0003] Jackets are produced and assembled on land and, subsequently, transported to the offshore site and thereby installed. In view of the considerable size of the jackets, which can reach tens of meters of height, considerable resources and extensive costs are involved in the production, assembly, stocking, logistics and loadout, transportation and installation of these structures.

[0004] Usually, before the installation of a jacket, piles, having the function of securing the jacket to the sea bed are driven into the sea bed by means of a hammer using a multi-use piling frame called a "piling template" which is removed once the piling operations are terminated. The use of such a multi-use template implies that additional substantial temporary resources have to be provided in addition to the transportation, storing and handling of the large size offshore jackets.

[0005] Generally, after removal of the piling template and prior to installation of the offshore jacket, the predriven piles require to be emptied of seabed material over sufficient length to accommodate the stabbing sections of the offshore jacket, as a result of their limited protrusion above the seabed.

[0006] In case a small number of wind turbines is to be installed in the forthcoming wind parks (also referred to as wind farms or wind energy farms), the use of the multiuse piling template, to be removed after piling operations, will imply considerable economical and logistic costs related to its production, stocking, transportation and installation/removal. In addition, the use of a multi-use piling template as a template for the installation of the piles implies that the footprint widths of the multiple jackets to be installed is bound by the geometry of a multi-use piling template for the installation of the jackets. Furthermore, the use of a multi-use piling template as a template for the installation of the piles requires a complex system of measurement and adjustment of the entire framework to adjust to any unevenness of the sea bed to achieve consistent verticality of the piles.

[0007] When installing offshore wind farms, for instance, multiple individual wind turbines are to be installed on a sea bed of which a depth below the water surface may vary across the wind farm. To be able to install the wind turbines at a same level with respect to the water surface one has to take the sea depth into account, which would require jacket foundations of various heights. This nowadays involves jackets specially made for individual wind turbines, which is costly and not efficient.

[0008] CN 102535510 A discloses a method comprising the following steps: A) arranging a jacket platform at the upper end of the jacket body and connecting the jacket platform and the jacket body into a whole; B) placing the jacket body on the seabed; C) inserting tubular piles into the jacket legs and firmly fixing the piles in the seabed; and D) grouting cement plaster into the clearances between the tubular piles and the jacket legs.

[0009] US 2013/272796 A1 discloses an offshore support tower assembly comprising a base disposed at the sea floor. In addition, the support tower assembly comprises a plurality of anchors securing the base to the sea floor. Further, the support tower assembly comprises a support frame coupled to the base. The support frame comprises plurality of modular tower sections in a stacked arrangement. The support tower assembly also comprises a deck supported by the support frame.

SUMMARY OF THE INVENTION

[0010] It is an objective of the invention to overcome at least some of the above-identified disadvantages of the known methods and installations.

[0011] It is another or alternative objective of the invention to provide an alternative for producing, assembling, stocking, loading out, transporting and/or installing a jacket that is able to support structures including, but not limited to, wind turbines, oil platforms, gas platforms and/or transformer platforms.

[0012] It is yet another or alternative objective of the invention to allow to install a plurality of jackets of a wind park without the need of using expensive and complicated multi-use piling templates.

[0013] It is yet another or alternative objective of the invention to allow to use a jacket of smaller dimensions than a conventional jacket, the use of smaller and lighter units allowing a reduction in costs related to the production, assembly, stocking, transportation, installation \and removal with respect to the commonly installed jackets.

[0014] It is yet another or alternative objective of the invention to allow to use a jacket, wherein the height of the jacket with respect to, for instance, the sea bed can be adapted to allow for appropriate installation with respect to the water surface at various water depths.

[0015] Embodiments and present disclosure provide a jacket for supporting a load structure, such as a wind turbine or transformer platform or an oil or gas platform, on a bed, floor or bottom of, for instance a sea, ocean, lake, harbor or river, as set out in claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Further features and advantages of the invention will become apparent from the description of the invention by way of non-limiting and non-exclusive embodiments. These embodiments are not to be construed as limiting the scope of protection. The person skilled in the art will realize that other alternatives and equivalent embodiments of the invention can be conceived and reduced to practice without departing from the scope of the present invention.

[0017] Embodiments of the invention will be described with reference to the accompanying drawings, in which like or same reference symbols denote like, same or corresponding parts, and in which

Figures 1A and 1B show top and side views, respectively, of a support installed on a sea bed according to an example not explicitly disclosing all of the features of the claims;

Figure 2A shows an isometric view of the support of figures 1A and 1B, while figures 2B, 2C and 2D show the isometric views of the jacket, the piles and the pile guiding frame, respectively, of the support depicted in Figure 2A;

Figures 3A, 3B and 3C show steps of a method to install a support on a sea bed according to an example not explicitly disclosing all of the features of the claims; and

Figures 4A and 4B show details of the support according to an example not explicitly disclosing all of the features of the claims.

DETAILED DESCRIPTION OF EMBODIMENTS

[0018] The following detailed description is made in relation to a jacket (10) for supporting a load structure, such as a wind turbine or a transformer platform or an oil or gas platform, thereon on a bed, floor or bottom of, for instance a sea, ocean, lake, harbor or river. The embodiments will be described with reference to a "sea bed" but generally apply to ocean, lake, harbor, river beds or floors or bottoms as well, or any other relevant bed, bottom or floor or the like. The embodiments will further be described with reference to "offshore" but generally apply to an inshore location, a port, a harbor or equivalents, or any other relevant location as well.

[0019] Figures 1A, 1B and 2B schematically show top and front views (Figures 1A and 1B) and an isometric view (Figure 2A) of an embodiment of an offshore support 100 which can be installed by using the method to which this invention relates. The offshore support structure 100 comprises an offshore jacket 10, a pile guiding frame 20 and a plurality of piles 30 passing through pile holding sections 21 of the pile guiding frame 20. The piles are configured to support the load of the offshore jacket 10 and of any load structure, such as a wind turbine, mounted on it. The offshore jacket 10 includes at least three pillars 12 interconnected by a plurality of beams (or bracings). The pile guiding frame 20 comprises, at its outside perimeter, a same number of pile holding sections 21 as the number of pillars of the offshore jacket 10, interconnected by diagonal cross-beams 25 and horizontal beams 26. Each of the plurality of the pile holding sections 21 is configured to confine a pile 30 in a horizontal direction, so that the pile is held in a substantially vertical orientation. Optionally, each pile holding section 21 comprises a pile stabbing cone 22 at the top of each pile holding section providing a guidance of the associated pile 30 when stabbing the associated pile into a respective pile holding section during piling operations.

[0020] The elements of the offshore support structure 100, i.e. the pile guiding frame 20, the piles 30 and the offshore jacket 10, are transported on vessels or barges to the offshore installation site and there set down on the sea bed by means of cranes or equivalents. As shown in Figure 3A, the pile guiding frame 20 is lowered onto the sea bed. The pile guiding frame 20 comprises at least three interconnected pile holding sections 21 at an outside perimeter of the pile guiding frame 20 in the embodiment shown, wherein the perimeter constituted by the bottom ends of the pile holding sections, proximal to the sea bed, may have a form of any regular or irregular polygonal shape, reflecting the shape of the offshore jacket to be positioned onto the piles. The pile holding sections 21 are interconnected by diagonal cross-beams 25 and horizontal beams 26 in order to maintain a mutually fixed position and parallelism between the pile holding sections and to provide rigidity.

[0021] The pile guiding frame 20 is used during piling operations to eliminate the use of a removable piling template. In addition, the pile guiding frame 20 provides stiffness and strength to the piles. The use of such a permanent pile guiding frame 20 allows the customization of the spacing of the plurality of piles used to support the offshore jacket 10 to suit the water depth and seabed situation at each individual location.

[0022] In the embodiment shown, the pile guiding frame 20 comprises a footing 23 configured to contact the sea bed and to give stability to the pile guiding frame 20. The footing 23 includes a system for adjusting the vertical position of each pile holding section 21 in order to achieve verticality of the piles 30 and ultimately the support structure 100, depending on the unevenness of the seabed at the installation location. The footing 23 may be placed in correspondence to each one of the pile holding sections 21 or may be positioned outside or inside the perimeter formed by the bottom ends of the pile holding sections. In these cases, the footing 23 is connected to the pile guiding frame 30 by means of bracings or equivalents.

[0023] This invention encompasses all embodiments in which the number of pile holding sections is larger than two, i.e. this invention is not limited to three, as shown for the embodiment in Figures 1A to 2D, or to four, as shown for the embodiment in Figures 3A to 4B, pile holding sections 21.

[0024] In a further embodiment, the pile holding sections 21 are substantially of the same length and are configured such that their bottom ends, proximal to the seabed, are coplanar with the plane formed by the sea bed. However, in case of an uneven or sloping sea bed the pile holding sections can be of different lengths in an alternative embodiment.

[0025] Each pile holding section 21 is configured to allow the guidance of a pile 30 and its maintaining along a guiding direction G in a substantially vertical orientation. In the embodiment shown the pile holding sections 21 comprise a hollow column, configured to receive the pile and fitted with a centralizer fitting to guide the associated pile when stabbing the associated pile into a respective pile holding section during piling operations. Furthermore, the pile holding sections 21 are fitted with a system for permanent fixation to the pile by means of grout or an alternative mechanical means of fixation such as by using wedges or hydraulic pistons to clamp the pile within a respective pile holding section. Especially, the piles 30 are secured to the pile holding sections 21 at the top end and bottom end of the pile holding sections and at positions A at which the diagonal cross-beams 25 are connected to the associated pile holding sections to provide strength and rigidity to the structure of the pile guiding frame 21 and the piles 30 driven through and secured to the pile holding sections. Strength and rigidity is further provided by having the diagonal cross-beams 25 connected at the top end and the bottom end of the respective pile holding sections, and to have a longitudinal direction of each respective diagonal cross-beam 25 and the pile guiding direction G of a pile holding section 21 to which the respective cross-beam is connected enclose an angle α in the range of 25 - 65 degrees, especially in the range of 35 - 55 degrees. The pile guiding frame 21 further has horizontal beams 26 connected in between pile holding sections at those locations where the diagonal cross-beams 25 are connected as well to further add to the strength and rigidity of the jointly rigid structure.

[0026] According to Figure 3B, when the pile guiding frame 20 is in place on the sea bed, it is used as a template for performing piling operations. A pile 30 is driven through each one of the pile holding sections 21 into the sea bed, such that, in its final position, each pile 30 projects in an upward direction out of its associated pile holding section 21, i.e. such that one end of each pile projects towards the sea surface out of its associated pile holding section 21.

[0027] The piles 30, having a tubular shape, are driven into the sea bed to a sufficient depth so as to be capable of securing the offshore jacket 10 to the sea bed and of supporting the load of the offshore jacket 10 and of any structure mounted on it. The piles 30 are driven into the sea bed so as to extend considerably above the sea bed and to also extend above the pile guiding frame 20, thus, allowing the use of a shorter offshore jacket 10 than the commonly used ones. It also allows a constant and selected distance of the top of the offshore jackets with respect to the surface of the sea with varying sea depth and spread locations of the supports of pile guiding frames, piles and offshore jackets over the sea bed. The projection length P (or stickup length) of the piles above the pile holding sections 21 of the pile guiding frame 20 can be, dependent on the specific application and circumstances, in the range of 1 - 10 times the diameter D of the piles, especially 2-5 times the diameter of the piles. The piles stick out over a projection length P of about 3.5 times the pile diameter D above the pile holding sections 21 in the embodiment shown. The jointly rigid structure of the pile guiding frame and the piles secured to the frame allow for a large upward stick out of the piles from the pile guiding frame. The piles can have any diameter but typically will be in the range of 2 - 3 meter, which implies that projection or stickup length P can be up to 20 - 30 meter under favorable conditions. Generally, the projection length P will be in the range of 2 - 10 meter. A pile guiding frame 20 can have a height of, for instance, 20 meter for application at a water depth of, for instance, 45 meter. The fact that piles extend well above the sea bed implies the additional advantage that no emptying of the piles is required before providing the offshore jacket 10 onto the piles.

[0028] As shown in Figure 3C, the offshore jacket 10 in the embodiment shown comprises a plurality of legs or pillars 12 interconnected by beams, bracings or equivalents which are configured to maintain a mutually fixed position between the plurality of legs. The offshore jacket 10 may further comprise stabbing projections 11 on its outer perimeter in correspondence to the bottom end of each leg 12. The pile guiding frame 20 and the piles 30 driven through the pile holding sections 21 of the pile guiding frame 20 together form a jointly rigid structure confining movement of the piles.<

[0029] The offshore jacket 10 is lowered from the vessel towards the piles 30 driven through the pile holding sections 21 such that each one of the stabbing projections 11 is provided onto and secured to an associated pile 30 driven into the sea bed and such that the offshore jacket 10 projects at least partially out of the water surface W. Each stabbing projection 11 is connected by means of a grouted connection or a mechanical connection to its associated pile 30. Alternatively, the offshore jacket 10 may be installed in a position below the water surface W.

[0030] The offshore jacket 10 may be secured to the piles 30 by means of at least one of a grouted connection or a mechanical connection. When the offshore jacket 10 is in its final position, the piles 30 provide support forthe load of the offshore jacket 10 and of any structure mounted on it.

[0031] In the embodiment shown in Figure 4A, each one of the stabbing projections 11 fits into an inner circumference of the associated pile 30. Furthermore, at least one of the stabbing projections 11 may comprise a jacket supporting skirt 13 protruding from at least a part of an outer perimeter of the stabbing projection 11 in a substantially radial direction and configured to couple with the associated pile 30 and, optionally, to transfer the load of the offshore jacket 10. In the embodiment shown in Figure 4B, the stabbing projections 11 have a hollow cylindrical shape and are configured to allow the insertion of an upper portion of the associated piles 30, such that each one of the piles 30 fits into an inner circumference of the associated stabbing projection 11.

[0032] The embodiments disclosed in the present specifications and drawings are provided merely to readily describe and to help a thorough understanding of the present invention but are not intended to limit the scope of the present invention. Therefore, it should be construed that, in addition to the embodiments disclosed herein, all modifications and changes or modified and changed forms derived from the technical idea of the present invention fall within the scope of the present invention.

[0033] Aspects of the disclosure may also be understood from the following clauses:

Clause 1: A method of installing a support for supporting a load structure, such as a wind turbine or a transformer platform or an oil or gas platform, thereon on a bed, floor or bottom of, for instance a sea, ocean, lake, harbor or river, the method comprising:

- positioning a pile guiding frame on the bed, floor or bottom, wherein the pile guiding frame comprises at least three pile holding sections, optionally at an outside perimeter of the pile guiding frame, each pile holding section allows guiding and maintaining a pile along a pile guiding direction in a substantially vertical orientation, and neighbouring and/or opposing pile holding sections are interconnected by mutually crossing diagonal cross beams;
- driving a pile through each pile holding section of the pile guiding frame into the bed, floor or bottom such that each pile projects in an upward direction out of the bed, floor or bottom and out of its associated pile holding section over a projection length from each pile holding section, and providing a jointly rigid structure of the pile holding frame and the piles driven through each pile holding section in the bed, floor or bottom, wherein the projection length is in the range of 1 - 10 times, optionally in the range of 2 - 5 times, a diameter of the piles; and
- providing a jacket on the piles projecting out of the pile holding sections, and securing the jacket to the piles so that the piles will bear the load of the jacket and of the load structure supported on the jacket.

Clause 2: The method according to clause 1, wherein each pile is secured to its associated pile holding section (21) to provide the jointly rigid structure.

Clause 3: The method according to any one of clauses 1-2, wherein each pile is secured to its associated pile holding section at positions at which a diagonal cross beam is connected to the associated pile holding section.

Clause 4: The method according to any one of clauses 1-3, wherein each pile is secured to its associated pile holding section at each position at which a diagonal cross beam is connected to the associated pile holding section.

Clause 5: The method according to any one of clauses 1-4, wherein each pile is secured to its associated pile holding section of the pile holding frame at a top end and a bottom end of the respective pile holding section.

Clause 6: The method according to any one of clauses 1-5, wherein neighbouring and/or opposing pile holding sections are interconnected by two mutually crossing diagonal cross beams, each connected at a top end and a bottom end of a respective pile holding section.

Clause 7: The method according to any one of clauses 1-6, wherein a longitudinal direction of each respective diagonal cross beam and the pile guiding direction of a pile holding section to which the respective cross beam is connected enclose an angle in the range of 25 - 65 degrees, optionally in the range of 35 - 55 degrees.

Clause 8: The method according to any one of clauses 1-7, wherein a horizontal beam is arranged in between neighbouring and/or opposing pile holding sections and connected to the respective pile holding sections at positions at which a diagonal cross beam is connected to the pile holding sections.

Clause 9: The method according to any one of clauses 1-8, wherein a bottom end of the jacket is provided on the piles.

Clause 10: The method according to clause 9, wherein at least one stabbing projection of the jacket is secured to the piles by at least one of a grouted connection and a mechanical connection.

Clause 11: The method according to clause 9 or 10, wherein the bottom end of the jacket comprises downward projecting stabbing projections, optionally at an outside perimeter of the jacket, each stabbing projection being provided to couple with a top end of an associated pile of the jointly rigid structure.

Clause 12: The method according to clause 11, wherein each stabbing projection is inserted into an inner circumference of the associated pile.

Clause 13: The method according to clause 11, wherein each pile is inserted into an inner circumference of the stabbing projection, wherein the stabbing projection has a hollow cylindrical shape.

Clause 14: The method according to clause 12 or

13, wherein the jacket comprises jacket supporting skirts, each stabbing projection being associated with a jacket supporting skirt, and wherein the jacket is provided onto the piles so that each jacket supporting skirt bears on the associated pile.

Clause 15: The method according to any one of clauses 1-14, wherein the pile holding sections comprise hollow columns, optionally fitted with centralizer fittings and an upward tapered pile stabbing cone at a top end of each pile holding section providing a guidance for the associated pile when stabbing the associated pile into a respective pile holding section during piling operations.

Clause 16: The method according to any one of clauses 1-15, wherein the pile guiding frame is provided with a footing at each pile holding section for supporting the pile guiding frame on the bed, floor or bottom, optionally the footing including a system for adjusting a vertical position of each pile holding section in order to achieve verticality of all pile holding sections.

Clause 17: The method according to any one of claims 1-16, wherein a pile driven into the bed, floor or bottom is secured to the associated pile holding section of the pile guiding frame by means of at least one of a grouted connection or a mechanical connection.

Claims

1. A jacket (10) for supporting a load structure, such as a wind turbine or transformer platform or an oil or gas platform, on a bed, floor or bottom (B) of, for instance a sea, ocean, lake, harbor or river, wherein the jacket is configured to be provided on a jointly rigid structure of a pile guiding frame, that comprises at least three pile holding sections (21), optionally at an outside perimeter of the pile guiding frame, wherein each pile holding section allows guiding and maintaining a pile (30) along a pile guiding direction in a vertical orientation, wherein neighbouring and/or opposing pile holding sections are interconnected by mutually crossing diagonal cross-beams (25); wherein each pile is secured to its associated pile holding section (21), and wherein said piles are driven through each pile holding section of the pile guiding frame in the bed, floor or bottom such that each pile projects in an upward direction out of the bed, floor or bottom and out of associated pile holding sections over a projection length from each pile holding section, wherein the projection length is in the range of 2 - 5 times a diameter of the piles, the jacket (10) comprising;
at least three, optionally inclined, inter-connected pillars (12), optionally at its outside perimeter, each pillar (12) being configured for providing onto an associated pile (30) driven in the bed, floor or bottom (B) such that the load of the jacket (10) is supported on the piles (30) driven in the bed, floor or bottom (B).and wherein the jacket is configured to be secured to the bed, floor or bottom (B), via the associated pile (30) so that the piles will bear the load of the jacket and of the load structure supported on the jacket.

2. The jacket (10) according to any one of claims 1, comprising a stabbing projection (11) provided at a bottom end of each pillar, optionally the stabbing projections (21) being at an outer perimeter of the jacket, wherein each stabbing projection is configured to be provided on a top end of an associated pile (30) or on a top of an associated pile holding section.

3. The jacket (10) according to claim 2, wherein at least one stabbing projection (11) of the jacket (10) is configured to be secured to the associated pile (30) driven into the bed, floor or bottom (B) by at least one of a grouted connection or a mechanical connection.

4. The jacket according to any one of claims 2-3, wherein the stabbing projections (11) are configured to fit into an inner circumference of the associated pile (30).

5. The jacket according to any one of claims 2-4, wherein the stabbing projections (11) have a hollow cylindrical shape and are configured to allow the insertion of an upper portion of the associated pile (30) therein, such that each one of the piles (30) fits into an inner circumference of the associated stabbing projection (11).

6. The jacket according to any one of claims 4-5, wherein at least one stabbing projection (11) comprises a jacket supporting skirt (13) protruding from at least a part of an outer perimeter of the at least one stabbing projection (11) in a substantially radial direction and configured to couple with the associated pile (30).

7. The jacket of any one of claims 1-6, wherein the jacket (10) is configured to, in its mounted configuration, to project at least partially out of a water surface (W) of a mass of water, such as a sea, ocean, lake, harbor or river, above the bed, floor or bottom (B).

8. The jacket of any one of claims 1-6, wherein the jacket is configured to, in its mounted configuration, to remain totally under a water surface (W) of a mass of water, such as a sea, ocean, lake, harbor or river, above the bed, floor or bottom (B).

Fig. 1A

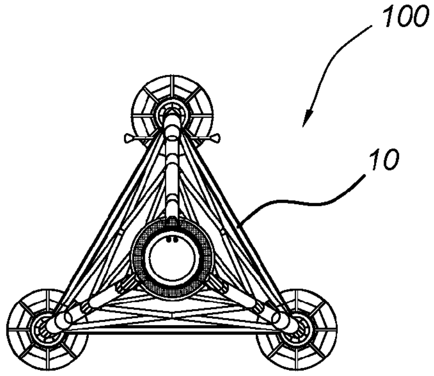


Fig. 1B

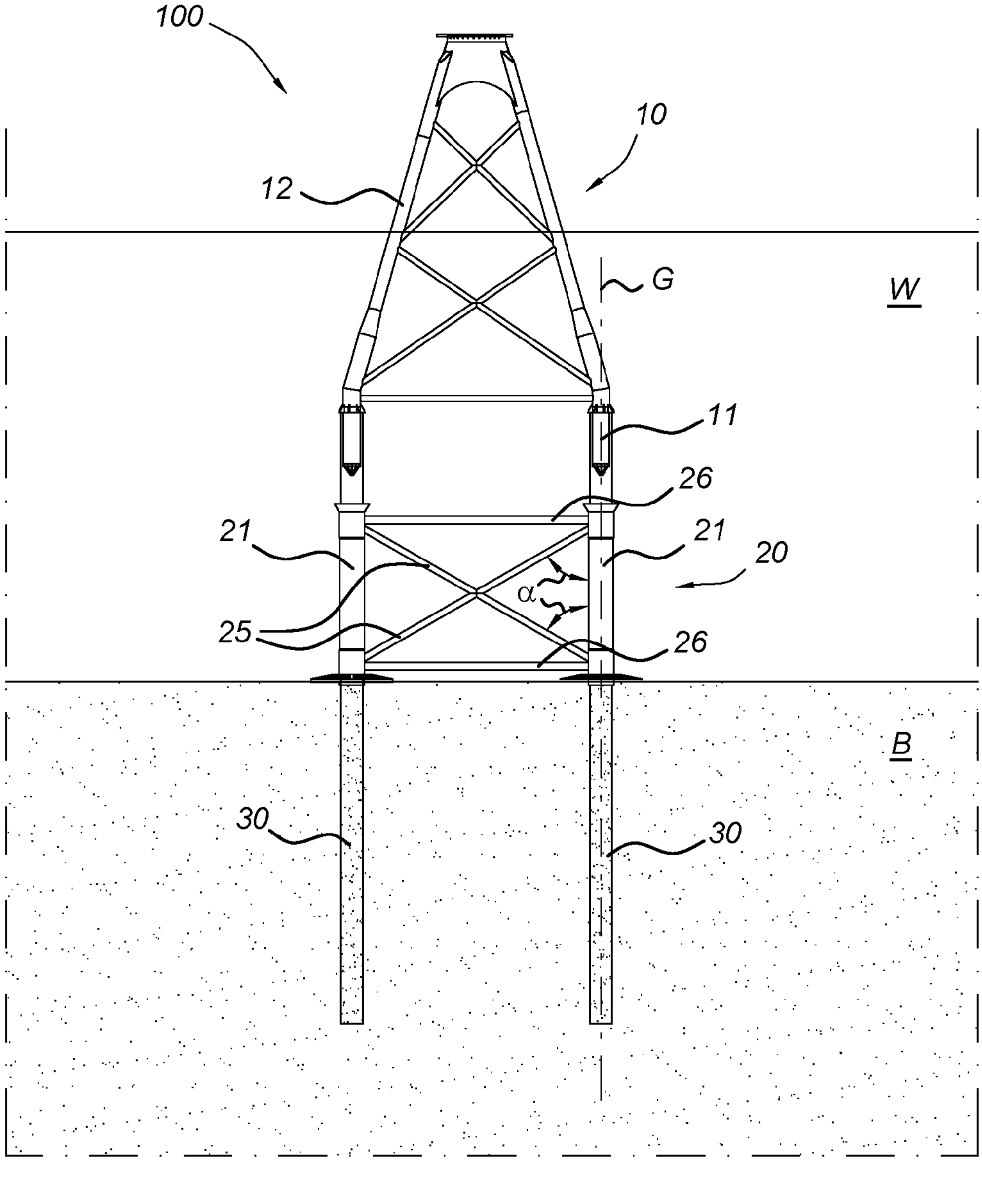


Fig. 2A

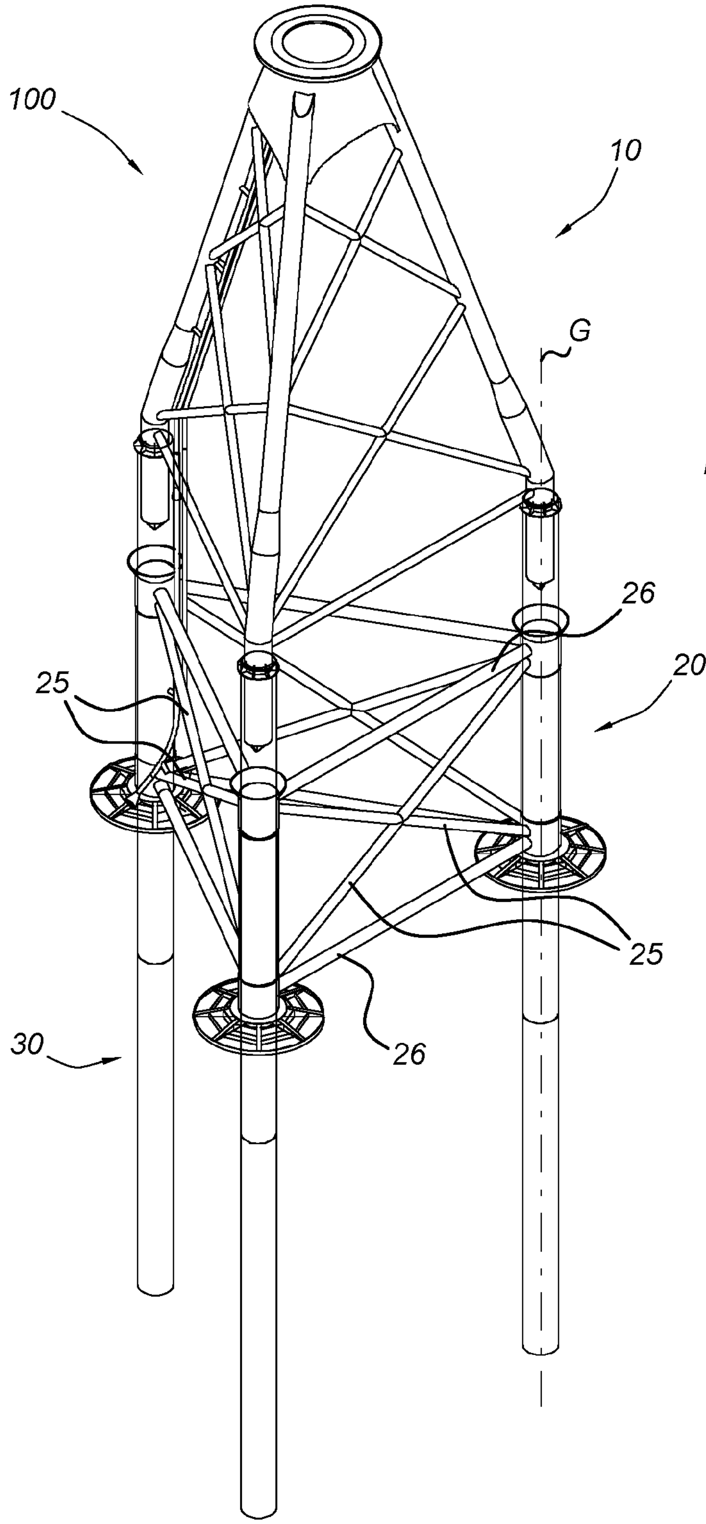


Fig. 2B

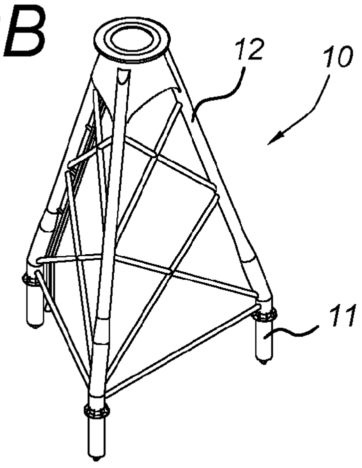


Fig. 2C

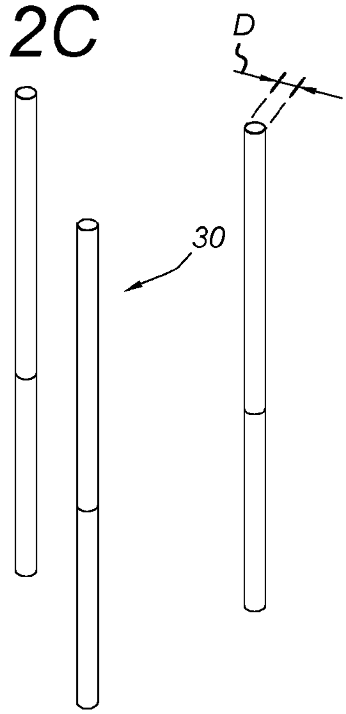


Fig. 2D

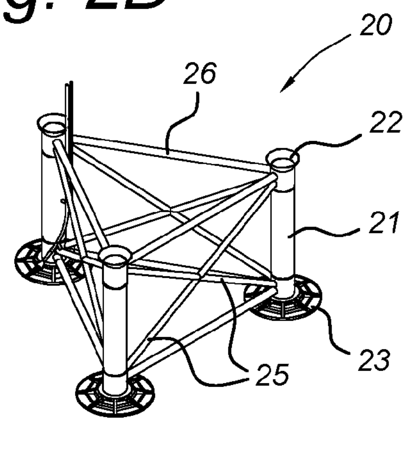


Fig. 3A

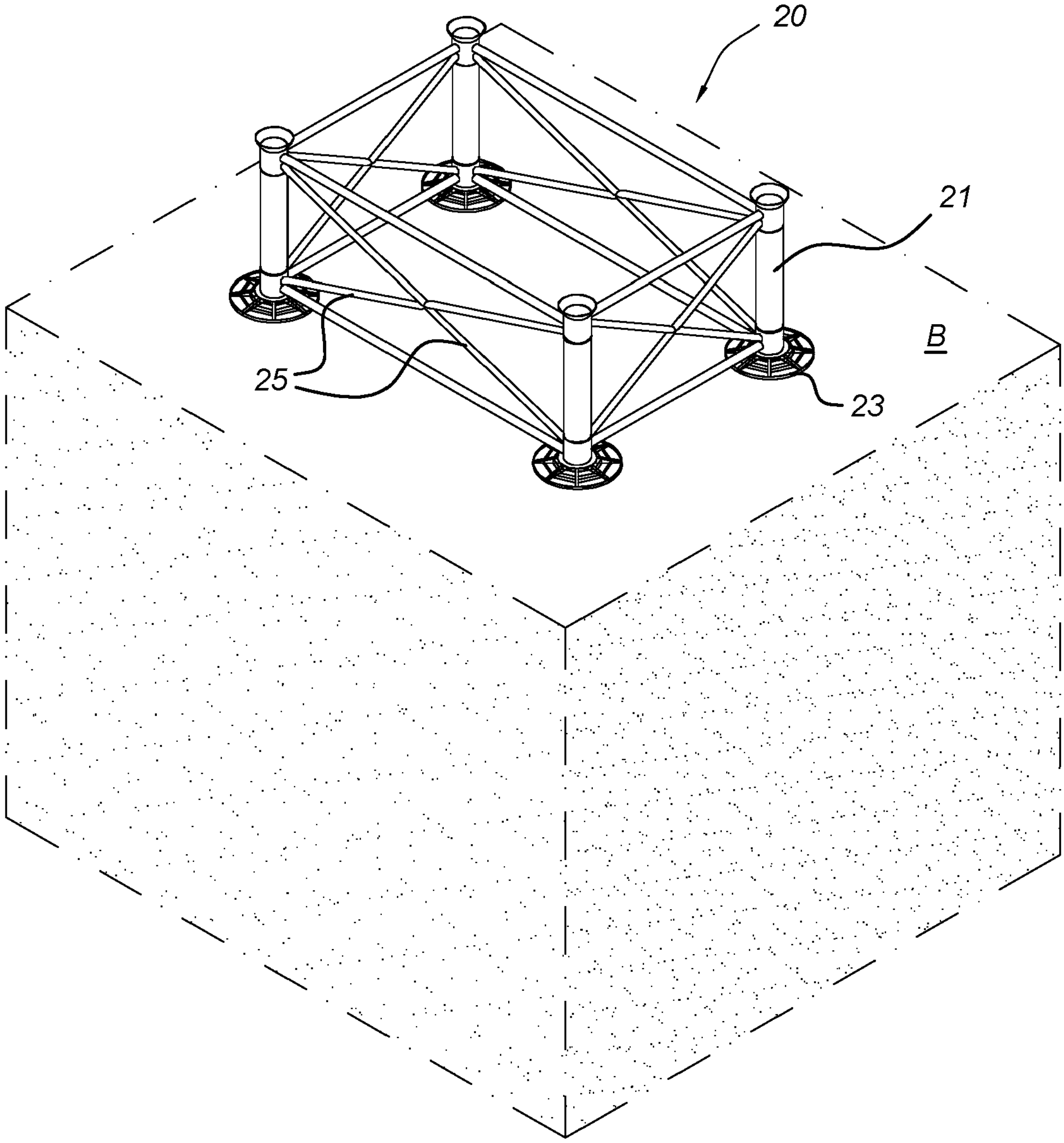


Fig. 3B

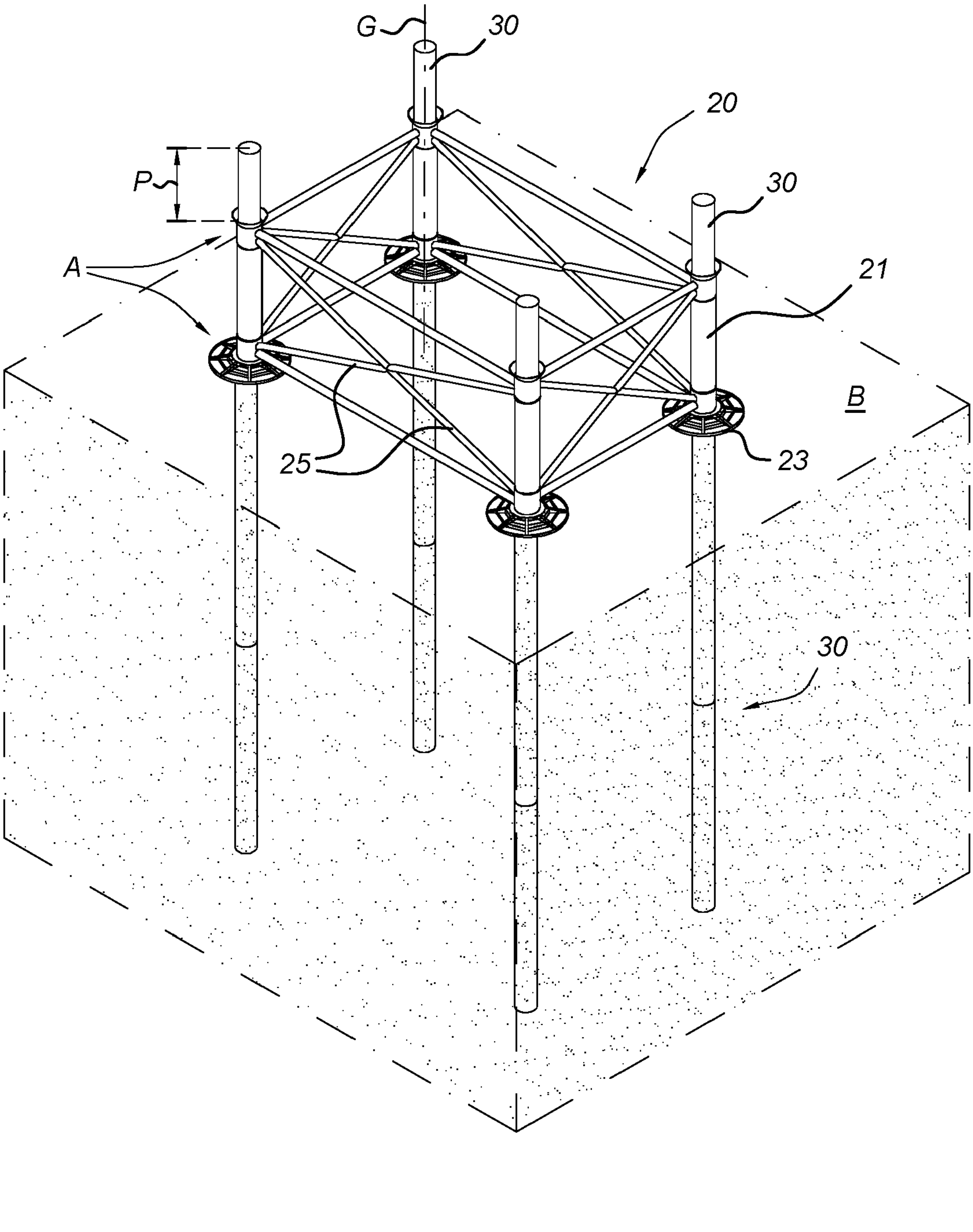


Fig. 3C

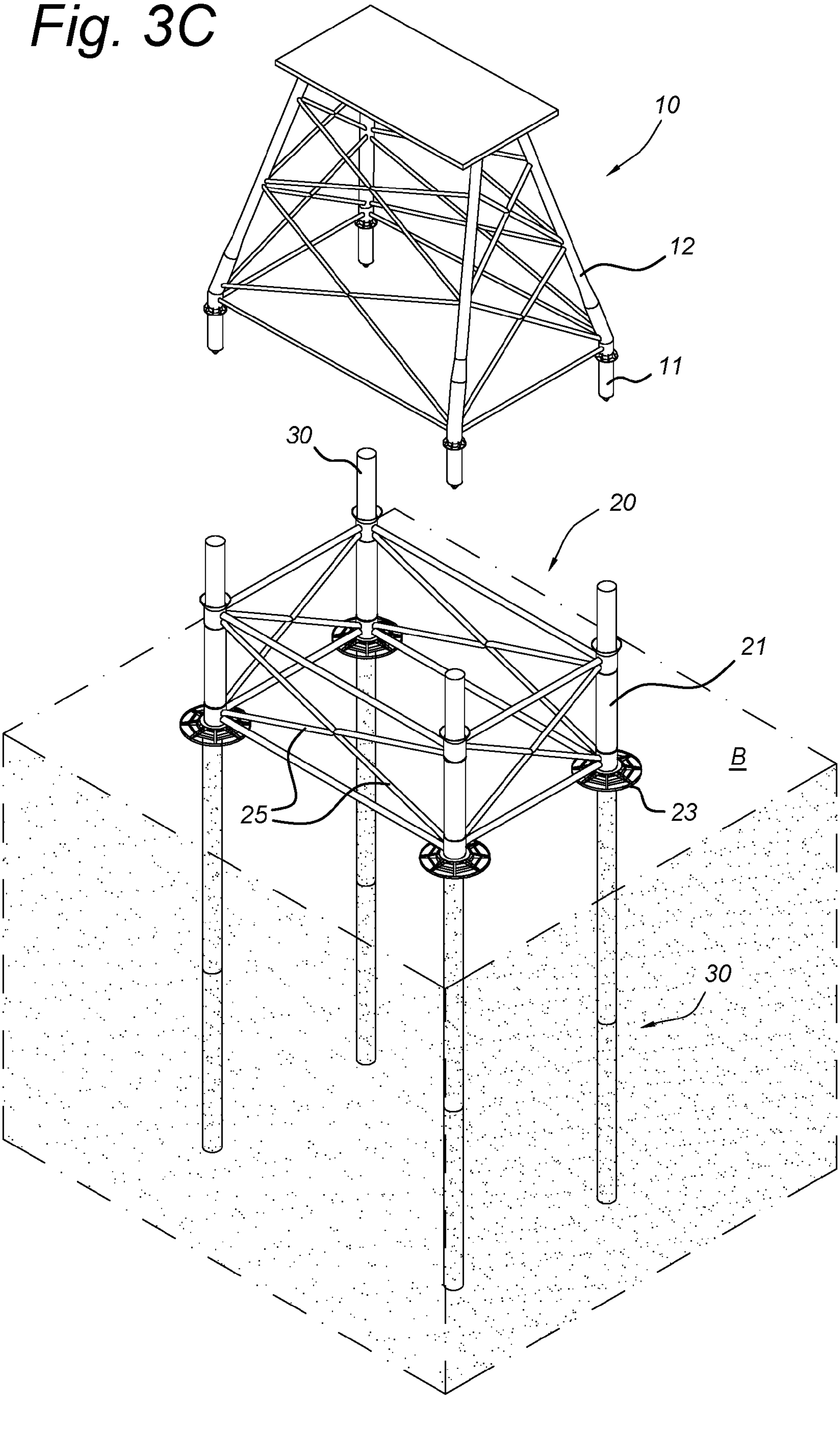


Fig. 4A

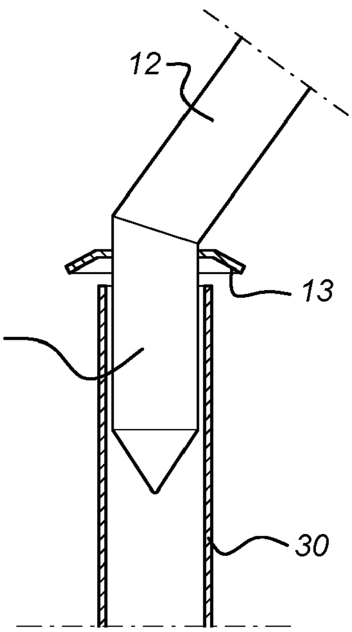
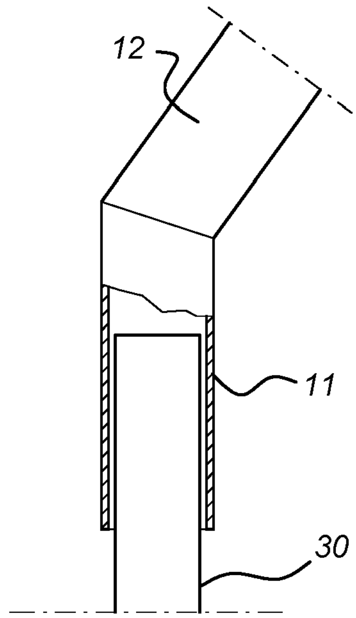


Fig. 4B



REFERENCES CITED IN THE DESCRIPTION

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- US 2013272796 A1 **[0009]**