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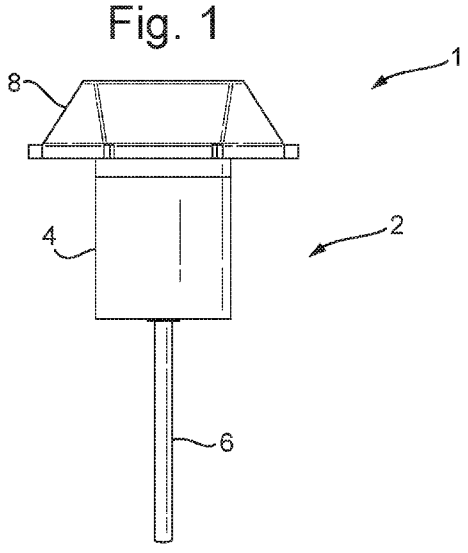
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(54) **Title**: SUBSEA FOUNDATION



(57) **Abstract**: A method of installing a subsea foundation is provided. The method comprises: providing a suction anchor, the suction anchor comprising an inner member, which may be a pipe for a well, and an outer suction skirt located around the inner member, wherein the inner member protrudes from the outer suction skirt, wherein the step of providing the suction anchor comprises attaching at least the portion of the inner member which protrudes from the outer suction skirt at the installation site; moving the suction anchor towards a seabed so the inner member penetrates the seabed before the outer suction skirt; further moving the suction anchor towards the seabed until the outer suction skirt reaches the seabed; and sucking the suction anchor into the sea bed. A subsea foundation is also provided. The foundation comprises a suction anchor, the suction anchor comprising an inner member, which may be a pipe for a well, and an outer suction skirt located around the inner member, wherein the inner member protrudes from the outer suction skirt.

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SUBSEA FOUNDATION

The invention relates to a subsea foundation which comprises a suction anchor and a method for installing the subsea foundation.

Many subsea devices, such as a well and wellhead equipment, require a foundation on which they can be located during use. For example, a subsea well assembly will generally comprise a foundation. The foundation is used to support the subsea well which extends into the seabed and the wellhead equipment such as a blowout preventer. A known type of subsea foundation is the suction anchor. A suction anchor used as a subsea foundation comprises a skirt. The suction anchor is lowered onto the seabed and then sucked into the seabed by reducing the pressure inside the skirt. Once the suction anchor has been sucked into the sea bed, a well may extend through the suction anchor into the sea bed or the suction anchor may provide a foundation for another subsea device.

It has been found that with a suction anchor foundation, the foundation may not always be at the correct orientation, e.g. the top surface may not be horizontal (relative to the seabed). Problems have also been known to arise with the seabed under the suction anchor being eroded/washed away, particularly when the foundation is used for a well. This may be known as washout.

There is therefore a desire for an alternative and/or improved subsea foundation which comprises a suction anchor.

In a broad aspect the present invention provides a subsea foundation, the foundation comprising: a suction anchor, the suction anchor comprising an inner member and an outer suction skirt located around/about the inner member, wherein the inner member protrudes from the outer suction skirt.

In a first aspect the present invention may provide a subsea foundation, the foundation comprising: a suction anchor, the suction anchor comprising an inner member and an outer suction skirt located around the inner member, wherein the inner member protrudes from the outer suction skirt, wherein the inner member comprises an upper inner member portion and a lower inner member portion, and wherein the upper inner member portion does not protrude from the outer suction skirt.

The subsea foundation may be a subsea well foundation.

The inner member may be a pipe for a well.

The well as referred to in the present specification may be an oil and/or gas well.

Thus, the present invention may provide, a subsea well foundation, the foundation comprising: a suction anchor, the suction anchor comprising an inner pipe for a well and an outer suction skirt located around/about the inner pipe, wherein the inner pipe protrudes from the outer suction skirt.

The inner member may comprise an upper inner member portion and a lower inner member portion, and the upper inner member portion may not protrude from the outer suction skirt.

The lower inner member portion (i.e. the portion of the inner member that protrudes from the outer suction skirt may been attached at the installation site. In another broadaspect, the present invention provides a method of installing a subsea foundation, the method comprising: providing a suction anchor, the suction anchor comprising an inner member and an outer suction skirt located around the inner member, wherein the inner member protrudes from the outer suction skirt; moving the suction anchor towards a seabed so the inner member penetrates the seabed before the outer suction skirt; further moving the suction anchor towards the seabed until the outer suction skirt reaches the seabed; and sucking the suction anchor into the sea bed.

In a second aspect the present invention provides a method of installing a subsea foundation, the method comprising: providing a suction anchor, the suction anchor comprising an inner member and an outer suction skirt located around the inner member, wherein the inner member protrudes from the outer suction skirt, wherein the step of providing the suction anchor comprises attaching at least the portion of the inner member which protrudes from the outer suction skirt at the installation site; moving the suction anchor towards a seabed so the inner member penetrates the seabed before the outer suction skirt; further moving the suction anchor towards the seabed until the outer suction skirt reaches the seabed; and sucking the suction anchor into the sea bed.

The subsea foundation may be a subsea well foundation.

The inner member may be a pipe for a well.

Thus, the present invention may provide a method of installing a subsea well foundation, the method comprising: providing a suction anchor, the suction anchor comprising an inner pipe for a well and an outer suction skirt located around the inner pipe, wherein the inner pipe protrudes from the outer suction skirt; moving

the suction anchor towards a seabed so the inner pipe penetrates the seabed before the outer suction skirt; further moving the suction anchor towards the seabed until the outer suction skirt reaches the seabed; and sucking the suction anchor into the sea bed. The method may comprise providing the suction anchor/subsea foundation of the first aspect. The following optional features and discussion may apply to all of the above aspects of the invention.

It has been found that by having a suction anchor wherein the inner member protrudes from the outer suction skirt, when the foundation is being installed the inner member may reach and penetrate the seabed before the outer suction skirt reaches the seabed. This means that the inner member may provide guidance (e.g. vertical guidance) for the subsea foundation as the suction anchor is sucked into the sea bed. For example, the orientation of the foundation may be adjusted to a desired orientation and then the inner member may be used to help maintain the foundation in that orientation until the outer suction skirt reaches the seabed and/or whilst the suction anchor is sucked into the sea bed.

The orientation/verticality of the suction anchor may be checked and/or adjusted before the outer suction skirt starts to penetrate the seabed. This means that it is possible to reliably provide a foundation which is at a desired orientation relative to the sea bed, such as horizontal, substantially horizontal, or horizontal within an acceptable limit. In this case, the inner member (which may be a pipe for a well) may be vertical, substantially vertical or vertical within an acceptable limit, such as up to 1, 1.2, 1.5 or 2 from vertical to be formed.

The inner member may be perpendicular to the top surface of the suction anchor which may in use provide a support surface for a subsea device.

The suction anchor may provide a foundation for a subsea device. The subsea device may be a subsea well and optionally the associated wellhead equipment. The subsea device may for example be any known subsea device such as a pump station, a separator, a compressor, a manifold, a control centre, a smart manifold, a control hub, power/hydraulic power unit, power equipment, gas compressor module and/or cooler.

The inner member may be a solid body such as a rod.

The inner member may be an elongate (i.e. its length may be significantly more than the width) member.

The inner member may be a hollow body such as a pipe. It may be advantageous for the inner member to be a hollow body as this may allow the inner member to have less resistance to penetrating the seabed.

The inner member may have a cross section which is substantially constant along its length. Alternatively, the inner member may have a cross section which is not constant along the length. For example, the inner member may have a smaller cross-sectional area at or towards the bottom (i.e. the end that will penetrate the seabed first) compared to that at or towards the top of the inner member.

The inner member may have a circular cross section or the inner member may have a non-circular cross-section.

When the inner member is a pipe (i.e. a hollow body), it may have an inner diameter which is not constant along its length. For example, the inner diameter may decrease towards the bottom of the inner member. The inner member may have an inner diameter which is larger at or towards the top of the suction anchor compared to the bottom of the suction anchor. Alternatively the inner diameter may decrease and increase along its length.

Additionally, if the inner member is hollow, such as a pipe, it may be possible to apply suction to the inner member so that a suction force can be created. The method may comprise reducing the pressure inside the inner member. This may be before or after the outer suction skirt has reached the seabed. This may reduce penetration resistance on the inner member (due to the effect it has on the material on the seabed) and/or may give additional force to cause penetration of the inner member. Thus, suction may be applied to the inside of the inner member so as to suck the suction anchor, at least in part, into the sea bed.

The suction anchor may include one or more internal stiffeners which connect the inner member to the outer suction skirt. In the case of a plurality of stiffeners these may be spaced circumferentially, such as by equal angles, around the inner member.

The stiffener(s) may be plates which extend in a plane parallel to the axis of the suction anchor. This is so the resistance of the stiffener(s) to penetration of the suction anchor into the seabed is minimised.

The stiffener(s) or at least a portion of the stiffener(s) may be located at or towards the bottom of the suction skirt.

Additionally or alternatively, the stiffener(s) or at least a portion of the stiffener(s) may be located at or towards the top of the suction skirt. For example the stiffener(s) may be underneath, such as directly underneath and/or in contact with, the top horizontal annular plate (that for example may be the plate that connected the suction skirt to the inner pipe) of the suction anchor. These stiffener(s) may be used to support the top annular plate of the suction anchor.

The stiffener(s) may be used to ensure that the orientation of the outer suction skirt is fixed relative to the orientation of the inner member.

Vertical may be the direction which is parallel to the direction of gravity. Vertical may be the direction which is perpendicular to the plane of the sea bed.

By "the inner member protrudes from the outer suction skirt" it may be meant that the inner member extends beyond the bottom of the outer suction skirt. The bottom may be the portion of the suction anchor/skirt which penetrates the seabed first during installation. The inner member may protrude from the top of the suction anchor in addition to protruding from the bottom of the suction anchor.

The top of the suction anchor may be the part, when the suction anchor is in use/installed on the seabed, closest to the surface of the water. The top of the suction anchor, or a component such as a steel beam platform on the top of the suction anchor, may be the part which supports the subsea device.

It may only be a portion of the inner member, e.g. a bottom portion of the inner member, which protrudes from the outer suction skirt.

The inner member may comprise an upper inner member portion and a lower inner member portion. When the inner member is a pipe, the upper inner member portion and the lower inner member portion may each be pipe portions. These two portions may be separate member portions. In use (e.g. as the suction anchor is sucked into the seabed and after it is sucked into the seabed), the two inner member portions may be rigidly connected to each other. This is so that the lower inner member portion may be rigidly fixed relative to the outer suction skirt.

The suction anchor may comprise an upper inner member portion which does not protrude from the bottom of the outer suction skirt. For example, the upper inner member portion may be the same length or shorter than the length of the outer suction skirt portion. The upper inner member portion may be integral with the outer suction skirt. The upper inner member portion may be directly

connected to the outer suction skirt by the connection portion (e.g. top plate of the suction anchor).

These two separate member portions may be joined together when the components are at the installation site. This for example may be subsea or not subsea but above where the suction anchor will be lowered down towards the sea bed. This may be before the outer suction skirt penetrates the seabed. It may be the lower inner member portion which protrudes from the outer suction skirt.

The connection between the lower inner member portion and the upper inner member portion may be at/about the bottom of the skirt (i.e. at or near the skirt opening). The upper member may be the same length as the suction skirt. Alternatively, the upper inner member, may be shorter than the outer suction skirt. However, the upper inner member may extend at least 05, or at least 0.75 or more of the length of the suction skirt. The connection between the lower inner member portion and the upper inner member portion may be within the length of the outer suction skirt.

By attaching at least the portion of the inner member that protrudes from the outer suction skirt at the installation site and/or the inner member being made of two parts, may facilitate transportation. This is because the suction anchor can be more easily transported (for example the suction anchors may be more easily stacked) to the installation site (such as on a vessel) without risk of damaging the inner member as there is no protruding part (e.g. because at least the protruding part of the inner member is installed later and if there is any protruding part this is within and may be protected by the outer suction skirt). However, at least the protruding part (e.g. lower inner member) may be attached at the installation site (once the difficulties with transporting a suction anchor with a protruding pipe are no longer in issue) to provide the discussed advantages of having a suction anchor with a protruding inner pipe.

By the inner member being the same length or nearly as long as the suction skirt (such as at least 0.5 of its length) this may make the joining of the upper and lower inner members easier as it is closer to the open end of the suction skirt where joining operations can be more easily performed.

The method may comprise attaching at least the portion of the inner member which protrudes from the outer suction skirt at the installation site. This may be subsea.

The inner member may provide an opening or channel through the suction anchor through which a well can be formed.

The inner member may be longer than the outer suction skirt.

The length of the inner member that protrudes from the outer suction skirt may be 0.1 to 5, or 1 to 5 times the diameter of the outer skirt.

The total length of the inner member (i.e. the length of both the protruding portion and the portion within the length of the skirt) may be 1.1 to 10 times the diameter of the outer skirt.

The outer suction skirt may have a diameter that is 3 to 8 meters.

The outer suction skirt height/length may be 1 to 5 times the diameter of the outer suction skirt.

The inner member may have a diameter which is between 26 and 60 inches. For example, when the inner member is a pipe for a well, the inner diameter of the inner member may be 26 to 42 inches.

The inner member may be a pipe with an inner diameter which is 50 to 60 inches. The inner member may have an inner diameter which is 50 to 60 inches for example when the inner member is for a well.

The inner member may be a pipe with an inner diameter which is 20 to 60.

The length of the inner member and/or outer skirt may depend on the geology of the installation site.

For example, the length of the inner member may be the same as the depth at which harder soil is located in the sea bed. This, for example in the case that the suction anchor is for a well, is to ensure that the inner member extends through the softer surface material so as to try to prevent washout during drilling.

The geology of the installation site may be determined before installation by a site survey and/or soil sampling.

The length of the portion of the inner member which protrudes from the outer suction skirt may depend on the geology of the installation site. This is because the length may be chosen to ensure that the at least a portion of the suction skirt will penetrate the sea bed under the weight of the suction anchor before friction prevents the suction anchor penetrating any further under action of its own weight. Thus the method may comprise selecting a length of the inner member based on the geology of the installation site.

The length is the dimension in the axial direction (i.e. the direction which in use may be approximately vertical).

The inner member may be coaxial with the outer suction skirt. The outer suction skirt may be located about the inner member. The outer suction skirt and the inner member may be concentric.

The volume between the inner member and the outer suction skirt may be the volume in which the pressure is reduced to allow the suction anchor to be sucked into the sea bed. This may be sealed at the top by a top annular plate of the suction anchor.

The inner member may be connected to the outer suction skirt in a pressure tight manner (e.g. via an annular plate). This is so that the pressure in the volume between the outer suction skirt and the inner member can be controlled.

The suction anchor may comprise a device, such as a pump, for reducing pressure inside the volume (for providing the suction force).

When the inner member is a hollow body, the suction anchor may comprise a device, such as a pump, for reducing pressure inside the inner member.

The inner member and outer suction skirt may be attached/connected to each other. This connection may be a rigid and/or structural connection.

The connection between the inner member and outer suction skirt may be such that the relative orientations of the inner member and outer suction skirt are fixed relative to each other. This means that if the inner member is maintained in a certain orientation relative to the seabed the outer suction skirt may also be maintained in a fixed orientation relative to the seabed. This may allow the orientation of the outer suction skirt relative to the seabed to be controlled/fixed during installation using the inner member.

For example, the outer suction skirt and the inner member may be connected by a connection portion (e.g. top annular plate of the suction anchor). The outer skirt, inner member and connection portion may together form the volume in which the pressure is reduced to allow the suction anchor to be sucked into the ground. The volume may be an annular volume around the outside of the inner member.

The connection portion may be an annular plate. The connection portion may extend between the top of the inner member and the top of the outer suction skirt.

In use a well may extend through the inner member.

In the case that the inner member is an inner pipe for a well, the inner member may replace the function of a conductor pipe. Therefore, a subsea well

which comprises the subsea (well) foundation may not comprise a conductor. Instead the inner member may act as a conductor.

The inner member may be integral with the outer suction skirt. For example, the inner member and the outer suction skirt may be a single piece. This single piece may have been formed by welding components together.

Alternatively, the inner member, or at least part of the inner member, may be a separate piece of the subsea foundation.

The upper inner member may be referred to as a centre member and/or the lower inner member portion may be referred to as an extender.

The inner member may be referred to as a guide member or guide pipe or as a centraliser. This is because the inner member may be used to guide the outer suction skirt so that it can be sucked into the sea bed in a desired orientation.

The inner member may be for guiding the suction anchor into the sea bed in a certain orientation.

The upper end of the inner member (e.g. upper end of the upper inner member portion) may be attached to the outer suction skirt at or near the top of the outer suction skirt.

The suction anchor may be arranged so that the inner member, or at least a portion of the inner member, such as the lower inner member portion, can be attached (directly or indirectly, such as via a connection portion or another portion of the inner member such as the upper inner member portion) to the outer suction skirt when the suction anchor is subsea.

The length of the lower inner member portion/the length the inner member protrudes from the outer suction skirt, may be chosen based on the geology of the installation site. This is to ensure that the suction anchor will penetrate the sea bed sufficiently under its own weight to allow the suction anchor to be sucked in by the final action of reducing the pressure inside the suction anchor.

The suction anchor and upper inner member portion (if present) may be the same length irrespective of the installation site geology (or it may be the same for many different geologies) but the length of the lower inner member portion may be selected accordingly.

The step of providing the suction anchor may comprise providing the inner member, or a portion of the inner member such as the lower inner member portion. The method may comprise the step of locating the inner member, or a portion of the inner member such as the lower inner member portion, at the installation site, e.g.

subsea. For example, the inner member, or a portion of the inner member such as the lower inner member portion may be located on the sea bed. The method may comprise providing the outer suction skirt. The method may comprise deploying the outer suction skirt subsea. This may be after the portion of the inner member, or the inner member has been deployed subsea.

The method may comprise attaching and/or securing the inner member, or a portion of the inner member such as the lower inner member portion, to the outer suction skirt when both components are subsea.

The method may comprise directing a guide, such as a wire, through the suction anchor, and connecting the inner member, or a portion of the inner member such as the lower inner member portion to the guide. The guide may be used to support the inner member (or portion of the inner member) and guide it into attachment with the rest of the suction anchor.

The inner member, or a portion of the inner member such as the lower inner member portion, may then be lifted and attached to the suction anchor (such as to the connection portion which connects the inner member to the outer suction skirt or to the upper inner member portion). Once the inner member, or a portion of the inner member such as the lower inner member portion, is connected to the suction anchor, the suction anchor may then be lowered towards the seabed for the rest of the installation method to be performed.

The inner member may be a telescoping member. In this case, the length of the inner member may be adjusted between a contracted length and an extended length. This may be regarded as one way of attaching at least the portion of the inner member which protrudes from the outer suction skirt at the installation site, i.e. by extending and locking the telescoping arrangement at the installation site.

In other words the step of providing the suction anchor comprises modifying the suction anchor at the installation site to provide the inner member which protrudes from the outer suction skirt at the installation site. As discussed above this may be achieved by attaching additional member to the suction anchor and/or extending an inner pipe that is already there.

The method of attaching and/or securing the inner member, or a portion of the inner member such as the lower inner member portion, to the outer suction skirt may comprise inserting the inner member, or a portion of the inner member into the outer skirt from the top of the suction anchor. This may be achieved by hammering the inner member, or portion of the inner member, in from the top.

When the arrangement comprises an upper inner member portion and a lower inner member portion, the lower inner member portion may be inserted into the top of the upper inner member portion and pushed through until the lower inner member portion protrudes from the bottom of the outer suction skirt.

When the method comprises attaching and/or securing a portion of the inner member, such as the lower inner member portion, to the outer suction skirt, the outer suction skirt may already be connected to another portion of the inner member such as the upper inner member portion. This connection between an upper inner member portion and the outer suction skirt may have been made onshore before the suction skirt was taken to the installation location.

The upper inner member portion, if present, may not protrude from the suction skirt.

Thus, the outer suction skirt may be transported to the location where the subsea foundation is to be installed without having a member protruding from the outer skirt. This can make transportation easier and minimise the risk that the suction anchor, or part of the suction anchor, is damaged during transportation.

Irrespective of whether the inner member, or a portion of the inner member, is attached to the outer suction skirt subsea or whether the suction anchor with the protruding inner member is ready formed before being deployed subsea, the inner member which protrudes from the outer suction skirt may be attached to the outer suction skirt (i.e. including indirectly via the inner upper member) before the suction anchor starts to penetrate the sea bed. Thus, the inner member a part of which protrudes from the bottom of the outer suction skirt may be installed in the sea bed simultaneously with the outer suction skirt.

The suction anchor may be supported during installation. The suction anchor may be supported by deployment apparatus. The deployment apparatus may comprise wires, winches, buoys, chains and dummy weights for example. The suction anchor may be lowered towards the sea bed. This may be under action of its own weight.

The deployment apparatus may be used to control roll and/or pitch of the suction anchor before it enters the seabed.

The connection point of the deployment apparatus to the suction anchor may be as near the outer edge of the structure as possible. This may give an optimal lever arm for controlling the orientation of the suction anchor.

The method may comprise lowering the suction anchor towards the sea bed until the lower most portion of the inner member is just above the sea bed. The method may then comprise holding the suction anchor for a period of time so that it can level under its own weight. This may be effective if the suction anchor will hang straight.

The level/orientation of the suction anchor or subsea foundation may be its angle relative to the sea bed.

Additionally or alternatively, the method may comprise checking the position of the suction anchor. If the suction anchor is not level, the method may comprise levelling the suction anchor. Levelling the suction anchor may comprise adjusting the position of the suction anchor. Levelling may be achieved by pitch and/or roll adjustments. This may be achieved by adjusting the support (e.g. deployment apparatus) holding the suction anchor (such as wires and winches). For example the winch, such as a lift winch, holding one side may be adjusted to change the angle of the suction anchor relative to the sea floor.

The foundation may comprise a sensor, such as an inclinometer or spirit level, for determining/checking the orientation of the foundation.

The orientation of the foundation may be checked continuously during installation. This case, an adjustment may be made as soon as the orientation is not, or a certain angle (e.g. above a threshold angle) from, the desired orientation.

Alternatively, the orientation of the foundation may be checked periodically during installation. This may for example be before the inner member contacts the seabed, when only the inner member contacts the seabed and/or when the outer suction skirt is in contact with the sea bed but before suction of the skirt into the sea bed begins.

Levelling the suction anchor may comprise using weight(s) (such as ballast or material taken from the sea bed). The weight(s) may be put on the suction anchor and may be moved to shift the centre of gravity in order to permit the control of the orientation of the suction anchor relative to the sea bed.

Levelling the suction anchor, such as adjusting the position of weights on the foundation, may be automatic and/or manual based on the sensed orientation of the foundation during installation.

The weight(s) may be movable, such as by hydraulic jacks.

The weight(s) may be rocks, (such as sacks of rocks) which are for example taken from the seabed or are pre-filled gravel bags deployed from a vessel.

The weights may be movable in at least two directions, such as two perpendicular directions. This is so that the roll and pitch, or the orientation in two axis, of the foundation may be controlled by moving the weights.

The weight(s) may be retrievable and/or reusable.

The method may comprise changing the position of the weight(s) until the foundation is at the desired angle relative to the sea bed.

The method may comprise ensuring that the inner member is vertical when it starts to penetrate the sea bed.

The present invention may be used to control the final orientation/inclination of the foundation after installation.

In some scenarios, such in the case of a well with a small overburden, it may be desirable to have a foundation which is not vertical. This is because, in the case of a well with a small overburden, the direction of the well may need to change over a very short distance (due to the small overburden) and thus it may be desirable to have a foundation which is at an angle from horizontal, e.g. greater than 2, 5, 10, 15, 25 or 45 degrees from horizontal such that the pipe for the well may be greater than 2, 5, 10, 15, 25 or 45 degrees from vertical.

The bottom surface of the inner member and/or outer suction skirt, may be angled/inclined relative to the main axis and/or top surface of the suction anchor. This may be useful if the suction anchor is intended to be located in the sea bed extending at an angle/incline relative to the plane of the sea floor.

If the bottom surface of the suction anchor (i.e. inner member and/or suction skirt) is angled when the suction anchor is lowered towards the sea floor under the action of its own weight, when it reaches the sea floor it will naturally extend at an angle from the direction perpendicular to the sea floor. As a result, as the suction anchor penetrates and/or is sucked into the seafloor it may be in an orientation which is at an angle from the direction perpendicular to the sea floor.

This aspect of the invention may be independently patentable from the other features of the invention, i.e. the suction anchor does not necessarily need to have an inner member which protrudes from the suction anchor.

The step of moving the suction anchor towards a sea bed so the inner member penetrates the seabed before the outer suction skirt, may involve lowering the suction anchor (with an inner member which protrudes from the outer suction skirt) until a portion of the inner member which protrudes from the outer suction skirt penetrates the sea bed.

Once at least a portion of the inner member penetrates the sea bed, and before the outer suction skirt contacts the sea bed, the method may comprise checking the position/level of the suction anchor. If the suction anchor is not at the desired position, e.g. not level relative to the sea bed or not at the desired orientation relative to the seabed, the method may comprise adjusting the position, such as levelling the suction anchor. Levelling the suction anchor may comprise adjusting the position of the suction anchor. The adjustment of the suction anchor may be achieved by adjusting the support (e.g. deployment apparatus) holding the suction anchor (such as wires and winches). Additionally or alternatively, levelling the suction anchor may comprise using weight(s). The weight(s) may the weights discussed above in relation to the adjusting action which may occur before the inner member contacts the sea bed. The weight(s) may be put on the suction anchor and may be moved/ have their position changed in order to adjust the foundation and/or the suction anchor into the desired angle relative to the sea bed. This desired angle may be the angle at which the inner member is perpendicular, or at least substantially perpendicular, to the sea floor. This is so that the resulting orientation of the foundation, when the support surface of the foundation is horizontal or at least substantially horizontal or parallel or substantially parallel to the seabed.

The position/level/orientation (these terms may be used interchangeably herein) of the suction anchor may be checked and/or adjusted both before and after the inner member has penetrated the sea bed or it may only be checked and/or adjusted at one of these occasions.

By checking and/or adjusting the orientation of the suction anchor relative to the sea bed when only a portion of the inner member penetrates the sea bed means that it is possible to adjust the orientation of the suction anchor without having to use excessive force but means that there is a component which acts to keep the position the suction anchor has been adjusted to.

The lowering and/or penetration of at least part of the inner member and/or outer suction skirt may be under the weight of the suction anchor itself.

Before the entire weight of the suction anchor is supported on the sea bed, i.e. during the initial part of the penetration of the suction anchor (when part of the weight of the suction anchor may still be supported by the deployment apparatus), the method may comprise reducing the pressure within the suction anchor (i.e. within the inner member and/or outer suction skirt).

This may create a suction pressure which acts to suck the suction anchor into the sea bed, at least in part. This may be done at the same time as, i.e. in combination with, adjusting the deployment apparatus holding of the suction anchor (such as wires and winches) and/or tension in the lifting wires or performing some other levelling operation (as discussed above). This may be done irrespective of whether the suction anchor has an inner member which protrudes from the suction anchor, i.e. this aspect of the invention may be independently patentable.

The method may additionally or alternatively comprise cycling the pressure within the suction anchor, (i.e. outer suction skirt and/or inner member) during installation. This may comprise raising and lowering (i.e. reversing) the pressure inside the outer suction skirt and/or inner member one or more, or a plurality of, times. This may result in the suction anchor moving up and down relative to the sea bed. This may allow additional penetration of the suction anchor to be achieved into a sea bed.

This aspect of the invention may be independently patentable from the other features of the invention, i.e. the suction anchor does not necessarily need to have an inner member which protrudes from the suction anchor.

Thus in another aspect the present invention may comprise a method of installing a suction anchor, the method comprising reducing the pressure inside the suction anchor to suck the suction anchor into the sea bed, and increasing the pressure inside the suction anchor to move the suction anchor out of the sea bed before again reducing the pressure inside the suction anchor to suck the suction anchor into the sea bed. The cycle of lowering, raising and then lowering the pressure inside the suction anchor may be performed two or more times and may be repeated until the suction anchor fully penetrates the seabed.

Once the suction anchor is at a desired position (e.g. level within an acceptable limit, which may for example be up to 1, 1.2, 1.5 or 2 degrees from vertical relative to the sea floor), the suction anchor may be lowered further until the outer suction skirt contacts the sea floor. The method may comprise lowering the suction anchor under the action of its own weight. The suction anchor, i.e. the inner member and outer suction skirt, may be lowered under the action of its own weight until it is fully supported by the seabed and does not penetrate the sea bed any further. The suction anchor may not penetrate the seabed any further under the action of its own weight due to friction acting on the suction anchor.

The weight of the suction anchor may push a portion of the inner member and the outer skirt into the sea bed.

If the weight of the suction anchor alone is not sufficient to push the outer suction skirt into the sea bed, the method may comprise applying additional force to the suction anchor to cause the suction skirt into the sea bed such that the suction anchor can be sucked into the sea bed by reducing the pressure inside the suction skirt.

The additional force may be provided by putting additional weights, such as ballast, gravel bags or rocks, onto the suction anchor. These weights may also be used to control/adjust the orientation of the foundation during installation, i.e. these may be the above described weights.

The additional force may be provided, in the case that the inner member is a pipe, reducing the pressure in the inner member such that the inner member is sucked into the seabed which will suck the outer suction skirt into the seabed.

The suction anchor may be lowered until it is supported entirely by the sea bed. At this point the suction anchor may be sucked into the sea bed or additional force may be applied to the suction anchor until the outer suction skirt can be sucked into the sea bed.

Once the suction anchor is supported entirely by its own weight and/or additional downward force is applied to the suction anchor, the outer suction skirt may have penetrated the sea bed sufficiently such that the method may comprise removing fluid (this fluid may for example be sea water or air) from inside the suction skirt. The removal of this fluid may reduce the pressure inside the suction skirt such that the suction anchor may be sucked into the seabed so as to form the subsea foundation.

The method may comprise installing the suction anchor with the long inner member in the sea bed without first removing soil for the inner member.

In the case of a subsea well foundation, the inner member (which may be a pipe for a well) may have the function of preventing or minimising washout which occurs around the well.

The inner member may have the function of acting as a 'centraliser' to help ensure that the foundation, and hence device supported by the foundation, are at a desired orientation such as, in the case of a well vertical or within an acceptable limit (such as up to 1, 1.2, 1.5 or 2 degrees) from vertical.

The inner member/subsea (well) foundation may have the function of providing lateral support for a well which extends therethrough.

The inner member/subsea (well) foundation may have the function of providing bearing capacity for a well which extends therethrough.

The subsea foundation may comprise a plurality of suction anchors.

This feature may be independently patentable of the above described features, including the optional features, of the subsea foundation and its method of installation or may be provided in combination with one or more of the features, or optional features.

One or more of the plurality of suction anchors may comprise one or more of the above described features. For example, one or more (but not necessarily all) of the plurality of suction anchors may have an inner member which protrudes from the outer suction skirt.

In a third aspect, the present invention may provide a subsea foundation, the foundation comprising: a plurality of suction anchors, wherein at least one of the suction anchors is for providing a foundation for a subsea device.

In another aspect the present provides a subsea foundation, the foundation comprising: a plurality of suction anchors, wherein at least one of the suction anchors is for providing a foundation for a subsea device, wherein the plurality of suction anchors are connected together by a connection and wherein the connection between two suction anchors is at a location which, when the suction anchors are installed in the sea bed, the connection is in the sea bed.

The subsea foundation may be a subsea well foundation. The subsea device may be a subsea well. At least one the anchors may be for having a well extend therethrough.

Thus the present invention may provide a subsea well foundation, the foundation comprising: a plurality of suction anchors, wherein at least one of the suction anchors is for having a well extend therethrough.

In a fourth aspect, the present invention may provide a method of installing a subsea foundation, the method comprising: providing a plurality of suction anchors, wherein at least one of the suction anchors is for providing a foundation for a subsea device, and sucking at least one of the suction anchors into a seabed.

In another aspect the present invention provides a method of installing a subsea foundation, the method comprising: providing a plurality of suction anchors, wherein at least one of the suction anchors is for providing a foundation for a

subsea device; and sucking at least one of the suction anchors into a seabed, wherein the plurality of suction anchors are connected and wherein the connection between two suction anchors is at a location which is in the sea bed when the suction anchors have been sucked into the sea bed.

The subsea foundation may be a subsea well foundation.

At least one of the suction anchors may for having a well extend therethrough.

Thus, the present invention may provide a method of installing a subsea well foundation, the method comprising: providing a plurality of suction anchors, wherein at least one of the suction anchors is for having a well extend therethrough, and sucking at least one of the suction anchors into a seabed.

One or more or each of the suction anchors of the plurality of suction anchors may be the above described suction anchor. However, this is not essential and for example, none of the suction anchors may have an inner member which protrudes from the suction skirt. The method of installing the subsea foundation may comprise one or more features of the above described installation method.

The following discussion of optional features applies to both the inventions of the first,second and associated aspects (in the case that the subsea foundation comprises a plurality of suction anchors) in addition to the third, fourth and associated aspects of the invention.

A suction anchor may be referred to as, and may encompass, a suction caisson, a suction pile, a suction bucket and/or a suction can.

Each of the suction anchors may be for providing a foundation for a subsea device. Alternatively only one, or some of the plurality of suction anchors may be for providing a foundation for a subsea device. The other of the plurality of suction anchors may be for helping to level the suction anchor(s) which in use will provide a foundation for a subsea device, as discussed below.

Each of the suction anchors may be for having a well extend therethrough. Alternatively only one, or some of the plurality of suction anchors may be for having a well extend therethrough. The other of the plurality of suction anchors may be for helping to level the suction anchor(s) which in use will have a well therethrough, as discussed below.

Each suction anchor which is for having a well extend therethrough may be for having only one well extend therethrough.

When the foundation comprises a plurality of suction anchors, only one of the suction anchors may have an inner member.

The inner member may not necessarily have a channel therethrough and may be an inner member which acts to allow the orientation of the foundation to be controlled as discussed above in detail.

Each suction anchor may comprise a suction skirt. The suction skirt may define a volume (together with a top annular plate), which in use, the pressure can be reduced in such that the suction anchor may be sucked into the ground.

The method may comprise reducing the pressure in one or more of the suction anchors so as to suck the suction anchors into the ground.

The suction anchors may be connected together. For example the suction anchors may be rigidly connected to each other. Each suction anchor of the plurality may be connected to at least one other suction anchor. Thus there may be one or more connection(s) between two suction anchors. For example there may be a first connection between a first and second suction anchor and there may additionally be a second connection between the second and a third suction anchor.

The connection between two suction anchors may be at a location which, when the suction anchor is installed in the sea bed, the connection, or at least a portion of the connection, is in the sea bed. In other words, as the suction anchor is lowered and/or suctioned into the seabed, the connection portion may also penetrate the sea bed.

The connection may be at the bottom, or towards the bottom, of the suction anchors connected by the connection.

This means that the foundation may be stiffer such that forces can be effectively transferred between the suction anchors.

The connection may act as a spacer to hold the suction anchors at a fixed distance from each other, even as the suction anchors are penetrating the seabed.

Thus the connection between two suction anchors may be used to provide a constant angle and/or distance between the two suction anchors. This may reduce the control/accuracy required during installing of the plurality of suction anchors.

The connection may have a relatively small dimension in a direction which is parallel to the plane of the seabed. This is so that the connection, if it itself penetrates the sea bed, may provide only a relatively small resistance to the penetration of the suction anchors into the sea bed.

The connection may for example comprise one or more plate(s) between the two suction anchors. The plane of the plate(s) may be perpendicular to the plane of the sea bed.

The connection between two suction anchors may for example comprise two plates that intersect between the two suction anchors. For example, the two plates may form an X-shape between the two suction anchors.

Such a connection may effectively transfer forces between the two suction anchors such that it can improve the control of installing two anchors connected together.

Each suction anchor may have, or be arranged to be connected to, a separate device, such as a pump, for reducing pressure inside the suction anchor (for providing the suction force). Each pressure reducing device may be independently controllable. Alternatively, the foundation may have a plurality of independently controllable valves that allow the pressure in each of the suction anchors to be controlled independently. Thus, the foundation may be arranged so that the pressure in each of the suction anchors is independently controllable. This means that it may be possible to level the subsea foundation using the independently controllable suction anchors.

One or more of the suction anchors may be controlled so as to cycle the pressure or reduce the pressure before the full weight of the foundation is on the sea bed (as is discussed above in more detail).

For example, the method may comprise putting the suction anchors on the seabed and allowing the suction anchors to penetrate the seafloor by action of their own weight. The suction anchors may then be sucked into the seabed by removing fluid from inside the suction skirt of the suction anchor.

The level of the subsea foundation (i.e. angle of the top/support surface relative to the sea bed), or at least part of it, such as suction anchors which are for providing a foundation for a subsea device, such as having a well extend therethrough, may be checked. If the level needs to be adjusted, this may be achieved by reducing the pressure in one suction anchor compared to another of the suction anchors. The method may comprise independently controlling and/or adjusting the pressure in each of the suction anchors.

In this way, different forces can be applied on each of the suction anchors so that the angle of the foundation relative to the sea bed can be adjusted.

Thus, the suction anchors may be controlled so that the foundation can be levelled.

The subsea foundation may comprise at least three suction anchors.

When the subsea foundation comprises at least three suction anchors the suction anchors may be arranged so that they are not in a line. For example, the suction members may be in a triangle, square or L-shaped arrangement. This is so that the orientation of the foundation can be controlled into two different dimensions, i.e. both the roll and pitch of the foundation may be controlled. Each suction anchor may be connected to at least one other suction anchor.

The suction anchors may be arranged so that both the roll and pitch of the subsea foundation may be controlled. The suction anchors may be arranged so that the orientation can be controlled in two orthogonal directions (which may both be parallel to the surface of the seabed).

The method of installation of the subsea foundation of any aspect of the invention may comprise providing one or more of the features of the subsea foundation.

The suction anchor may be a tall steel cylindrical structure that is open at the bottom and closed at the top. The suction anchor may have an internal stiffener system and may be used to support subsea structures. The suction anchor may be installed by first lowering it into the soil to self-penetration depth (i.e. penetration due to submerged anchor weight). The remainder of the required penetration may be achieved by pumping out the water trapped inside the suction anchor.

Any features, including optional features, of an aspect of the invention may be applied to any other aspect of the invention.

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

Figure 1 shows a subsea well foundation;

Figure 2 shows another subsea well foundation;

Figure 3 shows the subsea well foundation of Figure 2 in side view;

Figure 4 shows the subsea well foundation of Figure 2 in side view in bottom perspective view;

Figure 5 shows another subsea well foundation;

Figures 6 to 9 show an installation method;

Figure 10 shows a subsea well foundation with movable weights thereon; and

Figure 11 shows two connected suction anchors.

Figure 1 shows a subsea foundation 1. In this case the subsea foundation is a well foundation. However, the same concept could equally be used as a foundation for a different subsea device such as a pump station.

The foundation 1 comprises a suction anchor 2 through which a well (not shown in this figure) can extend. The suction anchor 2 comprises an outer suction skirt 4 and an inner pipe 6. The inner pipe 6 extends beyond the bottom of the suction skirt 6. In use, the well extends through the inner pipe 6.

On top of the suction anchor 2 is protection and support equipment 8. Once the foundation is fully installed production equipment such as a BOP may be mounted on the protection equipment 8.

The suction anchor 2 is arranged so that when it is placed on the sea bed the inner pipe 6 will contact and penetrate the sea bed before the outer suction skirt 4. This means that a part of the suction anchor 2 can be in the sea bed whilst levelling operations are carried out.

Figures 2 to 4 show an alternative subsea well foundation 100. This alternative foundation 100 comprises a plurality of suction anchors 2. Each of these suction anchors 2 is the same as the above described suction anchor 2 which is shown in figure 1.

As can be seen most clearly in Figure 4, the inner pipe 6 comprises an upper inner pipe portion 6a and a lower inner pipe portion 6b. The upper inner pipe portion 6a is located within the outer suction skirt 4 and does not protrude therefrom. This makes transportation of the suction anchor 2 more straightforward. Alternatively the inner pipe 6 may be a single piece which is attached to the suction skirt 4 either before deployment subsea or after deployment subsea.

The lower inner pipe portion 6b (when the inner pipe 6 is in multiple parts) can be connected to the upper inner pipe portion 6a to form the inner pipe 6 which protrudes from the outer suction skirt. The lower inner pipe portion 6b may be connected to the suction anchor 2 when the components are subsea but before any part has started to penetrate the seabed.

In the foundation 100 shown in Figures 2 to 4, the right hand inner pipe 6 is shown in its configuration for being penetrated into the sea bed (i.e. with the inner pipe 6 connected to the suction skirt 4) and the left hand inner pipe 6 shows the

lower inner pipe portion 6a in a position ready to be connected to the upper inner pipe portion 6a.

The suction anchor(s) may comprise a plurality of stiffener plates 7 which extend between the outer suction skirt 4 and the inner member 6. This can be seen for example in Figure 4 at the bottom of the suction skirt. Such stiffener plates 7 may additionally or alternatively be located at the top of the suction skirt immediately underneath the top plate of the suction anchor.

A single protection equipment 8 is used for the plurality of suction anchors 2, i.e. there is one protection equipment 8 for the entire subsea well foundation 100. The protection equipment 8 may thus be used to connect the suction anchors 4. The suction anchors 2 are (perhaps also) connected by a connector 10. Connection 10 is provided in a location which, when the suction anchors are installed subsea, will be in the sea bed. The connection 10 is provided towards the bottom of the suction skirts 4. The connection 10 will be submerged in the sea bed when the foundation 100 is installed.

Figure 5 shows an alternative subsea well foundation 200 which comprises a plurality of suction anchors 2 but in which the inner pipe 6 does not protrude from the bottom of the outer suction skirt 5.

Figures 6 to 9 show an exemplary installation method.

In an example installation method, first the inner pipe 6, or a portion of the inner pipe 6a is deployed subsea and put on the sea bed as shown in figure 6. The rest of the foundation 100 is then deployed subsea. During installation the foundation 100 is supported by a vessel 12 by deployment apparatus 14 which comprises guide wires 15, winches 17 and support lines 19.

The foundation 100 is supported subsea and a guide wire 15 is fed through the suction anchor 2 of the foundation 100 and connected to the inner pipe 6 (or portion of inner pipe 6a). The guide wire 15 is used to lift the inner pipe 6 off the sea bed and guide it to the bottom of the suction anchor 2 where it will be attached.

The inner pipe 6 is attached to the suction anchor so that the inner pipe 6 protrudes from the bottom of the outer suction skirt 4. An inner pipe 6 which is attached is shown on the right hand side of the foundation 100 in figure 6 and on the left hand side is shown a pipe 6 lying of the sea bed and an inner pipe 6 about to be connected to the bottom of the suction anchor 2.

Figure 7 shows the foundation 100 with the inner pipes 6 attached and protruding from the bottom of the outer suction skirts 4. The foundation 100 is

lowered towards the sea floor. The foundation 100 may optionally be held for a period of time just above the sea floor to give time for the foundation 100 to level under its own weight and/or the orientation of the foundation 100 may be controlled by moving weights 12 positioned on the foundation 100 (see figure 10) or adjusting the support lines 19.

Whilst both suction anchors 2 are shown having inner pipes 6 which protrude from the bottom of the suction skirt 4, it may be that only one of the suction anchors 2 has an inner pipe 6 which protrudes from the bottom of the suction anchor 2. Or in the case that the foundation 100 comprises more than two suction anchors 2, some, but not all of the suction anchors 2 may comprise an inner pipe 6 which protrudes from the bottom of the suction skirt.

The foundation 100 may be lowered further until a portion of the inner pipe(s) 6 has penetrated the seabed as shown in figure 8. At this point, the angle of the foundation 100 relative to the seabed may be checked and adjusted. Again, the orientation of the foundation 100 may be controlled by moving weights 12 positioned on the foundation 100 (see figure 10) or adjusting support lines 19. The position of the foundation 100 may be adjusted until the inner pipes 6 are vertical relative to the seabed, at least substantially vertical or vertical within an acceptable limit, such as up to 1, 1.2, 1.5 or 2 degrees from vertical.

The adjustment may be achieved by adjusting the deployment apparatus 14 so as to adjust the angle of the foundation 100 and/or by adding weight(s) (such as ballast, pre-filled gravel bags or rocks or other material form the sea floor) to the top of the foundation which can be moved to allow the angle of the foundation 100 relative to the seafloor to be adjusted.

As shown in Figure 10, weights 12, such as ballast weights, may be provided on the foundation 100. The weights are each supported on a support frame 13. The weights 14 and their respective support frame 13 may be removable after installation.

The weights 12 may be movable during installation of the foundation 100 so as to allow control of the orientation of the foundation 100 during installation. This movement of the weights 14 may be achieved by using hydraulic jacks 14. A plurality of jacks 14 may be provided so that the weight 14 can be moved in at least two different directions. This is so that the pitch and roll of the foundation 100 can be adjusted as required.

Each of the movable weights 14 may be associated with a control panel and inclinometer 16. The orientation of the foundation 100 may be checked during installation by the inclinometer and the weights 14 may be moved automatically in response to the sensed orientation of the foundation 100.

Due to the fact that the inner pipes 6, and only the inner pipes 6, are in the sea bed when the angle of the foundation 100 is adjusted, it is relatively easy to adjust the angle of the foundation 100 (as the inner pipes 6, compared to the suction skirts 4, provide a relatively small resistance to a change of angle of the foundation 100). Yet, because the inner pipes 6 are submerged they provide some resistance to motion so as to help retain the foundation 100 in the desired orientation as it is further lowered towards the seabed.

Once in the desired position, e.g. with the inner pipes vertical or substantially vertical, the foundation 100 is lowered further under the action of its own weight until the outer suction skirt 4 reaches and starts to penetrate the sea bed.

Once the foundation 100 is fully supported on the seabed (and prevented from penetrating any further by action of friction) and at least the bottom portion of the suction skirts 4 are in the sea bed, the pressure in the suction anchors 2 may be reduced so as to cause the suction anchors 2 to suck into the seabed. The pressure in the suction anchor 2 may be reduced by pumping fluid out of the volume created within the suction skirt 4. Fluid is pumped out until the suction skirt is sucked into the sea bed by a sufficient amount, for example as shown in Figure 9. The deployment apparatus 14 may then be removed and then further well operations (such as the addition of production equipment) required on the foundation 100 may be performed.

When the foundation 100 comprises a plurality of suction anchors 2, the pressure in each suction anchor 2 may be independently controllable. This independent control may be used to adjust the level of the foundation relative to the sea bed to ensure that the foundation is fixed into the sea bed in a position in which the wells running through the suction anchors 2 will be at least substantially vertical. Thus, when the foundation 100 comprises a plurality of suction anchors it is not essential that the inner pipe 6 protrudes from the bottom of the suction skirt 4 to allow the well(s) to be made vertical. This is because independent control of the pressure inside each of the suction anchors 2 may instead be used to ensure that the resulting wells are at least substantially vertical.

Figure 11 shows a foundation 200 with two connected suction anchors 204. The suction anchors 204 are connected to each other by means of a connector 210. The connector 210 comprises two plates 220 that intersect between the two suction anchors 204 to form an X-shaped connector 210.

The X-shaped connector 210 is located towards the bottom of the suction skirts of the suction anchors 204 and as a result when the suction anchors 204 are in the sea bed the connector 210 will be located within the seabed too.

CLAIMS:

1. A method of installing a subsea foundation, the method comprising:

providing a suction anchor, the suction anchor comprising an inner member and an outer suction skirt located around the inner member, wherein the inner member protrudes from the outer suction skirt, wherein the step of providing the suction anchor comprises attaching at least the portion of the inner member which protrudes from the outer suction skirt at the installation site;

moving the suction anchor towards a seabed so the inner member penetrates the seabed before the outer suction skirt;

further moving the suction anchor towards the seabed until the outer suction skirt reaches the seabed; and

sucking the suction anchor into the sea bed.

2. A method according to claim 1, wherein the method comprises:

attaching at least the portion of the inner member which protrudes from the outer suction skirt, to the outer suction skirt when both components are subsea.

3. A method according to claim 1 or 2, wherein the method comprises:

selecting the length of the inner member that protrudes from the outer suction skirt based on the geology of the installation site.

4. A method according to claim 1, 2 or 3, wherein once at least a portion of the inner member penetrates the sea bed, and before the outer suction skirt contacts the sea bed, the method comprises checking the angle of the suction anchor relative to the sea bed.

5. A method according to any preceding claim, wherein once at least a portion of the inner member penetrates the sea bed, and before the outer suction skirt contacts the sea bed, the method comprises adjusting the angle of the suction anchor relative to the sea bed.

6. A method according to claim 5, wherein adjusting the angle of the suction anchor is achieved by adjusting a support holding the subsea foundation.

7. A method according to claim 5 or 6, wherein adjusting the angle of the suction anchor is achieved using weight(s) which are added to the subsea foundation.

8. A method according to claim 7, wherein the method comprises moving the weight(s) to adjust the angle of the suction anchor.

9. A method according to any preceding claim, wherein once the suction anchor is at a desired angle relative to the sea floor, the suction anchor is lowered further until the outer suction skirt contacts the sea floor.

10. A method according to any preceding claim, wherein the inner member is a hollow body and the method comprises reducing the pressure inside the inner member.

11. A method according to any preceding claim, wherein the method comprises reducing the pressure inside the suction anchor before the full weight of the suction anchor is supported by the seabed.

12. A method according to any preceding claim, wherein the method comprises cycling the pressure within the suction anchor.

13. A method according to any preceding claim, wherein the method comprises providing at least one additional suction anchor such that a plurality of suction anchors is provided.

14. A method according to claim 13, wherein the plurality of suction anchors are connected and wherein the connection between two of the suction anchors is at a location which is in the sea bed when the suction anchors have been sucked into the sea bed.

15. A method according to claim 14, wherein the connection comprises two plates.

16. A method according to claim 15, wherein the two plates intersect between the two suction anchors so as to form an X-shape between the two suction anchors.

17. A method according to any of claims 13 to 16, wherein the method comprises independently controlling the pressure in each of the suction anchors.

18. A method according to any preceding claim, wherein the subsea foundation is a subsea well foundation and the inner member is an inner pipe for a well.

19. A subsea foundation, the foundation comprising:

a suction anchor, the suction anchor comprising an inner member and an outer suction skirt located around the inner member, wherein the inner member protrudes from the outer suction skirt,

wherein the inner member comprises an upper inner member portion and a lower inner member portion, and

wherein the upper inner member portion does not protrude from the outer suction skirt.

20. A subsea foundation according to claim 19, wherein the length of the inner member protruding from the suction skirt is 0.1 to 5 times the diameter of the outer suction skirt.

21. A subsea foundation according to claim 19 or 20, wherein the subsea well foundation comprises a plurality of suction anchors.

22. A subsea foundation according to claim 21, wherein only one of the suction anchors has an inner member that protrudes from the outer suction skirt.

23. A subsea foundation according to claim 21 or 22, wherein the plurality of suction anchors are connected together by a connection and wherein the connection between the suction anchors is at a location which, when the suction anchor is installed in the sea bed, the connection, or at least a portion of the connection, is in the sea bed.

24. A subsea foundation according to claim 23, wherein the connection between the plurality of suction members comprises a plate between two suction anchors.

25. A subsea foundation according to claim 24, wherein the connection comprises two plates.

26. A subsea foundation according to claim 25, wherein the two plates intersect between the two suction anchors so as to form an X-shape between the two suction anchors.

27. A subsea foundation according to any of claims 21 to 26, wherein each suction anchor has a separate independently controllable device for reducing pressure inside the suction anchor.

28. A subsea foundation according to any of claims 19 to 27, wherein the subsea foundation is a subsea well foundation and the inner member is an inner pipe for a well.

29. A method according to any of claims 1 to 18, wherein the subsea foundation is a subsea foundation according to any of claims 19 to 28.

30. A subsea foundation, the foundation comprising:

a plurality of suction anchors, wherein at least one of the suction anchors is for providing a foundation for a subsea device,

wherein the plurality of suction anchors are connected together by a connection and wherein the connection between two suction anchors is at a location which, when the suction anchors are installed in the sea bed, the connection is in the sea bed.

31. A subsea foundation according to claim 30, wherein the connection between the plurality of suction members comprises a plate between two suction anchors.

32. A subsea foundation according to claim 31, wherein the connection comprises two plates

33. A subsea foundation according to claim 32, wherein the two plates intersect between the two suction anchors so as to form an X-shape between the two suction anchors.

34. A subsea foundation according to any of claims 30 to 33, wherein each suction anchor has a separate independently controllable device for reducing pressure inside the suction anchor.

35. A subsea foundation according to any of claims 30 to 34, wherein at least one of the suction anchors comprises an inner member and an outer suction skirt located around the inner member, wherein the inner member protrudes from the outer suction skirt.

36. A subsea foundation according to claim 35, wherein only one of the suction anchors has an inner member that protrudes from the outer suction skirt.

37. A subsea foundation according to claim 35 or 36, wherein for each suction anchor that comprises an inner member, the length of the inner member protruding from the outer suction skirt is 0.1 to 5 times the diameter of the outer suction skirt.

38. A subsea foundation according to claim 35, 36 or 37, wherein for each suction anchor that comprises an inner member, the inner member comprises an upper inner member portion and a lower inner member portion.

39. A subsea foundation according to claim 38, wherein the upper inner member portion does not protrude from the outer suction skirt.

40. A subsea foundation according to any of claims 30 to 39, wherein the subsea foundation is a subsea well foundation, and wherein at least one of the suction anchors is for having a well extend therethrough.

41. A subsea foundation according to claim 40, when dependent on any of claims 35 to 39, wherein each inner member is an inner pipe for a well.

42. A method of installing a subsea foundation, the method comprising:

providing a plurality of suction anchors, wherein at least one of the suction anchors is for providing a foundation for a subsea device; and

sucking at least one of the suction anchors into a seabed,

wherein the plurality of suction anchors are connected and wherein the connection between two suction anchors is at a location which is in the sea bed when the suction anchors have been sucked into the sea bed.

43. A method according to claim 42, wherein the connection comprises two plates.

44. A method according to claim 43, wherein the two plates intersect between the two suction anchors so as to form an X-shape between the two suction anchors.

45. A method according to any of claims 42 to 44, wherein each suction anchor has a separate, independently controllable device for reducing pressure inside the suction anchor and wherein the method comprises independently controlling the pressure in each of the suction anchors.

46. A method according to any of claims 42 to 45, wherein at least one of the suction anchors comprises an inner member and an outer suction skirt located around the inner member, wherein the inner member protrudes from the outer suction skirt; and

wherein the method comprises:

moving the suction anchor towards a seabed so the inner member penetrates the seabed before the outer suction skirt;

further moving the suction anchor towards the seabed until the outer suction skirt reaches the seabed; and

sucking the suction anchor into the sea bed.

47. A method according to claim 46, wherein the method comprises:

attaching at least the portion of the inner member which protrudes from the outer suction skirt at the installation site.

48. A method according to claim 46 or 47, wherein the method comprises:

attaching at least the portion of the inner member which protrudes from the outer suction skirt, to the outer suction skirt when both components are subsea.

49. A method according to claim 46, 47 or 48, wherein the method comprises:

selecting the length of the inner member that protrudes from the outer suction skirt based on the geology of the installation site.

50. A method according to any of claims 46 to 49, wherein once at least a portion of the inner member penetrates the sea bed, and before the outer suction skirt contacts the sea bed, the method comprises checking the angle of the suction anchor relative to the sea bed.

51. A method according to any of claims 46 to 50, wherein once at least a portion of the inner member penetrates the sea bed, and before the outer suction skirt contacts the sea bed, the method comprises adjusting the angle of the suction anchor relative to the sea bed.

52. A method according to claim 51, wherein adjusting the angle of the suction anchor is achieved by adjusting a support holding the foundation.

53. A method according to claim 50, 51 or 52, wherein adjusting the angle of the suction anchor is achieved using weight(s) which are added to the foundation.

54. A method according to claim 53, wherein the weight(s) are movable.

55. A method according to any of claims 46 to 54, wherein once the suction anchor is at a desired angle relative to the sea floor, the suction anchor is lowered further until the outer suction skirt contacts the sea floor.

56. A method according to any of claims 42 to 55, wherein the subsea foundation is a subsea well foundation, and wherein at least one of the suction anchors is for having a well extend therethrough.

57. A subsea foundation according to claim 56, when dependent on any of claims 46 to 55, wherein each inner member is an inner pipe for a well.

58. A method according to any of claims 42 to 56, wherein the subsea foundation is a subsea foundation according to any of claims 30 to 41.

Fig. 1

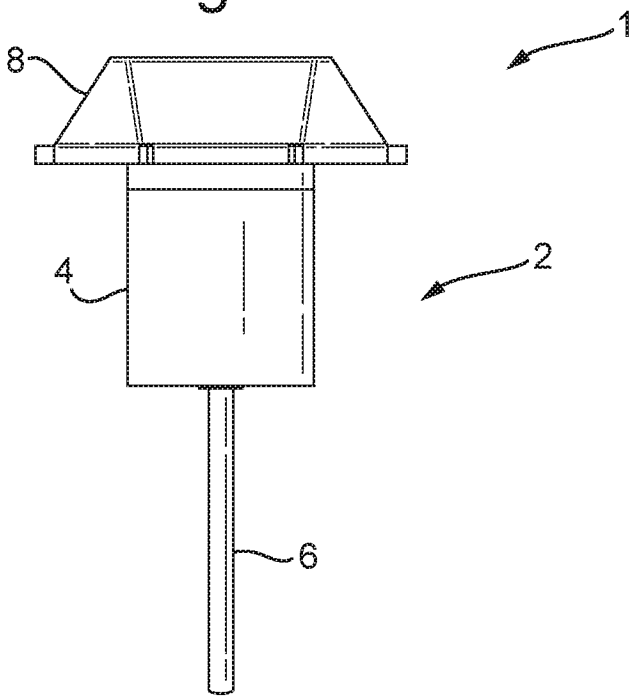


Fig. 2

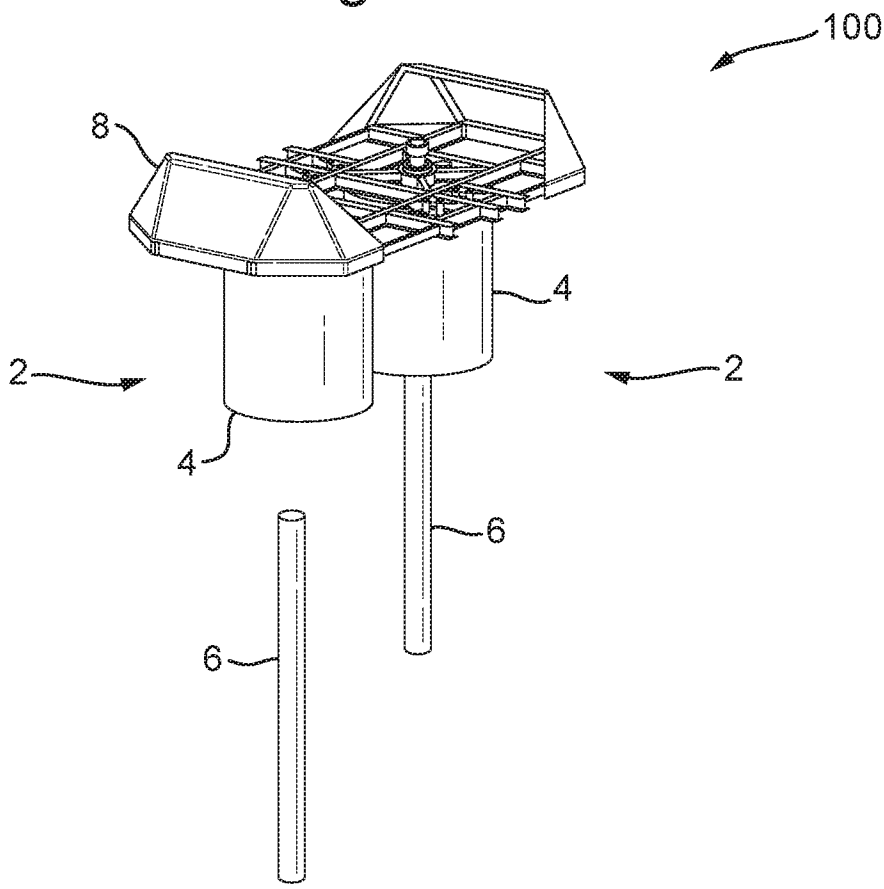


Fig. 3

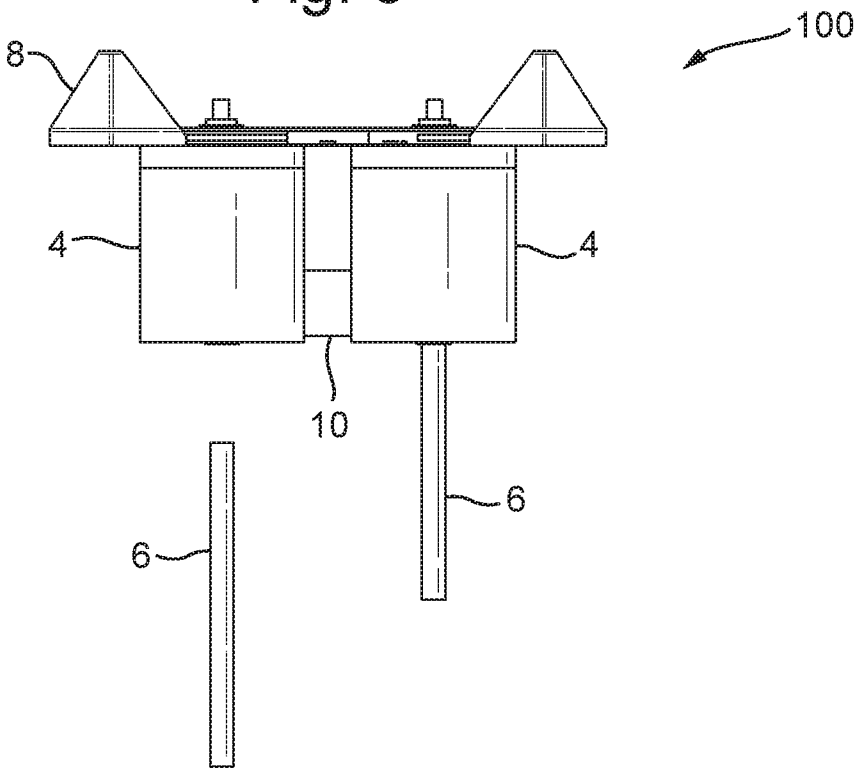


Fig. 4

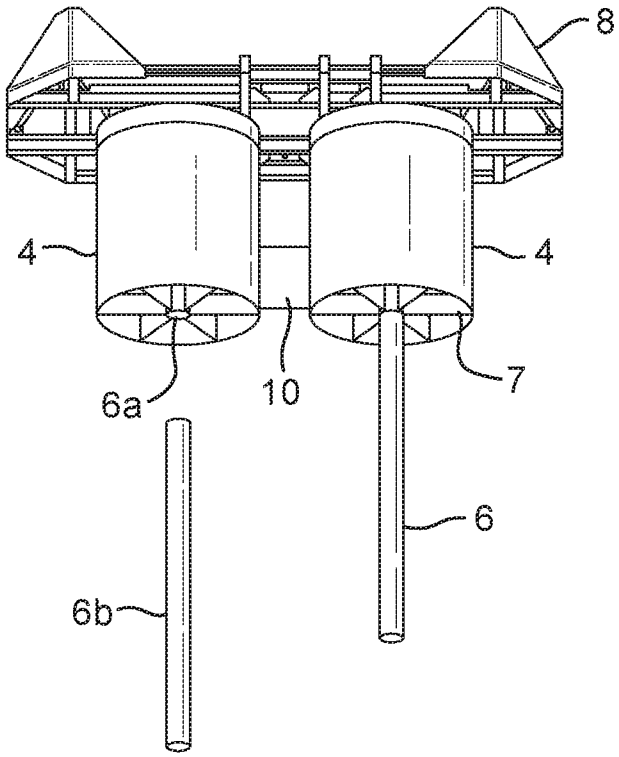


Fig. 5

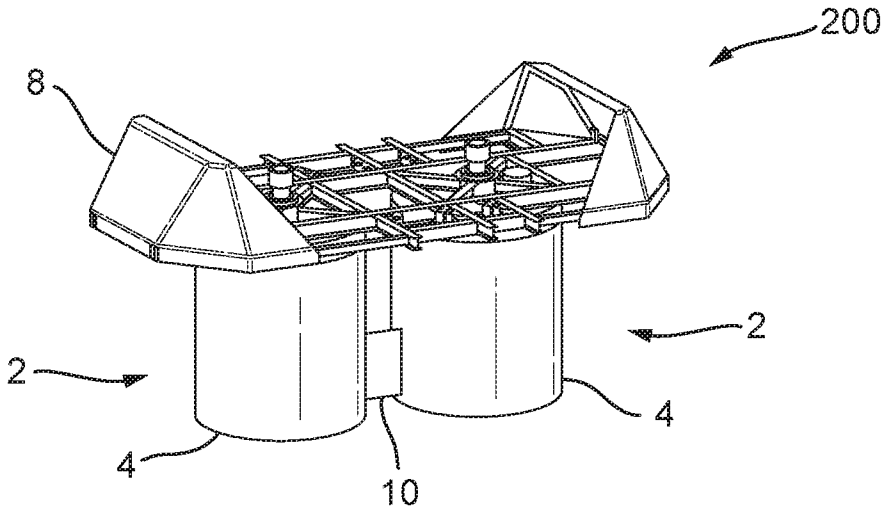


Fig. 6

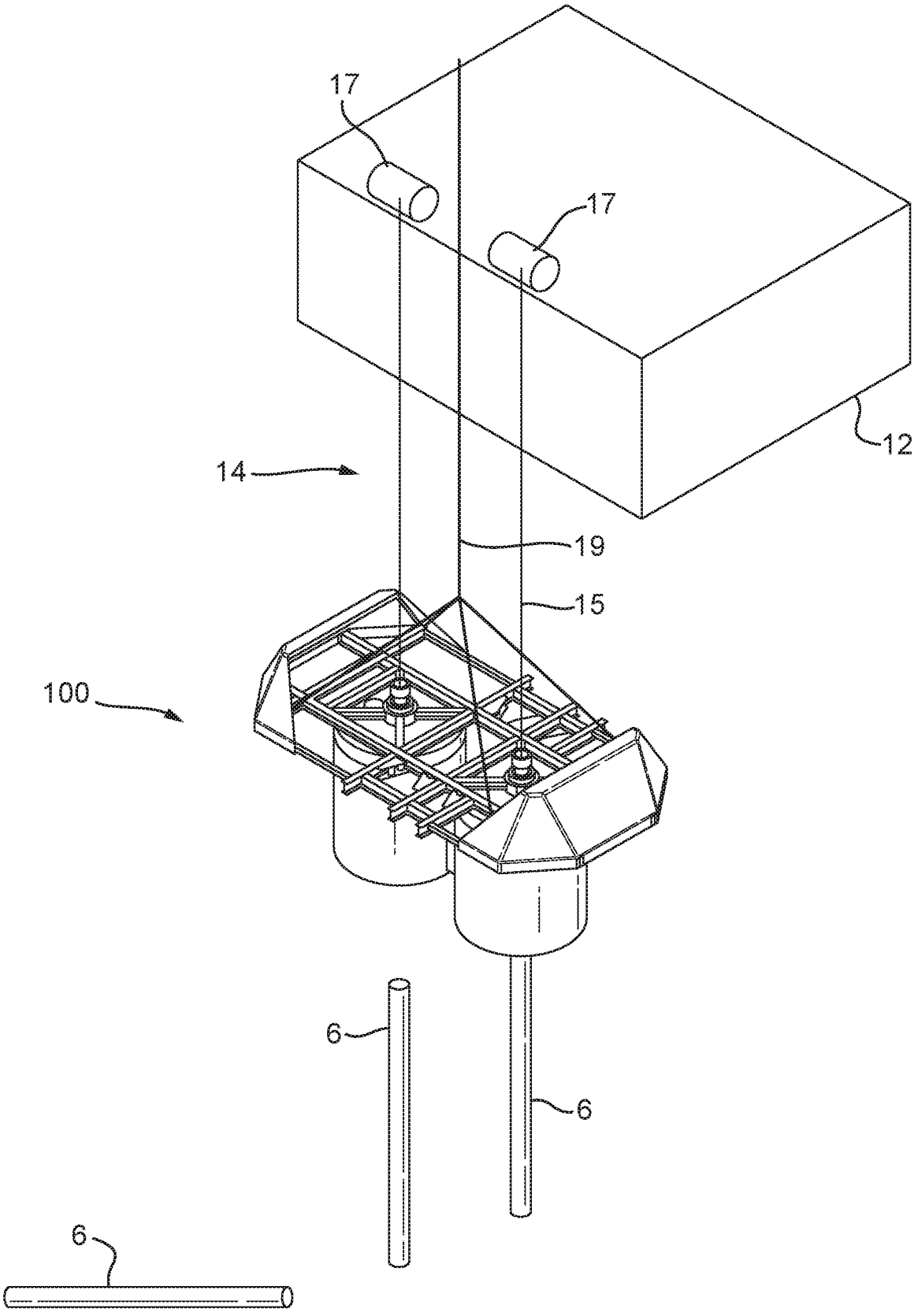


Fig. 7

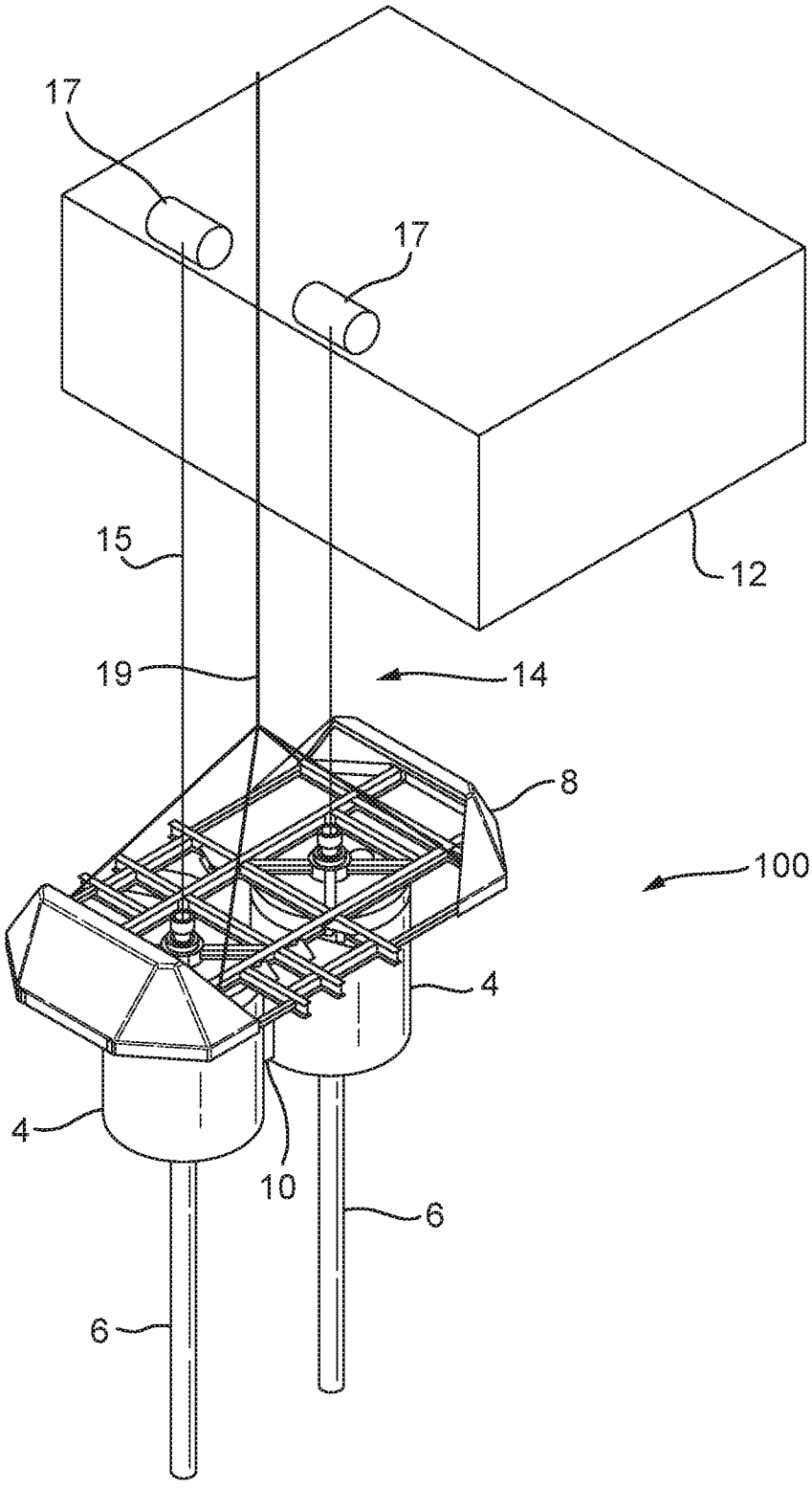


Fig. 8

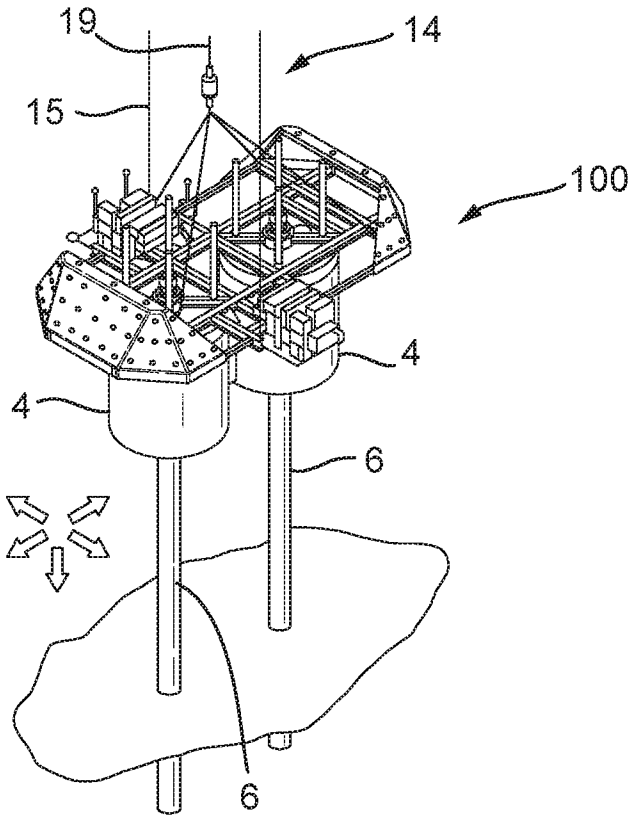


Fig. 9

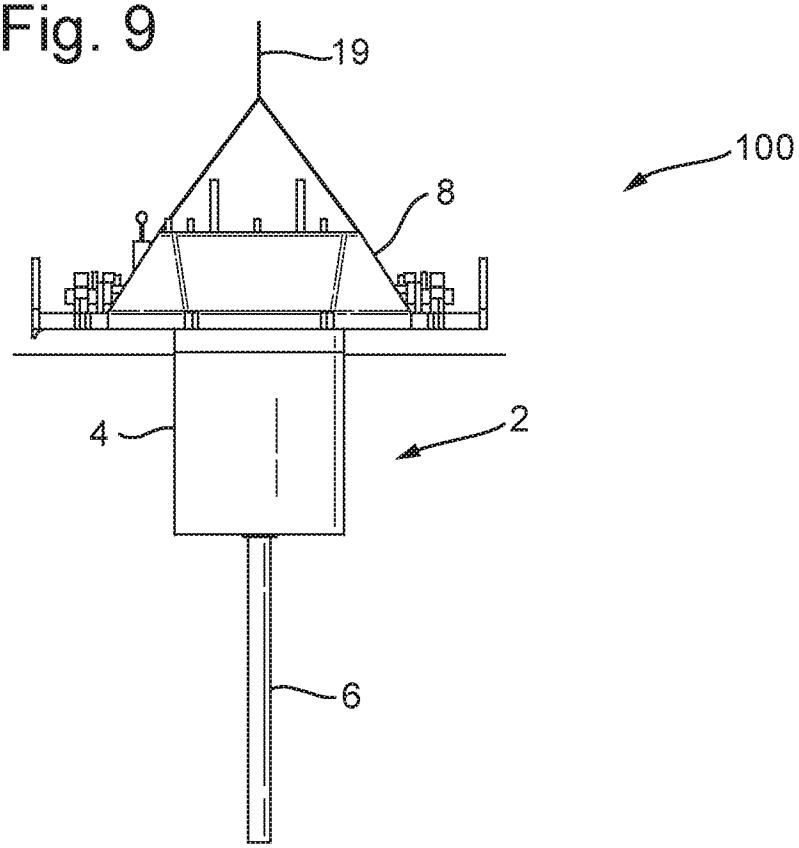


Fig. 10

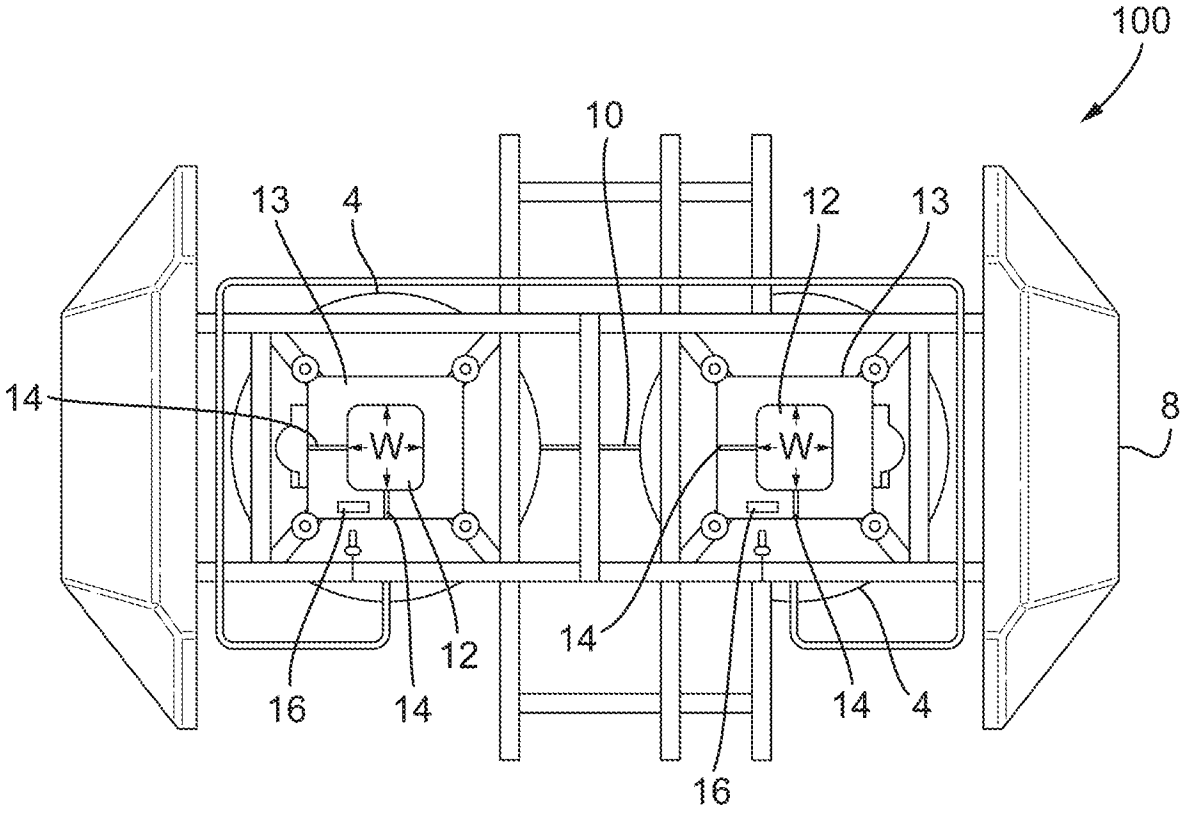
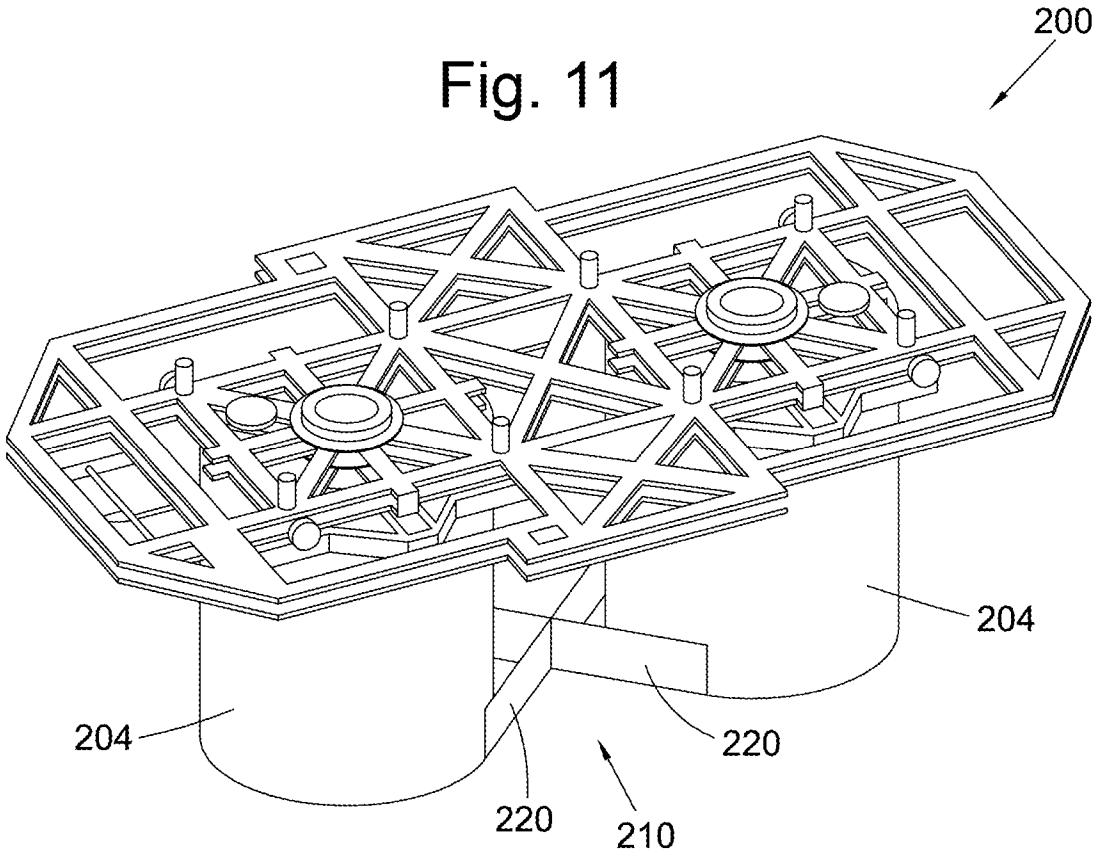


Fig. 11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO2017/050088

A. CLASSIFICATION OF SUBJECT MATTER

IPC: IPC: E02D 27/52 (200601), B63B 21/27 (200601), E21B 33/037 (200601)

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)

IPC: E21B, E02D, B63B

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

DK, NO, SE, FI: Classes as above.

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

WPI, EPODOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012/0003048 A1 (HOSØY, Ø. et al.) 2012.01.05 Paragraphs [0003], [0007], [0029], [0032], [0039], [0048], figs. 5-7.	1-12, 18-20, 28, 29
Y		13-17, 21-27, 35-39, 41, 46-57
X	US 6659182 B1 (SAUGIER, K. et al.) 2003.12.09 Abstract, col. 3 line 65-col. 4 line 12, col. 4 line 35-col. 6 line 14, figs. 3A-3D, 4A-4D.	1, 19
X	US 4830541 A (SHATTO, H.) 1989.05.16 Col. 1 lines 43-56, col. 3 line 64-col 4 line 28, figs. 1-4.	30-34, 40, 42-45, 58
Y		13-17, 21-27, 35-39, 41, 46-57
X	US 4558744 A (GIBB, P. R.) 1985.12.17 Col. 9 lines 10-29, figs. 31-33.	30-32, 34, 42, 43, 45, 58
A	WO 2015/118348 A1 (ENOVATE SYSTEMS LTD) 2015.08.13 Page 8 line 31-page 9 line 34, page 10 lines 23-34, figs. 1, 3, 5, 6a-6d.	1-58
A	JPS 6149029 A (NIPPON STEEL CORP) 1986.03.10 Abstract, figs. 1-6	1-58

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

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

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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"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
28/06/2017	30/06/2017
Name and mailing address of the ISA Nordic Patent Institute Helgeshøj Allé 81 DK - 2630 Taastrup, Denmark. Facsimile No. + 45 43 50 80 08	Authorized officer Kalland, Bjørn Inge Telephone No. +47 22 38 74 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO2017/050088

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1: Claims 1 and 19 are directed, respectively, to a method of installing a subsea foundation, the method comprising providing a suction anchor with an inner member and an outer suction skirt, and to a subsea foundation comprising a suction anchor with said features.

2: Claims 30 and 42 are directed, respectively, to a subsea foundation comprising a plurality of suction anchors and associated interconnection means, and to a method for installing a subsea foundation with said features.

In conclusion, the two groups of claims are not linked by common or corresponding special technical features and define two different inventions not linked by a single general inventive concept. The application, hence does not meet the requirements of unity of invention as defined in Rules 13.1 and 13.2 of PCT.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/NO2017/050088

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