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(54) **GRAVITY INSTALLED ANCHOR**

DURCH SCHWERKRAFT INSTALLIERTER ANKER

ANCRE INSTALLÉE À L'AIDE DE LA GRAVITÉ

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Description

[0001] The present invention is a gravity installed anchor and a method for installing such an anchor. The field of use is for mooring heavy marine constructions such as semisubmersible drilling platforms, petroleum production vessels or similar vessels. A gravity installed anchor is installed by connecting it to a mooring line, using an installation/retrieval line to lower it to a desired height above the seafloor, and releasing the anchor to fall and penetrate to a desired depth below the seafloor into the sediments. Then the anchor line may be put in tension.

Background art

[0002] Gravity installed anchors usually comprise a long, vertical central shank, i. e. a weight stem; a massive shank comprising a solid steel cylinder or steel pipe filled with a heavy material such as steel grit, or a shank built of a massive steel plate structure, and provided with symmetrically arranged so-called "flukes", i.e. short laterally extending steel fins which extend along either the upper portion of the stem, or both the upper and lower portion of the stem. The fins are arranged for guiding the stem during the fall through the sea and into the relatively soft seabed. An attachment point for an anchor line is arranged either in the top stern end of the anchor or in a rotating ring about the stem. Typical weight ranges for such anchors are from 15 to 45 tons.

[0003] US patent application US20060107886 describes an anchor for mooring large structures to a sea bottom, with an elongated central body with several channel members radiating outward from the central stem, each with a channel. A plurality of nose and tail plates are disposed within the channels and hingedly connected to the central body, so that the plates may be swung in or out from the central body, and fixed by pins inserted in mating holes. A load ring is arranged encircling the central body and the load ring is provided with an arm for linking to an anchor line.

[0004] WO2009/105630 describes a method and an apparatus for placing gravity installed anchors under offshore conditions for mooring structures to such anchors. In an embodiment a gravity install anchor has an outward extending load arm which is rotatable with respect to the anchor's vertical axis. A load line is attached to the load arm, and a subsea connector is attached to the remote end of the load line. The subsea connector is held in a frame at the seafloor and arranged for simplifying the connection. the gravity install anchor and the mooring assembly is lowered from the anchor handling vessel on a lowering line and released from a release hook at the end of the lowering line.

[0005] International patent application PCT/BR97/000044 Petrobras, published as WO98/08734 describes a plate-type anchor with a flat rectangular plate pointed in a front end and with laterally arranged flanges with an inclination to the principal plate.

At the rear end of the rectangular plate is a cut-out to allow fitting of a vertical injector pole for use during the launching of the anchor plate, said injector pole retractable after installation. Having the large area of the anchor plate at the lower end and the trailing injector pole above, that arrangement may prove unstable during the drop from the required elevation above the sea bed. Further, the launching of the device according to WO98/08734 requires two vessels which is a disadvantageous use of resources.

[0006] International patent application PCT/NL2002/000509 "Sheet anchor" published as WO2004/011327 describes an anchor plate to be hingedly mounted at its central portion to an upwards extending vertical split pipe with a threaded-in anchor chain before being stabbed into the seabed. The sheet anchor of WO2004/011327 requires a vibratory hammer for liquidifying the soil in order to penetrate into the seabed, and is as thus not a gravity install anchor. After launching the split pipe is removed and the anchor chain is tensioned.

[0007] US patent US6598555 "Marine anchors" is considered to be the closest prior art and describes a plate-shaped anchor provided with a vertically arranged rigid stack of weights forming a weight pile. The weight pile is driven down into the seabed by the gravity force of the weight pile, whereby the weight pile is removed and the anchor loaded by an attached anchor line. However, the weight of the weight pile is not sufficient to drive the anchor of US6598555 to the required depth, and in Figs. 22-24 it is shown that the weight pile anchor has to be pulled in a complex sequence in order to pull out the pile vertically and then pull the anchor plate laterally and downwards to the required depth. The device of US6598555 is thus not purely a gravity install anchor. The outcome of operating such a complexly arranged anchor pile and plate in a marine operation may be unpredictable.

Problems related to background art

[0008] The symmetrical gravity installed anchors of the background art have generally symmetrical properties about their vertical axis. They may be loaded generally to the same amount in all azimuthal directions. For a four-finned anchor two of the fins may extend in a direction generally near a transverse plane relative to the anchor line direction, please see Fig. 5, and provide a horizontal retention capacity in the sediments, while the area of the two other orthogonally arranged fins contribute less or not at all to the horizontal retention capacity because they are more or less in-line with the anchor line direction. The area of half of the fins is thus not fully exploited in the background art.. Further, much of the mass is in the generally cylindrical shank and the steel mass contributes comparatively less to the retention capacity in the transverse direction than it would have done if formed as fins.

[0009] For gravity installed anchors having the anchor line attached in the upper, stern portion there is a risk of

inadvertently pulling the anchor back out of the sediments during heavy loading because a large component of the anchor line force may be in the direction of the stem, and another, orthogonal component causing an overturning moment i.e. rotating the anchor so that a greater portion of the load is transferred in the direction of the stem.

Brief summary of the invention:

[0010] Some of the disadvantages of the background art i.e. three- or four-finned gravity installed anchor, may be significantly reduced if using an anchor according to the present invention. The invention is, in a material aspect, a gravity installed anchor (1) comprising a metal plate (22) with one or more connection points (8) on a front face (221) of said plate (22) for an anchor line (17). The massive metal plate (22) is arranged for being gravity installed in sedimentary layers under the seafloor. The plate (22) is arranged for being installed transverse to the extension of the anchor line (17) direction when in its operative state.

[0011] In an advantageous embodiment of the invention the gravity installed anchor according to the invention comprises an elongated shank (0) connected to the plate (22) and arranged for being directed along the plate (22) during the gravity installation process, the elongated weight stem (0) provided with a nose portion (5) with a nose (51). In a further advantageous embodiment of the invention a hinge, preferably centrally arranged on the plate, may form the link between the plate and the stem, so as for the plate to be able to rotate about the hinge when the anchor line is pulled taut.

[0012] Thus, the anchor according to the invention may be defined as a gravity installed anchor (1) comprising a main anchor plate (22) with one or more connection points (8) for extending an anchor line (17) from a front face (221) of said anchor plate (22), and with an elongated shank (0) provided with a nose portion (5), said elongated shank (0) connected near its top stem portion (6) to said anchor plate (22) and extending near vertically downward in its installation state and arranged for being directed along said anchor plate during a gravity installation process, characterised by

- said anchor plate (22) pivotally attached to a hinge (61) on said shank (0),
- said hinge (61) having a generally horizontal axle (62) for allowing rotation of said anchor plate (22) relative to said shank (0) in its installed state, with said shank extending downwards out from an opposite rear face (222) relative to said front face (221) of said anchor plate (22).

[0013] In an embodiment of the invention the gravity installed anchor (1) further comprises that said hinge (61) is arranged near a centre of said anchor plate (22).

[0014] In an embodiment of the invention the gravity

installed anchor (1), further comprises that said hinge (61) is arranged near a central part of an upper portion of said anchor plate (22). An embodiment of the invention may constitute an intermediate arrangement with the hinge (61) arranged somewhere between the centre of the plate (22) and the central part of the upper portion of the plate (22).

[0015] According to a method aspect of the invention, it is a method for anchoring using a gravity installed anchor (1), comprising:

- an anchor with a massive metal plate (22) with a hinged shank (0) extending downwards and an installation connection point (9) at a top end;
- connecting an anchor line (17) to one or more connection points (8) at a front face (221) of said plate (22);
- attaching an installation line (172) to said one or more installation connection points (9);
- using said installation line (172), lowering said anchor (22) to a desired elevation (h) above a predetermined position (x, y) on the seafloor;
- releasing said anchor from said elevation (h);
- letting said anchor drop and penetrate said seafloor due to gravity;
- tensioning said anchor line (17) along said predetermined line of tension;
- connecting an opposite end of said anchor line (17) to a vessel to be anchored.

Advantages of the invention

[0016] The anchor according to the invention may be oriented with the plate (22) generally transverse to the desired direction of the anchor line's operative direction, which is usually determined during the planning of the mooring operation. This helps achieving a high retention capacity in the desired direction. An anchor for this use wherein a major proportion of the wings are directed normal to the load direction will provide better horizontal retention capacity.

[0017] The distribution of the anchor's mass on one single large plate with a stem instead of distributing the same mass on a single stem or a stem with three or more smaller flukes will increase the available anchor plate area available for holding the tension in the anchor line if aligned normal to the loading direction.

[0018] The anchor of the invention, having a large two-winged heavy anchor plate and a weight stem extending below and parallel with the anchor plate, is completely stable during the gravity installation due to the mass distribution relative to the wing area distribution. The said shank (0) has weight for leading, and stabilising during the drop. The shank forms a spearhead during gravity installation. The invention is distinct from those of the prior art in which a large area anchor plate is arranged at the lower part of a trailing weight pile, which is less stable.

[0019] The anchor according to the invention may be rotated about a horizontal axis after gravity installation, during the tightening of the anchor line. Thus the retention capacity may be further adjusted to have the highest retention capacity in the direction of the taut anchor line. The hinged shank (22) is not preventing said plate (22) from rotating after gravity installation, thus the hinge link between the shank and the plate advantageously reduces the torsion moment required for this pivoting operation for the plate. Further, the anchor according to the invention has a reduced risk of being pulled out of the sediments because the anchor's plate will seek to arrange itself orthogonal to the anchor line when taut, and there will be no or little force component in the "easy" pull-out direction i.e. parallel to the anchor plate (22).

[0020] In an advantageous embodiment of the invention with the connection points (8) slightly offset downwards in their elevation on the plate (22). The connection points may be arranged slightly below the geometrical centre of the plate (22), so as if the anchor is pulled with a force past its holding capacity, to enable the anchor to be tilted to an angle which will make it penetrate deeper into the sediments, thereby attaining a greater holding capacity.

Figure captions

[0021] The anchor according to the invention is illustrated in the attached figures, in which:

Fig. 1 illustrates three different perspectives of an anchor according to the invention:

Fig. 1a is a side elevation view in the plane of the main plate of an embodiment vertically oriented anchor according to the invention, with a front face for being oriented towards an anchor line directed to the right, and with a shank, a weight stem directed downwards.

Fig. 1b is an isometric view as seen about 45 degrees out of the plane of the same, and showing an opposite rear face relative to the front face. A hinge is illustrated in the junction between the shank and the recess in the rear face of the main plate and the weight shank. The shank is illustrated in the parallel position with the main plate.

Fig. 1c shows in general a front elevation plane view of the front face of the main plate of the above-mentioned embodiment of the invention.

Fig. 2 illustrates another preferred embodiment of the invention with a hinged connection between the main plate and the shank.

Fig. 2a is an isometric view as seen in an elevation and about 45 degrees out of the rear face of the main plane of a vertically oriented anchor

according to the invention, with the main plate and the weight shank arranged in-line.

Fig. 2b is an elevation view into the plane of the main plate of the same.

Fig. 2c is a top view of the same.

Fig. 2d is a side elevation view of the same, but with the main plate turned about the hinge point into an operative position with an angle of about 35-40 degrees inclination relative to the vertically oriented shank. This corresponds to the operative position shown in Fig. 4c with the anchor penetrated to a desired depth and the anchor line with its bridle lines put under tension.

Fig. 2e is a top view of the anchor according to the invention with the position of the top plate turned in the same way as for the view of Fig. 2d.

Fig. 3 illustrates an embodiment of the invention rather similar to the embodiment shown in Fig. 1.

Fig. 3a is an isometric view of the embodiment with the shank in a vertical position and the main plate tilted at an angle with the shank and the vertical line. The second, rear face of the main plate relative to the anchor line is shown. The tilted plate is stabilised in the rotary movement about the hinge by the guide fin through the slot near the upper part of the shank or weight stem. Fig. 3b is an isometric view similar to the view of the embodiment in a tilted position as in Fig. 3a but from an azimuthal angle about 90 degrees to the previous illustration, and showing the front face of the main plate from which the anchor line shall extend.

Fig. 4 illustrates the method of installing the anchor according to the invention.

Fig. 4a shows a vertical section of the seafloor and an elevation view of the anchor lowered in an installation line to a desired elevation (h) above a predetermined geographical position (x, y) on the seafloor. The plate is directed in an azimuthal direction transverse to a predetermined line of tension of the anchor line (17). The installation line may also be used for pulling the anchor out of the seabed during retrieval or removal of the anchor.

Fig. 4b shows the anchor gravity-installed in sediments below the same seafloor with the installation line and the anchor line extending generally up along a vertical penetration channel formed by the falling anchor.

Fig. 4c illustrates a further development from the situation in Fig. 4b. The installation line is now connected to a marker buoy in the sea. The anchor line, here connected via three bridle lines to the connecting points on the front face of the

anchor's main plate has been tightened and has turned the main plate into a position nearer to a plane normal to the direction of the anchor line's direction in space.

Fig. 5 shows an elevation and plan view of a typical gravity installed anchor of the background art. The plan view shows a typical load in a random azimuthal orientation relative to the fins.

Description of embodiments of the invention

[0022] The anchor according to the invention is illustrated in Figs. 1, 2, 3, and 4. The invention is a gravity installed anchor (1) comprising a massive metal plate (22), preferably of steel, with one or more connection points (8) on a front face (221) of said plate (22) for an anchor line (17). The plate may be slightly kinked along a central line which will be generally vertical during the gravity installation, please see Figs. 1 and 4. Preferably the convex face of the kinked plate is the front face, i.e. the face from which the anchor line extends. The anchor comprising at least the massive metal plate (22) is for being arranged in a vertical position in the sea before being dropped from a desired elevation above the seafloor. The anchor with the massive metal plate (22) is arranged for being gravity installed in this way in the sedimentary layers under the seafloor. The plate (22) arranged for being installed transverse to the anchor line's (17) extension when in an operative state. Thus the orientation of the plate is not random: the anchor according to the invention has a significantly higher retention force when loaded by a tension line normal to the plane of the plate (22) than if loaded by a tension line directed in a plane parallel with the plate. In an embodiment of the invention the plate (22) is tapered in its lower portion to a general V-shape pointing along with the shank.

[0023] The connection points (8) may in an embodiment be slightly asymmetrically located on plate (22) with the one or more lower connected bridle lines shorter than higher connected bridle lines, such that if the anchor is pulled with a force past its holding capacity, the anchor plate (22) and shank (0) will be rotated to an angle which will make it penetrate deeper into the sediments thereby attaining a greater holding capacity.

[0024] In an embodiment the plate (22) has a general rectangular shape forming two fin portions symmetrically extending about a vertical central symmetry line as counted in the vertical operational position of the anchor. The two fin portions may be slightly kinked about the vertical central line so that the centre of gravity is at or near the vertical axis of the anchor. The upper, rear part of the fins may form a horizontal edge, and the lower, front edge part of the fins may be tapered off as illustrated in Fig. 1c and Fig. 2b. Preferably a main part of the outer edge of each fin is straight and parallel to the vertical central line. The tapering may be extensive so that the shape of the plate (22) may have a general triangular, downward-

pointed shape.

[0025] It is envisaged that the anchor may generally be constituted by the main plate (22) with necessary connection points (8) to the anchor line's bridle lines (17a, 17b, 17c). Such an embodiment would simply be a main plate (22) similar to what is illustrated in Fig. 1, 2, 3 or 4 without a weight stem. In an embodiment of the invention the anchor (1) comprises an elongated weight stem or so-called shank(0) connected to the plate (22) and arranged for being directed along the plane before and during the gravity installation process, such as illustrated in Fig. 4a and Fig. 4b. The weight shank may be massive or comprise a hollow section ballasted for example with heavy grit. In a preferred embodiment of the invention the elongated shank(0) is provided with a nose portion (5) with a nose (51). The elongated shank(0) is advantageously generally of cylindrical shape, i.e. rotationally symmetric about a longitudinal axis along a significant portion of the shank. The shank (0) may also be made of vertical plates with a cross-section in a general X-shape.

[0026] The anchor line's bridle lines (17a, 17b, 17c) should be generally of equal lengths in order for the taut anchor line arrangement to have the plate oriented orthogonal to the anchor line's direction. In order for the plate to penetrate deeper in case of being loaded beyond its holding capacity in the sediment, the upper bridle line or lines should be slightly longer than the lower bridle line or lines, so as for the plate to be slightly tilted and forced to penetrate deeper to regain hold.

Examples of dimensions

[0027] In the embodiments shown in Figs. 1 to 4 the anchor may have a submerged weight of 15 to 45 tons (15000 - 45000 kg) or even more. The main plate (22) is a thick steel plate of thickness 50 to 100 mm or more. The steel plate may be massive or laminated from a stack of thinner steel plates. A main purpose of the thick steel plate is to provide a large surface area transverse to the direction of the anchor line's direction, and to provide sufficient mechanical stiffness to the anchor, and to provide sufficient weight for the anchor to penetrate to a desired depth below the seafloor. The overall height of the anchor may be in the range of 6 to 12 metres, and the height of the main plate about 4 to 6 m, with the width across the main plate being about 3 to 5 m. The area of the main plate may be in the range between 8 and 20 m². Such an anchor may have an operational tension capacity of about 300 to 750 tons at 15 - 20 m penetrated depth depending on the mechanical properties of the sedimentary layers below the sea floor.

[0028] In an advantageous embodiment of the invention the plate (22) is pivotally attached to a hinge (61) near an upper part of the stem (0), preferably at a top stem portion (6) of the shank(0) such as illustrated in the operative position in Fig. 4c, and in further mechanical detail in Fig. 1b, Figs. 2b and 2c, and Fig. 3a. The hinge

(61) may have a generally horizontal axle (62) for tilting the plate (22) relative to the shank (0). In this manner the plate may be tilted away from the vertical position after having been dropped into the sediments wherein the shank initially is in the gravity installed vertical position. After rotating the plate (22), the shank extends with some angle out from an opposite, rear face (222) of the main plate (22), as illustrated in Fig. 4c.

[0029] In an embodiment of the invention the hinge (61) is arranged near a centre of said plate (22). The hinge may comprise a short robust axle through massive hinge eyelets arranged on top of the stem near the centre of the plate (22) as shown in Fig. 1b and Fig. 3a.

[0030] In an embodiment of the invention the gravity installed anchor (1), further comprises that said hinge (61) is arranged near a central part of an upper portion of said anchor plate (22). An embodiment of the invention may constitute an intermediate arrangement with the hinge (61) arranged somewhere between the centre of the plate (22) and the central part of the upper portion of the plate (22).

[0031] As illustrated in Figs. 1b, 3a, and also in Fig. 2b, the gravity installed anchor (1) according to the invention may have a recess of generally concave or V-shape (63) for receiving at least an upper part (6) of said shank (0) in said rear face (222) of said plate (22). The recess (63) illustrated in Figs. 1b and 3a may correspond to a ridge (64) on the opposite front face (221) as shown in Fig. 1c.

[0032] The ridge and recess (63, 64) along the main plate (22) increases the main plate's bending stiffness about a horizontal axis through the main plate. This allows increasing the area of the main plate (22) as compared to an allowable area of a plain plate without any such ridge or recess, thus increasing the bearing capacity of the installed anchor. A ridge may also be arranged on the rear face. Further, the recess allows integration of the weight shank during installation in order to reduce the cross-section area of the descending anchor so as for reducing the resistance of the anchor in the drop phase in the water and down through the sediments.

[0033] In an embodiment of the invention illustrated in Figs. 1a, 1b, and 3a the recess (63) or at least the lower portion of the main plate (22) is provided with one or more guide fin or plate (224) extending at right angles to the hinge's (61) axis and parallel to a slot (225) in or along the upper stem portion (6). This slot is for receiving said guide plate (224) so as for stabilising the weight stem and the main plate during the gravity installation process with the fall through the water and the penetration through the sediments, and also for stabilizing the main plate relative to the stem during the subsequent rotation when tightening the bridle lines, please see below. The guide plate (224) may go through the shank as shown or may comprise two guide plates arranged in parallel with a separation equal to the local diameter of the shank such that the shank is not split or weakened in any way.

[0034] In an embodiment of the invention the number

of said connection points (8) is at least two. The connection points (8) are preferably arranged on either sides of the vertical central line of the plate (22), which is said ridge (64) if present, the connection points (8) for being connected to two bridle lines (17a, 17b) of said mooring line (17). This arrangement of at least two bridle lines is for enabling to adjust and stabilize the azimuth of the anchor using the mooring line (17)].

[0035] If the number of said connection points (8) is three, and at least one of the bridle lines is arranged below the tilting point of the plate, the plate may be forced to rotate by tensioning the anchor line such as shown in Fig. 4c. The connection points (8) may in such an embodiment be arranged generally in a triangular pattern about the centre of said plate (22), two of said connection points (8) arranged on either sides of said ridge (64) for being connected to first and second bridle lines (17a, 17b) of said mooring line (17) and a third connection point arranged on said ridge (64) for being connected to a third bridle line (17c) of said mooring line (17).

[0036] The connection points (8) may be formed as one or more of the following:

- eyelets welded to the first, front face;
- holes through which the mooring line passes and is fixed at the rear face;
- slits with through eyelets to the front face, the eyelets attached to the second, rear face. Ways of attaching the mooring line to the plate may be envisaged by the person skilled in the art.

Method according to the invention

[0037] The anchor may be installed as follows:

- An anchor at least comprising a massive, rigid metal plate (22) with an installation connection point (9) for an installation line, preferably near a top edge end, is provided from a surface vessel, please see Fig. 4a.
- An anchor line (17), usually provided with two or more bridle lines (17a, 17b, 17c) is connected in a suitable way to one or more corresponding connection points (8) at a front face (221) of the plate (22).
- An installation line (172) is attached to the installation connection points (9);
- Using said installation line (172), the plate (22) is lowered to a desired elevation (h) above a usually predetermined position (x, y) on the seafloor, such as is the situation in Fig. 4a.
- The plate (22) is then preferably directed in an azimuthal direction transverse to a predetermined line of tension of said anchor line (17), as this operation is necessary if the gravity installed anchor shall be used in a predetermined pattern about a desired mooring position. One may possibly correct the azimuthal direction of the plate (22) to a transverse direction of the anchor line after gravity installation if the sediments allow so.

- The plate (22) is then released from said elevation (h);
- The plate (22) will then drop and penetrate said seafloor due to gravity, and will stop in the situation illustrated in Fig. 4b. The plate will generally now be nearly vertical, aligned with the shank. The installation line may still be connected to the tail of the anchor.
- The anchor line (17) is then put under tension along the above mentioned predetermined line of tension, please see Fig. 4c. The tensioning may be done immediately or completed with the subsequent final step below.
- Finally, an opposite end of said anchor line (17) is connected to a vessel to be moored, or connected to a buoy for being prepared to connect to the vessel, such as a petroleum drilling or production platform, if the vessel to be moored has not yet arrived.

[0038] A floating or subsea marker buoy (173) may be attached to the installation line (172) for being used for retrieving the anchor if desired.

[0039] According to the method of the invention the anchor line (17) is put under tension so as for tilting the plate (22) towards an orthogonal position relative to said anchor line (17), please see Fig. 4c. As mentioned above the anchor line's connection may be arranged with the lower bridle line slightly shorter so as for forcing the anchor to plough deeper into the seabed if its present holding capacity is overcome.

[0040] A fixed shank will, due to a longer vertical extension of the combined stem and plate, require a significantly higher overturning moment than what may be available set up by the anchor line's (17) bridle lines (17a, 17b, 17c). An anchor with no shank (0) or a hinged shank (0) may require a higher moment than what may be available set up by the anchor line's (17) bridle lines (17a, 17b, 17c).

[0041] The above discussed anchor of the invention may be used to make a mooring array of 8 to 12 or more anchors arranged in a pattern about a central predefined mooring location for a marine floating structure such as a drilling platform or petroleum production platform.

Penetrometer

[0042] Having predetermined weights of gravity installed anchors may incur that all anchors are designed according to the heaviest anchor required for an operation. It may be advantageous to vary the mass or the penetration depth or fluke area of an anchor by testing one or more drop locations using a penetrometer model anchor of significantly reduced size. This may advantageously be conducted before determining the type of anchor and its size. A method for installing a gravity installed anchor (1) may thus comprise the following steps:

- providing a penetrometer (100) of reduced dimen-

sions and with similar design and penetration properties as compared to a real size gravity installed anchor;

- lowering said penetrometer to a controlled elevation above the seafloor near a selected anchor installation location;
- releasing said penetrometer to penetrate said seafloor;
- measuring at least a penetration depth of said penetrometer, and preferably providing sediment samples and/or consolidation data;
- if possible, measure retention capacity after having tensioned the anchor line
- configuring a gravity installed anchor according to the measurement above by conducting one or more of the following actions:
 - determining the release drop elevation for an available gravity installed anchor;
 - selecting an anchor between available different gravity installed anchors;
 - designing a gravity installed anchor based on said measurement;
 - ballasting an existing gravity install anchor to higher or lower weight based on said measurement;
 - providing a gravity installed anchor of the so determined design;

[0043] The penetrometer (100) may be measured for its penetration depth and it may also carry instruments for measuring sediment properties such as consolidation and shear resistance, and it may comprise a sediment core sampler. The penetrometer could be dropped and retrieved using the installation line.

[0044] Advantages of using a penetrometer:

- One may prepare each anchor for each desired anchor installation position. Each anchor may thus be prepared or selected to reach a required minimum penetration depth. As the sediment conditions may vary from one position to another, this may save the number of anchors, reduce the required size of each anchor, determine the type of each anchor, determine the drop elevation of each anchor, or the ballast volume of each anchor. The method may also prevent anchors from ending up deeper than required, thus simplifying the tensioning of the anchor line and easing the adaptation of the anchor line [anchor chain] length for each anchor line.

Claims

1. A gravity installed anchor (1) comprising

- a main anchor plate (22) with one or more connection points (8) for extending an anchor line (17) from a front face (221) of said anchor plate (22) and with a rear face (222) opposite to said

- front face (221),
 - an elongated shank (0) connected at hinge (61) to said anchor plate (22) and arranged for extending near vertically and parallel with said anchor plate (22) during gravity installation,
 - **characterised by**
 - said hinge (61) being arranged for allowing rotating said anchor plate (22) away from a vertical plane and said shank (0) after gravity installation,
 - said shank (0) extending downwards from said hinge (61).
2. The gravity installed anchor (1) claim 1, said hinge (61) arranged at a top stem portion (6) of said shank (0).
3. The gravity installed anchor (1) of claim 1 or 2, said hinge (61) having a generally horizontal pivot axis.
4. The gravity installed anchor (1) of any of the preceding claims, a horizontal rotation axle forming said horizontal pivot axis.
5. The gravity installed anchor (1) of any of the preceding claims, further comprising that said hinge (61) is arranged near a centre of said anchor plate (22).
6. The gravity installed anchor (1) of any of the preceding claims, said plate (22) being tapered in its lower portion to a general V-shape.
7. The gravity installed anchor (1) of any of the preceding claims, the number of said connection points (8) being at least two, each said connection points (8) for being connected to corresponding respective bridle lines (17a, 17b, ...) of said mooring line (17).
8. The gravity installed anchor (1) of any of the preceding claims, provided with a recess (63) for receiving said shank (0) in said rear face (222) of said anchor plate (22), said recess (63) corresponding to a ridge (64) on said front face (221).
9. The gravity installed anchor (1) of any of the preceding claims, said anchor plate (22) being provided with one or more guides such as a guide plate (224) extending at right angles to said hinge's (61) axis, said guide plate (224) being parallel to a slot (225) along part of said shank (0), said slot for receiving said guide plate or plates (224).
10. The gravity installed anchor (1) of any of the preceding claims, at least two of said connection points (8) arranged on either sides of a vertical central line on said anchor plate (22).
11. The gravity installed anchor (1) of any of the preceding claims, the number of said connection points (8) being three, said connection points (8) arranged in a triangular pattern about near a centre of said anchor plate (22), one of said connection points (8) arranged near said vertical central line on said anchor plate (22) for being connected to a bridle line (17c) of said mooring line (17)..
12. The gravity installed anchor of any of the preceding claims, provided with an installation connection point (9) for an installation line (172) near a top end of said anchor plate (22).
13. The anchor of any of the preceding claims, said plate (22) being laminated from a number of thinner steel plates.
14. A method for anchoring using a gravity installed anchor (1) **characterized by**
- providing a massive metal plate (22) with a downwards extending stem (0) hinged to said plate (22) and an installation connection point (9) at a top end;
 - connecting an anchor line (17) to one or more connection points (8) at a front face (221) of said plate (22);
 - attaching an installation line (172) to said installation connection point (9);
 - using said installation line (172), lowering said plate (22) to a desired elevation (h) above a predetermined position (x, y) on the seafloor;
 - releasing said plate (22) from said elevation (h);
 - letting said plate (22) drop and penetrate said seafloor due to gravity;
 - tensioning said anchor line (17) along a predetermined line of tension;
 - connecting an opposite end of said anchor line (17) to a vessel to be anchored.
15. The method of claim 14, tensioning said anchor line (17) so as for tilting said plate (22) towards an orthogonal position relative to said anchor line (17).
16. The method of any of claims 14-15, wherein after the step of lowering the plate to a desired elevation (h) above the seafloor,
- directing said plate (22) in an azimuthal direction transverse to said predetermined line of tension of said anchor line (17).
17. A method for installing a gravity installed anchor (1) according to claim 14, comprising
- providing one or more gravity installed anchors (1);

- providing a penetrometer (100) of reduced dimensions and with similar design and penetration properties as said one or more gravity installed anchor;
 - lowering said penetrometer to a controlled elevation above the seafloor near a selected anchor installation location;
 - releasing said penetrometer to penetrate said seafloor;
 - measuring at least a penetration depth of said penetrometer;
 - configuring one of said gravity installed anchor according to the measurement above by one or more of the below actions:
 - determining the release drop elevation for the gravity installed anchor;
 - selecting an anchor between available different gravity installed anchors;
 - designing a gravity installed anchor based on said measurement;
 - ballasting a gravity installed anchor to higher or lower weight based on said measurement.
18. The method according to claim 17, using a sediment sampler in said penetrometer for providing sediment samples.
- Patentansprüche**
1. Durch Schwerkraft installierter Anker (1) umfassend
- eine Hauptankerplatte (22) mit einem oder mehreren Verbindungspunkten (8), um eine Ankerleine (17) von einer Vorderseite (221) der Ankerplatte (22) weg zu erstrecken, und mit einer Rückseite (222) gegenüberliegend der Vorderseite (221),
 - einen länglichen Schaft (0), der an einem Scharnier (61) mit der Ankerplatte (22) verbunden und angeordnet ist, um sich nahezu vertikal und parallel mit der Ankerplatte (22) während der Installation durch Schwerkraft zu erstrecken,
 - **dadurch gekennzeichnet, dass**
 - das Scharnier (61) angeordnet ist, um die Drehung der Ankerplatte (22) weg von einer vertikalen Ebene und dem Schaft (0) nach der Installation durch Schwerkraft zu erlauben,
 - wobei sich der Schaft (0) von dem Scharnier (61) aus nach unten erstreckt.
2. Durch Schwerkraft installierter Anker (1) nach Anspruch 1, wobei das Scharnier (61) an einem oberen Stielabschnitt (6) des Schafts (0) angeordnet ist.
3. Durch Schwerkraft installierter Anker (1) nach Anspruch 1 oder 2, wobei das Scharnier (61) eine allgemein horizontale Schwenkachse aufweist.
4. Durch Schwerkraft installierter Anker (1) nach einem der vorhergehenden Ansprüche, wobei eine horizontale Drehachse die horizontale Schwenkachse bildet.
5. Durch Schwerkraft installierter Anker (1) nach einem der vorhergehenden Ansprüche, des Weiteren umfassend, dass das Scharnier (61) nahe einer Mitte der Ankerplatte (22) angeordnet ist.
6. Durch Schwerkraft installierter Anker (1) nach einem der vorhergehenden Ansprüche, wobei die Platte (22) in ihrem unteren Abschnitt auf eine allgemeine V-Form verjüngt ist.
7. Durch Schwerkraft installierter Anker (1) nach einem der vorhergehenden Ansprüche, wobei die Anzahl der Verbindungspunkte (8) zumindest zwei beträgt, wobei jeder der Verbindungspunkte (8) dazu dient, mit jeweiligen entsprechenden Waageleinen (17a, 17b, ...) der Mooringleine (17) verbunden zu werden.
8. Durch Schwerkraft installierter Anker (1) nach einem der vorhergehenden Ansprüche, der mit einer Ausnehmung (63) zur Aufnahme des Schafts (0) in der Rückseite (222) der Ankerplatte (22) versehen ist, wobei die Ausnehmung (63) einem Wulst (64) an der Vorderseite (221) entspricht.
9. Durch Schwerkraft installierter Anker (1) nach einem der vorhergehenden Ansprüche, wobei die Ankerplatte (22) mit einer oder mehreren Führungen wie etwa einer Führungsplatte (224) versehen ist, die sich in einem rechten Winkel zu der Achse des Scharniers (61) erstreckt, wobei die Führungsplatte (224) parallel zu einem Schlitz (225) entlang eines Teils des Schafts (0) ist, wobei der Schlitz zur Aufnahme der Führungsplatte oder -platten (224) dient.
10. Durch Schwerkraft installierter Anker (1) nach einem der vorhergehenden Ansprüche, wobei zumindest zwei der Verbindungspunkte (8) auf beiden Seiten einer vertikalen Mittellinie auf der Ankerplatte (22) angeordnet sind.
11. Durch Schwerkraft installierter Anker (1) nach einem der vorhergehenden Ansprüche, wobei die Anzahl der Verbindungspunkte (8) drei beträgt, wobei die Verbindungspunkte (8) in einem dreieckigen Muster in etwa nahe einer Mitte der Ankerplatte (22) angeordnet sind, wobei einer der Verbindungspunkte (8) nahe der vertikalen Mittellinie auf der Ankerplatte (22) angeordnet ist, um mit einer Waageleine (17c) der Mooringleine (17) verbunden zu werden.
12. Durch Schwerkraft installierter Anker nach einem

der vorhergehenden Ansprüche, der mit einem Installationsverbindungs-
punkt (9) für eine Installationsleine (172) nahe einem oberen Ende der Anker-
platte (22) verbunden ist

13. Anker nach einem der vorhergehenden Ansprüche, wobei die Platte (22) aus einer Anzahl von dünneren Stahlplatten laminiert ist.

14. Verfahren zur Verankerung unter Verwendung eines durch Schwerkraft installierten Ankers (1), **gekennzeichnet durch**

- Bereitstellen einer massiven Metallplatte (22) mit einem sich nach unten erstreckenden Schaft (0), der an die Platte (22) angelenkt ist, und einem Installationsverbindungs-
punkt (9) an einem oberen Ende;
- Verbinden einer Ankerleine (17) mit einem oder mehreren Verbindungspunkten (8) an einer Vorderseite (221) der Platte (22);
- Befestigen einer Installationsleine (172) an dem Installationsverbindungs-
punkt (9);
- Absenken der Platte (22) unter Verwendung der Installationsleine (172) auf eine gewünschte Höhe (h) über einer vorbestimmten Position (x, y) auf dem Meeresboden;
- Freigeben der Platte (22) von der gewünschten Höhe (h);
- Fallenlassen der Platte (22) und Eindringen-
lassen in den Meeresboden auf Grund der Schwerkraft;
- Spannen der Ankerleine (17) entlang einer vorbestimmten Spannungslinie;
- Verbinden eines gegenüberliegenden Endes der Ankerleine (17) mit einem Schiff, das auf Anker gelegt werden soll.

15. Verfahren nach Anspruch 14, wobei die Ankerleine (17) gespannt wird, um die Platte (22) in eine rechtwinkelige Stellung relativ zu der Ankerleine (17) zu kippen.

16. Verfahren nach einem der Ansprüche 14 bis 15, wobei nach dem Schritt des Absenkens der Platte in eine gewünschte Höhe (h) über dem Meeresboden,

- die Platte (22) in einer azimuthalen Richtung quer zu der vorbestimmten Spannungslinie der Ankerleine (17) geführt wird.

17. Verfahren zum Installieren eines durch Schwerkraft installierten Ankers (1) nach Anspruch 14, umfassend die folgenden Schritte:

- Bereitstellen eines oder mehrerer durch Schwerkraft installierter Anker (1);
- Bereitstellen eines Penetrometers (100) mit

verringerten Abmessungen und mit ähnlichem Aufbau und ähnlichen Penetrationseigenschaften wie der eine oder die mehreren durch Schwerkraft installierten Anker;

- Absenken des Penetrometers auf eine gesteuerte Höhe über dem Meeresboden nahe einer ausgewählten Ankerinstallationsposition;
- Freigeben des Penetrometers, um in den Meeresboden einzudringen;
- Messen zumindest einer Eindringtiefe des Penetrometers;
- Konfigurieren eines durch Schwerkraft installierten Ankers in Übereinstimmung mit der obigen Messung durch eine oder mehrere der folgenden Maßnahmen:

- Bestimmen der Freigabefallhöhe für den durch Schwerkraft installierten Anker;
- Auswählen eines Ankers aus verfügbaren unterschiedlichen durch Schwerkraft installierten Ankern;
- Konstruieren des durch Schwerkraft installierten Ankers auf der Grundlage der Messung;
- Ballastieren des durch Schwerkraft installierten Ankers auf ein höheres oder niedrigeres Gewicht auf der Grundlage der Messung.

18. Verfahren nach Anspruch 17, wobei eine Sediment-Probenahmeeinrichtung in dem Penetrometer verwendet wird, um Sedimentproben bereitzustellen.

Revendications

1. Ancre installée par gravité (1) comprenant

- une plaque d'ancrage principale (22) avec un ou plusieurs point (s) de raccordement (8) pour étendre une ligne d'ancrage (17) à partir d'une face avant (221) de ladite plaque d'ancrage (22) et avec une face arrière (222) opposée à ladite face avant (221),
- un arbre allongé (0) raccordé au niveau d'une charnière (61) à ladite plaque d'ancrage (22) et agencé pour s'étendre presque verticalement et parallèlement à ladite plaque d'ancrage (22) au cours de l'installation par gravité,
- **caractérisée par**
- ladite charnière (61) étant agencée pour permettre la rotation de ladite plaque d'ancrage (22) à l'écart d'un plan vertical et dudit arbre (0) après l'installation par gravité,
- ledit arbre (0) s'étendant vers le bas à partir de ladite charnière (61).

2. Ancre installée par gravité (1) de la revendication 1,

ladite charnière (61) étant agencée au niveau d'une partie de tige supérieure (6) dudit arbre (0).

3. Ancre installée par gravité (1) de la revendication 1 ou 2, ladite charnière (61) ayant un axe de pivotement globalement horizontal. 5
4. Ancre installée par gravité (1) de l'une des revendications précédentes, comprenant un essieu de rotation horizontal formant ledit axe de pivotement horizontal. 10
5. Ancre installée par gravité (1) de l'une des revendications précédentes, comprenant en outre que ladite charnière (61) est agencée à proximité d'un centre de ladite plaque d'ancrage (22). 15
6. Ancre installée par gravité (1) de l'une des revendications précédentes, ladite plaque (22) étant effilée dans sa partie inférieure en une forme globale en V. 20
7. Ancre installée par gravité (1) de l'une des revendications précédentes, le nombre desdits points de raccordement (8) étant au moins deux, chacun desdits points de raccordement (8) étant destiné à être raccordé à des lignes de bride respectives correspondantes (17a, 17b, ...) de ladite ligne d'amarrage (17). 25
8. Ancre installée par gravité (1) de l'une des revendications précédentes, pourvue d'un évidement (63) pour recevoir ledit arbre (0) dans ladite face arrière (222) de ladite plaque d'ancrage (22), ledit évidement (63) correspondant à une arête (64) sur ladite face avant (221). 30
35
9. Ancre installée par gravité (1) de l'une des revendications précédentes, ladite plaque d'ancrage (22) étant pourvue d'un ou de plusieurs guide(s) tel(s) qu'une plaque de guidage (224) s'étendant à angle droit vers l'axe de ladite charnière (61), ladite plaque de guidage (224) étant parallèle à une fente (225) le long d'une partie dudit arbre (0), ladite fente étant destinée à recevoir ladite plaque ou lesdites plaques de guidage (224). 40
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10. Ancre installée par gravité (1) de l'une des revendications précédentes, au moins deux desdits points de raccordement (8) étant agencés de part et d'autre d'une ligne centrale verticale sur ladite plaque d'ancrage (22). 50
11. Ancre installée par gravité (1) de l'une des revendications précédentes, le nombre desdits points de raccordement (8) étant trois, lesdits points de raccordement (8) étant agencés selon un motif triangulaire autour d'un centre de ladite plaque d'ancrage (22), l'un desdits points de raccordement (8) étant 55

agencé à proximité de ladite ligne centrale verticale sur ladite plaque d'ancrage (22) pour être raccordé à une ligne de bride (17c) de ladite ligne d'amarrage (17).

12. Ancre installée par gravité de l'une des revendications précédentes, pourvue d'un point de raccordement d'installation (9) pour une ligne d'installation (172) à proximité d'une extrémité supérieure de ladite plaque d'ancrage (22).
13. Ancre de l'une des revendications précédentes, ladite plaque (22) étant stratifiée à partir d'un certain nombre de plaques d'acier plus fines.
14. Procédé d'ancrage utilisant une ancre installée par gravité (1), **caractérisé par le fait**
 - de fournir une plaque métallique massive (22) avec une tige s'étendant vers le bas (0) articulée à ladite plaque (22) et un point de raccordement d'installation (9) au niveau d'une extrémité supérieure ;
 - de raccorder une ligne d'ancrage (17) à un ou à plusieurs point(s) de raccordement (8) au niveau d'une face avant (221) de ladite plaque (22) ;
 - de fixer une ligne d'installation (172) audit point de raccordement d'installation (9) ;
 - d'abaisser, en utilisant ladite ligne d'installation (172), ladite plaque (22) jusqu'à une hauteur souhaitée (h) au-dessus d'une position prédéterminée (x, y) sur le fond marin ;
 - de libérer ladite plaque (22) de ladite hauteur (h) ;
 - de laisser ladite plaque (22) chuter et pénétrer dans ledit fond marin sous l'effet de la gravité ;
 - de tendre ladite ligne d'ancrage (17) le long d'une ligne prédéterminée de tension ;
 - de raccorder une extrémité opposée de ladite ligne d'ancrage (17) à un navire à ancrer.
15. Procédé de la revendication 14, comprenant le fait de tendre ladite ligne d'ancrage (17) de manière à incliner ladite plaque (22) vers une position orthogonale par rapport à ladite ligne d'ancrage (17).
16. Procédé de l'une des revendications 14 et 15, dans lequel, après l'étape d'abaissement de la plaque jusqu'à une hauteur souhaitée (h) au-dessus du fond marin, comprenant le fait
 - de diriger ladite plaque (22) dans une direction azimutale transversale à ladite ligne prédéterminée de tension de ladite ligne d'ancrage (17).
17. Procédé d'installation d'une ancre installée par gravité (1) selon la revendication 14,

comprenant le fait

- de fournir une ou plusieurs ancre(s) installée(s) par gravité (1) ;
 - de fournir un pénétromètre (100) de dimensions réduites et avec des propriétés de conception et de pénétration similaires à ladite ou auxdites plusieurs ancre(s) installée(s) par gravité ;
 - d'abaisser ledit pénétromètre jusqu'à une hauteur commandée au-dessus du fond marin à proximité d'un emplacement d'installation d'ancre sélectionnée ;
 - de libérer ledit pénétromètre pour pénétrer dans ledit fond marin ;
 - de mesurer au moins une profondeur de pénétration dudit pénétromètre ;
 - de configurer l'une desdites ancres installées par gravité en fonction de la mesure ci-dessus par une ou plusieurs des actions ci-dessous qui consistent :
 - à déterminer la hauteur de chute par libération pour l'ancre installée par gravité ;
 - à sélectionner une ancre parmi différentes ancres installées par gravité disponibles ;
 - à concevoir une ancre installée par gravité sur la base de ladite mesure ;
 - à ballaster une ancre installée par gravité jusqu'à un poids supérieur ou inférieur en fonction de ladite mesure.
- 18.** Procédé selon la revendication 17, utilisant un dispositif d'échantillonnage de sédiments dans ledit pénétromètre pour fournir des échantillons de sédiments.

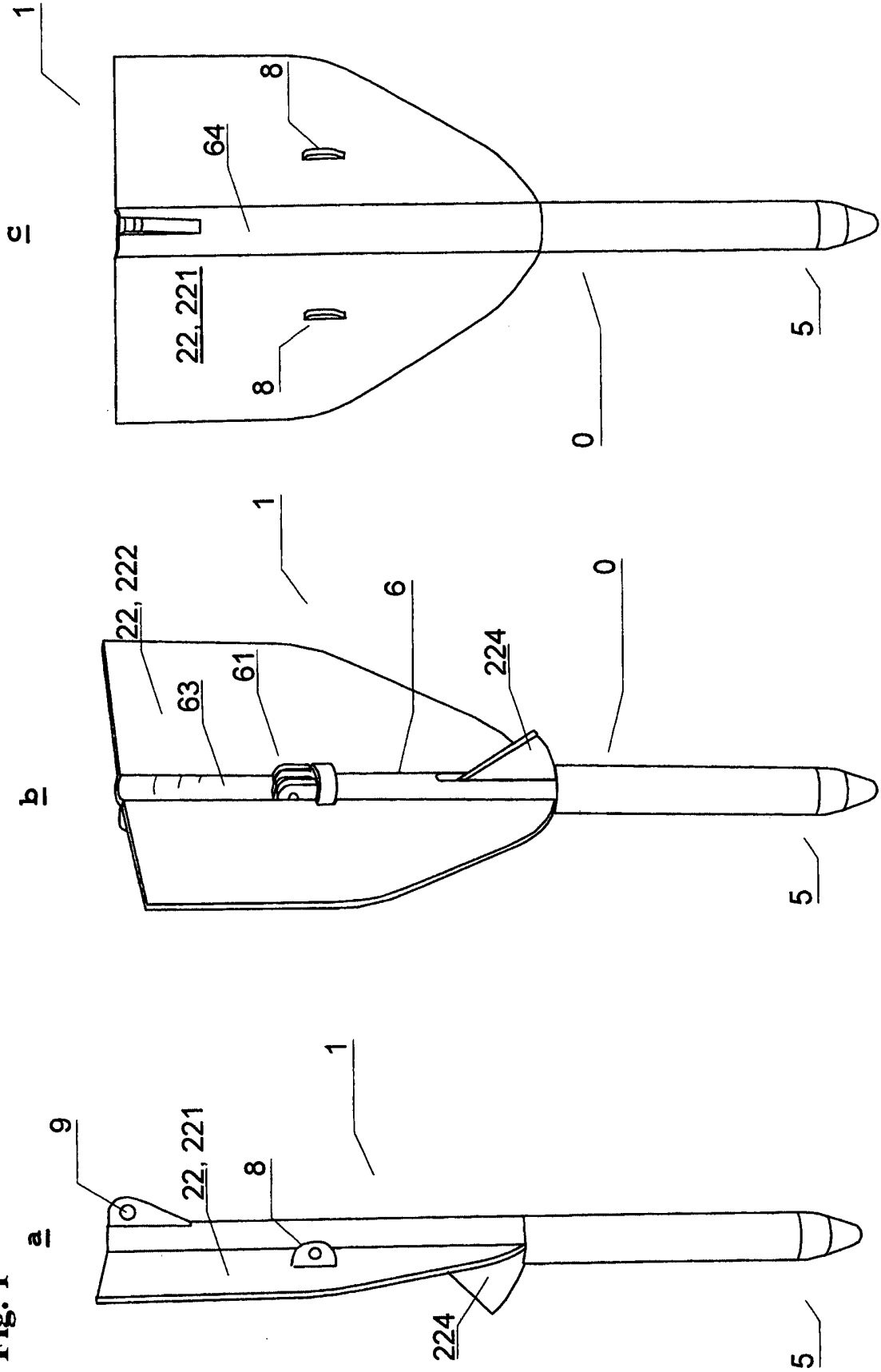
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Fig. 1



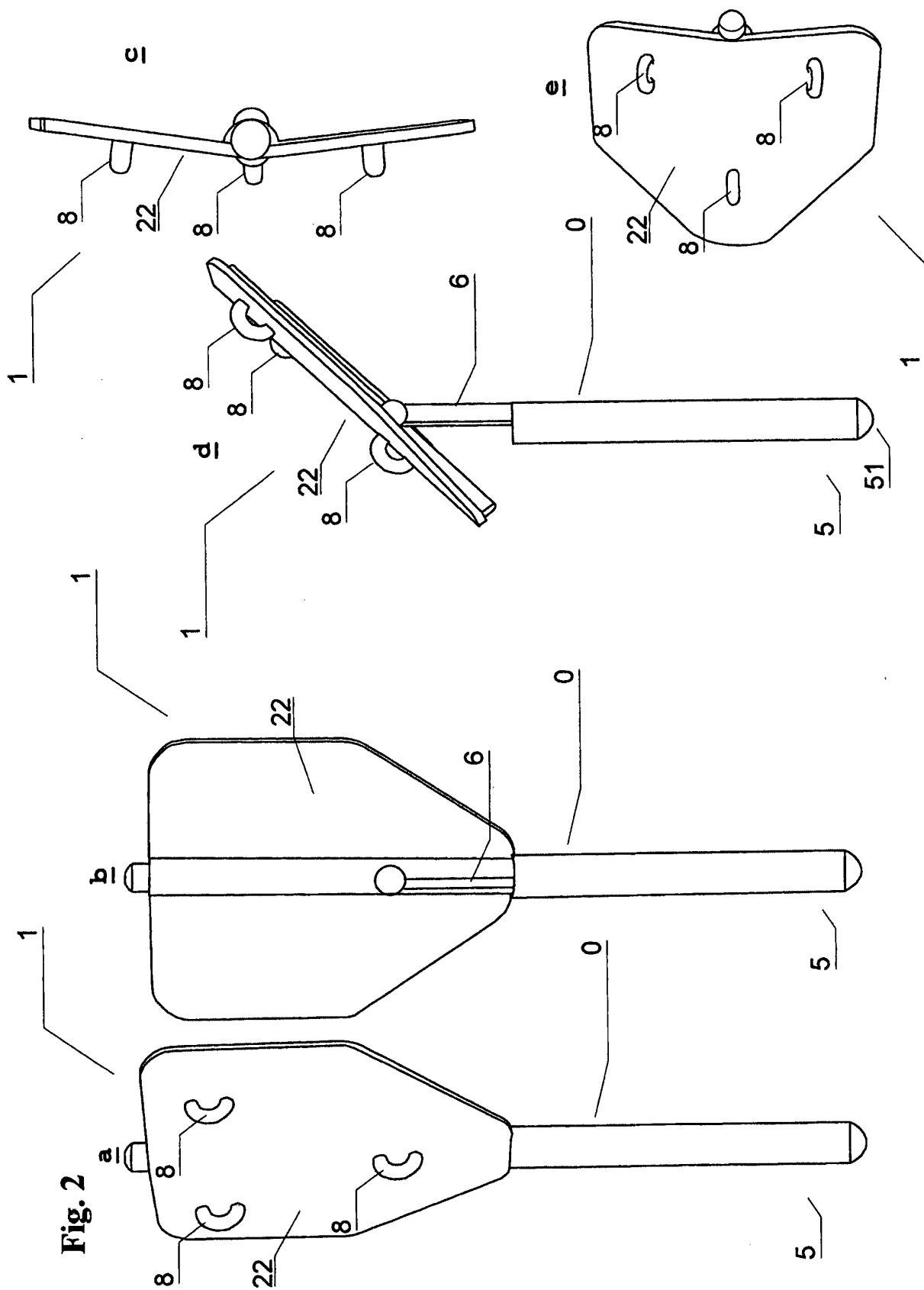
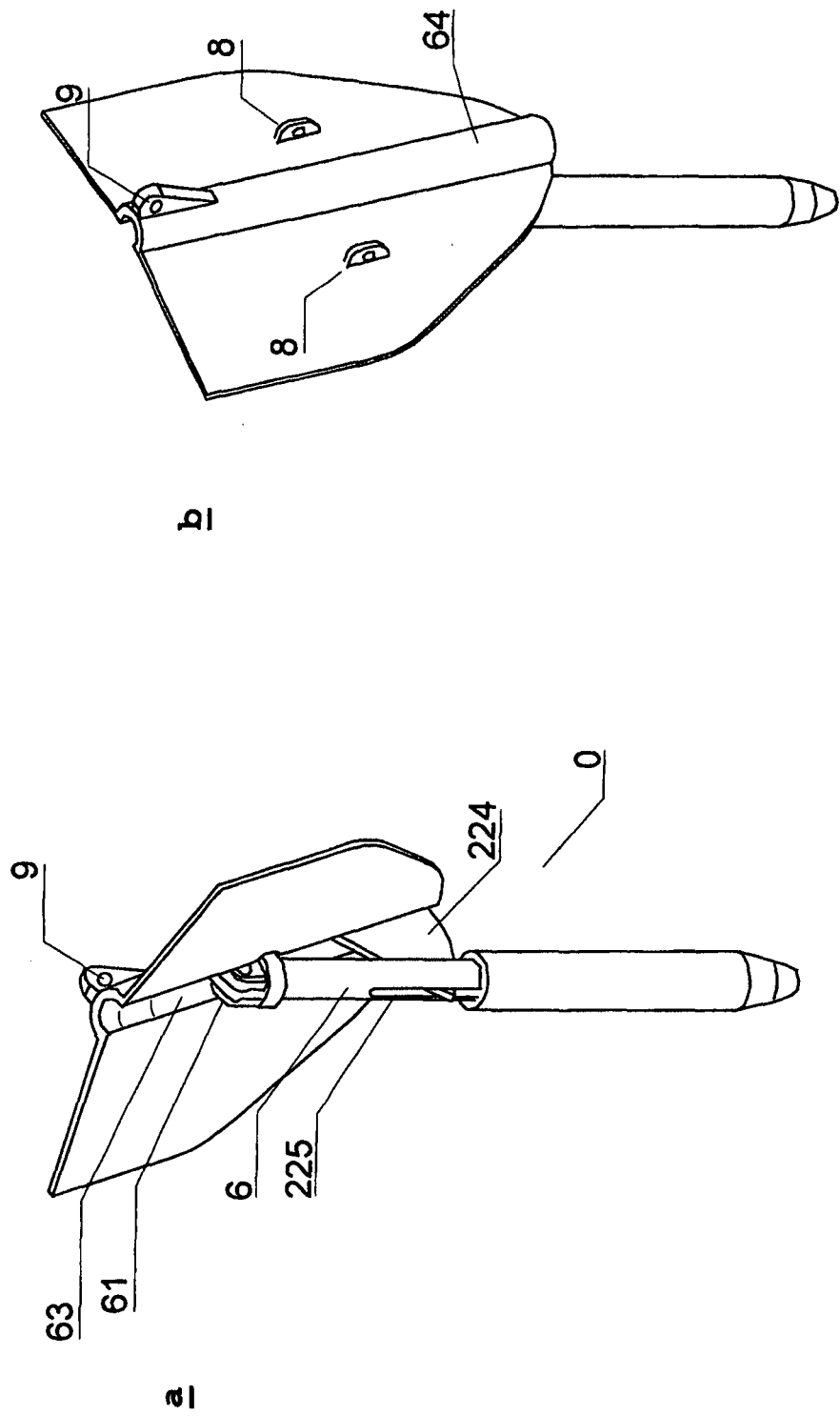
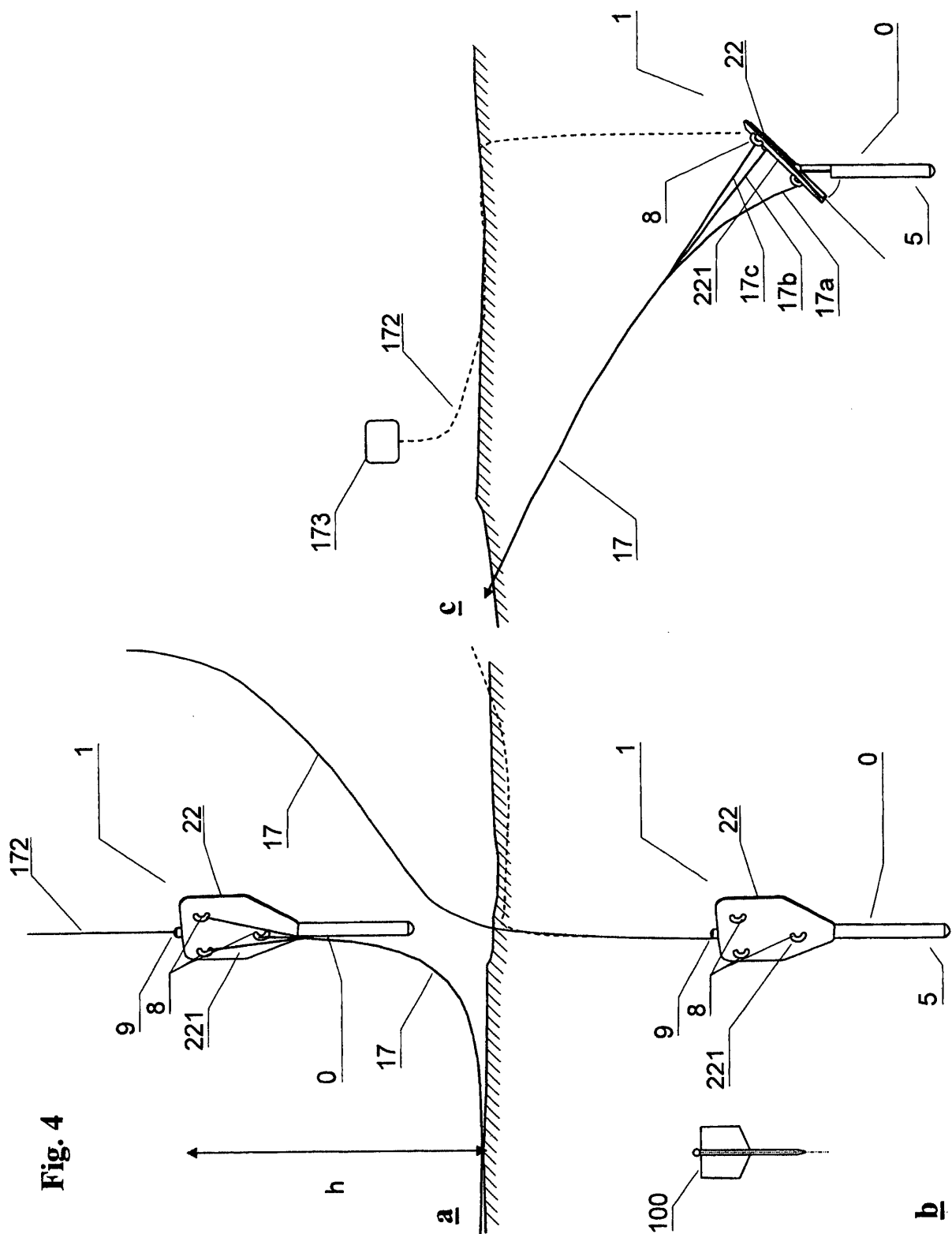


Fig. 3





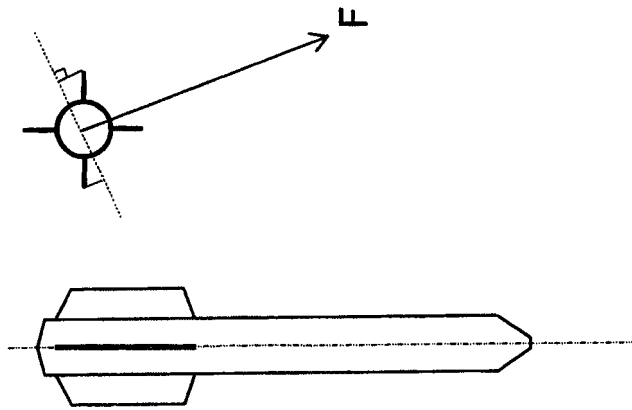


Fig. 5
(background art)

REFERENCES CITED IN THE DESCRIPTION

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