(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 615 239 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
17.07.2013 Bulletin 2013/29

(51) Int Cl.:
E21B 4/18 *(2006.01)* ***E21B 7/20*** *(2006.01)*
E21B 21/00 *(2006.01)* ***E02D 7/26*** *(2006.01)*

(21) Application number: **13150026.6**

(22) Date of filing: **02.01.2013**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **02.01.2012 BE 201200003**

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(54) **Device and method for drilling shafts in a ground consisting of rock, clay and/or related materials**

(57) The invention relates to a device and method for drilling shafts in a ground consisting of rock, clay and/or related materials. The device (1) comprises a borehole casing (4) and means for arranging the borehole casing (4) in the ground (3); a drilling means (10) which can be lowered into the borehole casing (4) by means of a flexible suspension; wherein the drilling means (10) comprises a hollow drill string (5) provided with a drill head (7) with cutting tools (8) and means (13) for setting the drill string (5) into rotation, and wherein the drilling means (10) is further provided with securing means with which the drilling means (10) can be secured in the borehole casing, and with discharge means for dislodged ground material connected to the hollow drill string. The invention also relates to a lifting platform provided with the device. Using the invented device drilling can take place with higher efficiency than with the known device and method.

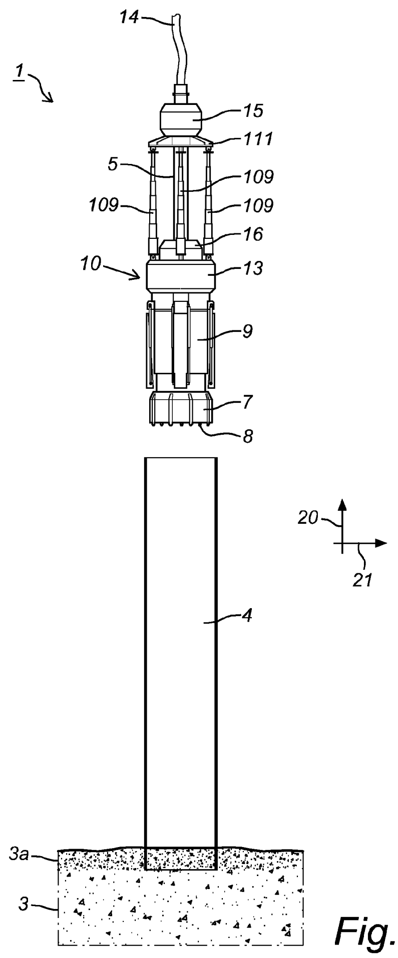

Fig. 1

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Description

[0001] The present invention relates to a device and method for drilling shafts in a ground consisting of rock, clay and/or related materials. The phrase "rock, clay and/or related materials" is understood to mean diverse types of ground which can form the ground layers of a water basin or a land area up to a very variable depth. Such ground layers for instance form part of sea arms, streams and rivers, docks, storage reservoirs, access channels to locks or inlet docks, and coastal sea areas. Rocky bottoms also fall within these types of ground. Drilling a shaft can for instance be necessary in order to arrange piles in the ground or to realize piles by filling the shaft with a binder during or after the drilling, and curing this binder.

[0002] Devices and methods for drilling shafts are for instance advantageous when arranging dolphins, mooring posts and/or piles of jetties (berthing) in hard bottoms. Another suitable application comprises of arranging in underwater bottoms pile foundations on which jackets and/or monopiles for wind turbines can be placed.

[0003] A known method for the drilling cavities or shafts in ground layers consisting of rock, clay and/or related materials comprises of arranging a borehole casing in the ground, lowering into the borehole casing a drill string built up of segments and provided with a drill head with cutting tools, then setting the drill string into rotation in the borehole casing so that ground material is dislodged by the cutting action of the cutting tools, and discharging the dislodged ground material. In order to be able to reach the desired drilling depth, the drill string is lengthened in the known method by adding segments thereto. For this purpose the drill string has to be moved in its entirety above ground level and optionally rotated to a horizontal position. Following lengthening the drill string is once again arranged in the borehole casing and set into rotation, wherein a greater depth can be reached.

[0004] The known method has the drawback, among others, that much time is lost in lengthening the drill string. This is detrimental to the drilling efficiency, this being understood to mean that the quantity of ground material drilled out per unit of time and power can be further increased.

[0005] The invention has for its object to provide a method and device for drilling shafts in a ground consisting of rock, clay and/or related materials which at least partially obviate the above stated and other drawbacks.

[0006] The invention provides for this purpose a device for drilling shafts in a ground consisting of rock, clay and/or related materials comprising a borehole casing and means for arranging the borehole casing in the ground; and a drilling means which can be lowered into the borehole casing by means of a flexible suspension; wherein the drilling means comprises a hollow drill string provided with a drill head with cutting tools and means for setting the drill string into rotation, and wherein the drilling means is further provided with securing means with which the drilling means can be secured in the borehole casing, and with discharge means for dislodged ground material connected to the hollow drill string.

[0007] Using the device according to the invention a method can be performed for drilling shafts in a ground consisting of rock, clay and/or related materials, comprising of arranging a borehole casing in the ground at a first depth, this such that it admits substantially no water on its underside, lowering into the borehole casing by means of a flexible suspension a drilling means which comprises a hollow drill string provided with a drill head with cutting tools and means for setting the drill string into rotation, securing the drilling means in the borehole casing, then setting the drill string into rotation in the borehole casing so that ground material is dislodged by the cutting action of the cutting tools, and discharging the dislodged ground material via discharge means connected to the hollow drill string.

[0008] It has been found that with the method and device according to the invention the drilling efficiency is increased markedly relative to the known method, among other reasons because the drill head can be carried deeper into the ground without a time-consuming extension of the drill string by arranging additional drill string segments being necessary for this purpose. This is because according to the invention the drilling means lowerable into the borehole casing comprises the means necessary for setting the drill string (and cutting tools) into rotation. By securing the drilling means both in the longitudinal direction of the borehole casing and perpendicularly thereof (the radial direction) against the inner wall of the borehole casing using the securing means the drilling forces can be absorbed in effective manner by transmitting these forces to the borehole casing. Because the length of the drill string is relatively short (corresponding roughly to the length of the drilling means) the drilling torque can be transmitted with little or no loss to the ground.

[0009] A further advantage of the invention is that the working safety is also increased; people are after all no longer present in the vicinity of rotating parts or at great heights, as is the case in the known method.

[0010] An embodiment of the device according to the invention comprises means for maintaining a water column in the borehole casing, which water column maintains a flow in the hollow drill string for the purpose of discharging the dislodged ground material. The water column which is arranged in the borehole casing, and which otherwise extends into the space between the borehole casing and the drilling means lowered into the borehole casing and disposed substantially coaxially with the borehole casing, provides for a pressure difference between the upper side of the discharge means for dislodged ground material connected to the drill string and the underside of the drill string, wherein the pressure is of course higher on the underside. A flow is hereby maintained in the hollow drill string, and thus also in the discharge means connected to the drill string, in which flow the dislodged ground material is discharged to the upper side of the discharge means, which comprise for instance a discharge hose connected to the upper side of the drill string. In order not to lose water pressure unnecessarily, the borehole casing is preferably arranged in a manner such that it admits substantially no water on its underside. The borehole casing is generally placed for this purpose on or in the (underwater) bottom, so creating a good seal and water sealing at the lower outer end of the borehole casing. If the water sealing is insufficient, use can also be made of a (dredge) pump to discharge dislodged ground material. Because the drilling means according to the invention must be received in the borehole casing, the borehole casing has somewhat greater transverse dimensions than the drilling means. The borehole casing preferably takes a cylindrical form, wherein a preferably also substantially cylindrical drilling means can be lowered into the borehole casing in a direction corresponding to the longitudinal direction of the borehole casing.

[0011] The invention provides a device comprising translation means for displacing the drill head over a determined stroke length in the longitudinal direction of the borehole casing, wherein the drilling means is in secured state. The drilling means more particularly comprises translation means for moving the drill head out of the borehole casing or retracting it into the borehole casing over a determined stroke length. The stroke length can be selected by the skilled person depending on conditions, or is adjustable.

[0012] In a preferred embodiment the translation means are adapted to provide for a stroke length such that the drill head can extend deeper than a lower edge of the borehole casing.

[0013] This embodiment makes it possible to displace the drill head through a determined stroke length in the longitudinal direction of the borehole casing, wherein the drilling means is in secured state, whereby the drill head can reach a greater depth without it being necessary to release the secured state of the drilling means. If desired, the drill head can extend deeper here than the lower edge of the borehole casing. Although in principle any stroke length of the drill head can be set, in a preferred embodiment the stroke length of the drill head is limited to 2 metres, and more preferably to 1.5 metres. Such a relatively limited stroke length makes it possible to likewise limit the dimensions of the drilling means in the longitudinal direction of the borehole casing to 10 metres, more preferably to 5 metres, and most preferably to 3 metres.

[0014] An embodiment of the invention provides translation means in the form of jacks slidable into each other and/or hydraulic cylinders.

[0015] Being able to move the drill head out of the borehole casing allows ground layers lying deeper than the underside of the borehole casing to be provided with a shaft. Because the structure of the ground is weakened at this position, the borehole casing can penetrate more easily into the ground. If desired, use can be made of so-called underreaming. In underreaming the drill string is provided on the drill head outer end with a construction having radially fold-out side arms. When drilling is carried out with the arms in the folded-out position a borehole will be created which is wider than the diameter drilled by the drill head. The ground directly beneath the borehole casing is hereby drilled away and the borehole casing can be moved even deeper into the ground. Underreaming is also applied when a wider foot must be drilled in order to obtain extra pile bearing capacity or anchoring.

[0016] The drilling means can be secured at the desired depth in the borehole casing using any securing means suitable for the purpose. A preferred embodiment according to the invention provides a device wherein the securing means comprise wedge-like peripheral parts which run in the longitudinal direction of the borehole casing and co-act such that a relative translation of the peripheral parts in the longitudinal direction provides for a radial clamping force between the drilling means and the borehole casing. It has been found that such a manner of fixing the drilling means relative to the borehole casing produces a clamping force which is sufficiently great to be able to absorb and transmit the forces occurring during the drilling to the borehole casing. The clamping force ensures here that movement of the drilling means in the longitudinal direction of the borehole casing and perpendicularly thereof (in the peripheral direction of the borehole casing) is substantially prevented.

[0017] In an embodiment of the device the securing means comprise, preferably hydraulic, jacks for the relative translation of the wedge-like peripheral parts in the longitudinal direction of the borehole casing.

[0018] Although the flexible suspension of the drilling means can comprise any suitable means, such as for instance a cable, it is advantageous in respect of simplicity to characterize the device according to the invention in that the flexible suspension of the drilling means comprises the discharge means for dislodged ground material connected to the hollow drill string.

[0019] The device comprises means with which the borehole casing can be arranged in the ground. In an embodiment of the invention a device is provided wherein the means for arranging the borehole casing in the ground comprise an oscillator. It is advantageous to provide the device on a lifting platform anchored in the vicinity of the shafts to be formed, although this is not essential according to the invention.

[0020] In an embodiment such a lifting platform comprises an adjustable outboard frame (an 'outrigger') provided with the means for arranging the borehole casing in the ground, such as preferably an oscillator. The means for arranging the borehole casing in the ground are preferably adapted to arrange the borehole casing in the ground at an angle to the vertical direction other than zero. This can for instance be achieved by connecting the oscillator to the frame for pivoting around a substantially horizontal axis so that the oscillator can be tilted at an angle to the horizontal direction other than zero. In the context of the present application the vertical direction designates the direction running substantially perpendicularly of the water surface. In the context of the present invention the horizontal direction designates the direction running substantially parallel to the water surface.

[0021] A further embodiment of the device according to the invention comprises a drill head connected to feed lines and provided with substantially radially outward directed nozzles and adapted to inject a first fluid into the ground at the position of the drill head under a first pressure of at least 200 bar, more preferably at least 350 bar, and most preferably at least 500 bar. Using the present preferred embodiment the nozzles can be positioned such that they inject the first fluid substantially radially outward into ground layers situated at a greater depth than the lower outer end of the borehole casing. It has been found that this preferred embodiment renders the use of an underreaming construction unnecessary, whereby the borehole casing can be moved in relatively simple manner to a greater depth. The drilling efficiency is moreover further increased. The radially outward directed first fluid jets do indeed ensure that the ground is at least partially removed or weakened at the position of the underside of the borehole casing, so that the borehole casing can move deeper into the ground. An additional advantage hereof is that less deep drilling is necessary in order to achieve the same shaft depth. The first fluid can comprise any injectable substance, although particularly suitable is water to which additives, such as for instance abrasives and other abrading means, are added if desired.

[0022] Yet another embodiment of the invented device also comprises means connected to feed lines and adapted to inject a second fluid into the hollow drill string of the drilling means at the position of the drill head under a second pressure of a maximum of 50 bar, more preferably a maximum of 30 bar, and most preferably a maximum of 20 bar. The second fluid preferably has a lower density than water, whereby this second fluid rises and expands in the drill string (and the discharge means connected thereto), whereby the upward flow is further supported. A particularly suitable second fluid comprises air.

[0023] The invention likewise relates to a method to be performed with the device for drilling shafts in a ground consisting of rock, clay and/or related materials. According to the invented method a borehole casing is arranged in the ground at a first depth, this such that it preferably admits substantially no water on its underside. The borehole casing is arranged in the ground by for instance oscillation, pile-driving and/or vibration. Preferably provided here is a lifting platform provided with an outrigger, wherein the borehole casing is arranged from the frame into the ground at an angle to the vertical direction differing if desired from zero.

[0024] A drilling means is then lowered by means of a flexible suspension into the borehole casing to a position in the vicinity of the underside of the borehole casing. The drilling means comprises a hollow drill string provided with a drill head with cutting tools, and means for setting the drill string into rotation, and is secured in the borehole casing at said position. In a preferred embodiment of the method the securing means comprise wedge-like peripheral parts which run in the longitudinal direction of the borehole casing and co-act such that a relative translation of the peripheral parts in the longitudinal direction provides for a radial clamping force between the drilling means and the borehole casing, wherein the wedge-like peripheral parts are translated until a radial clamping force between the drilling means and the borehole casing is obtained which is sufficient to substantially secure the drilling means both in the longitudinal direction of the borehole casing and in the rotation direction of the drill head.

[0025] The drill string (and so also the drill head) is then set into rotation in the borehole casing so that ground material is dislodged by the cutting action of the cutting tools. The ground material can here be a soil plug formed in the borehole casing as well as ground material lying deeper than the underside of the borehole casing. The dislodged ground material is discharged via discharge means, for instance in the form of a flexible discharge hose, connected to the hollow drill string. A preferred method comprises of arranging in the borehole casing a water column which maintains a flow in the hollow drill string and with which the dislodged ground material is discharged, as already described above. In order to further facilitate the transport of the dislodged ground material in the hollow drill string and the preferably flexible discharge means connected thereto, an embodiment of a method is provided wherein a second fluid is injected into the hollow drill string of the drilling means at the position of the drill head under a second pressure of a maximum of 50 bar, more preferably a maximum of 30 bar, and most preferably a maximum of 20 bar, whereby the flow for the purpose of upward discharge of the dislodged ground material is supported. The second fluid preferably has a lower density than water, and more preferably comprises air.

[0026] In order to be able to drill a deeper shaft an embodiment of the method is applied wherein the borehole casing is moved to a second depth greater than the first depth, the drill head is moved deeper into the borehole casing and the drill string is rotated so that ground material is dislodged by the cutting action of the cutting tools and discharged via the discharge means connected to the hollow drill string.

[0027] In order to further increase the drilling efficiency and facilitate penetration of the borehole casing into the ground, a method is provided in a preferred embodiment wherein a first fluid is injected substantially radially outward into the ground at the position of the drill head under a first pressure of at least 200 bar, more preferably at least 350 bar, and most preferably at least 500 bar. The first fluid preferably comprises water.

[0028] Other details and advantages of the invention will become apparent from the following description of a device and method for drilling shafts in a ground consisting of rock, clay and/or related materials. This description is given solely by way of example, without the invention being limited thereto. The reference numerals relate to the accompanying figures. In the figures:

figure 1 is a schematic side view of an embodiment of the device according to the invention;
figure 2 is a schematic side view of the embodiment shown in figure 1 wherein the drilling means is in the lowered state;
figure 3 is a schematic side view of the embodiment shown in figure 2 wherein the drilling means is in the secured state;
figure 4 is a schematic perspective view of the embodiment shown in figure 3 wherein the drill head of the drilling means has formed a shaft in the ground;
figures 5A, 5B and 5C show a number of successive steps of an embodiment of the method according to the invention;
figures 6A, 6B, 6C and 6D show a number of other successive steps of an embodiment of the method according to the invention;
figure 7 is a schematic side view of an assembly of a lifting platform with an embodiment of the device according to the invention; and
figure 8 shows the embodiment of figure 7 with the drilling means in lowered state in the borehole casing.

[0029] Referring to figure 1, a device 1 is shown for drilling a shaft 2 in a ground layer 3. Ground layer 3 preferably comprises rock, but may also comprise clay and/or related materials. The ground layer 3 may be covered with a top layer 3a (also referred to as overburden), which generally comprises somewhat more loosely packed stone. Device 1 comprises a borehole casing 4 which can be arranged over at least part of its length in ground 3 by means of for instance pile-driving, oscillation or vibration. In the situation shown in figure 1 borehole casing 4 has been driven into overburden 3a. The diameter of borehole casing 4 can in principle be chosen within wide limits, but preferably amounts to at least 1 m, more preferably at least 2 m, still more preferably at least 4 m and most preferably at least 6 m. Because borehole casing 4 supports on its underside on a ground layer 3, a substantially water-impermeable sealing is achieved, though this may depend to some extent on the properties of ground layer 3 and is not therefore essential to the invention. In the shown embodiment borehole casing 4 comprises a thick-walled steel tube which is suitable for withstanding the forces exerted during insertion of borehole casing 4 into ground layer 3 and the drilling.

[0030] Borehole casing 4 is sufficiently large to provide space for a drilling means 10, which can be lowered by means of a flexible suspension in the form of cable 26 (see figure 7) into borehole casing 4 to a position at a height of the underside of borehole casing 4. Drilling means 10 comprises a hollow drill string 5 which is provided on the side facing toward the ground 3 with a drill head 7 with cutting tools 8. Drill string 5 is received in a housing 9 (in figure 4 the housing is cut-away and therefore not visible), the peripheral surface of which is provided with securing means with which drilling means 10 can be secured in borehole casing 4. In the shown embodiment the securing means comprise four wedge-like peripheral parts (11, 12) distributed evenly over peripheral surface 9 and running in longitudinal direction 20 of borehole casing 4. Peripheral parts 11 are fixedly connected to the peripheral surface of housing 9 and have a thickness increasing in upward direction. Peripheral parts 12 are connected for translation in longitudinal direction 20 to the peripheral surface of housing 9 and have a thickness increasing in downward direction. By means of jacks 110 connected to the fixed peripheral parts 11 (see figure 2) the movable peripheral parts 12 can be translated in longitudinal direction 20 relative to the fixed peripheral parts 11, this from a position as shown in figure 2, in which they lie in a lowermost position, to a position as shown in figure 3 in which they lie in an uppermost position. Owing to the varying thickness of the peripheral parts (11, 12) the movable peripheral parts 12 co-act in their upper position with the fixed peripheral parts 11 such that a clamping force is created in radial direction 21 between drilling means 10 and the borehole casing 4. The developed clamping force substantially prevents a movement of drilling means 10 in longitudinal direction 20, radial direction 21 and peripheral direction 22.

[0031] In order to increase the weight of drill head 7, drill string 5 is provided in the shown embodiment with a weighting collar 15 which simultaneously serves as stop. The height position 17 of collar 15 relative to upper part 16 of drilling means 10 in the uppermost position of drill head 7 (see figure 2) therefore defines the maximum stroke length of drill head 7.

[0032] Drilling means 10 is further provided with means in the form of a rotary motor 13 for setting drill string 5 (and so also drill head 7) into rotation and translation, and with discharge means for dislodged ground material 21 in the form of a flexible hose 14 connected to the hollow drill string 5. The means for setting drill string 5 into translation in longitudinal direction 20 of borehole casing 4 comprise four jacks 109 which are slidable into each other and connect the upper part of the housing of rotary motor 13 to a web plate 111 of weighting collar 15. The hollow drill string 5 and the flexible hose together form a central cavity 6 through which dislodged ground material 21 can be discharged. The translating of drill string 5 by motor 13 takes place in longitudinal direction 20 of borehole casing 4 so that drill head 7 can hereby be moved out of or retracted into borehole casing 4.

[0033] The means for setting drill string 5 into rotation and translation preferably comprise a transmission in the form of a swivel provided with motor 13. The transmission is designed such that it can transfer a fluid flow through cavity 6 from the stationary part (discharge hose 14) to the rotating part (drill shaft 5) of the device. The transmission is further suitable for transmitting the necessary torque from the stationary to the rotating part of the device and for discharging the water-ground material mixture 3. The transmission is further suitable for retaining these properties under the influence of the vibrations which inevitably occur during the drilling.

[0034] By setting drill string 5 into rotation and translation on the upper side thereof the drill head 7 is likewise set into rotation and translation in longitudinal direction 20 of borehole casing 4, this direction 20 also being the drilling direction, wherein ground 3 is crushed by the action of cutting tools 8 and a shaft 2 is formed. Although borehole casing 4 and drill string 5 run substantially vertically in the shown figures, they can be adjusted to any angle to the vertical direction other than zero, for instance from a jack-up platform or pontoon (see figures 7 and 8) or from the shore when the device forms part of for instance a vehicle.

[0035] In the shown embodiment device 1 is also provided with means (not shown) for maintaining a water column in borehole casing 4, for instance in the form of a pump with sufficient rise height and flow rate (typically for instance 1000 m^3/h) so as to maintain the highest possible water level in borehole casing 4. The water column provides for a pressure difference between the upper side of flexible discharge hose 14 at the position of the water level and the underside of drill string 5 at the position of cutting tools 8, wherein the pressure is of course higher on the underside. Owing to this pressure difference and because borehole casing 5 is open on the underside, so that a throughfeed is possible to cavity 6, water and dislodged ground material 21 flow into cavity 6. An upward flow is thus maintained in cavity 6 of drill string 5 and discharge hose 14, in which flow the dislodged ground material 21 (see figure 4) is discharged to the upper side of discharge hose 14, where it is discharged to for instance a storage reservoir (not shown) via an overflow. The water pressure is substantially maintained due to the substantially water-tight sealing between the underside of borehole casing 4 and ground 3.

[0036] In order to further increase the discharge of dislodged ground material 21 through cavity 6 of drill string 5 and discharge hose 14, a preferred variant also comprises means for injecting air under a second pressure into the hollow drill string 5 at the position of drill head 7. These means (not shown) comprise feed lines which are arranged on drill string 5 and which are connected at the one outer end to a compressor and which debouch at the other outer end into cavity 6 of drill string 5 via air inlet valves. The compressor ensures that air is carried under a certain pressure through the lines and enters the upward flow in cavity 6. Because the compressed air has a lower density than the water flowing in cavity 6, the air rises as bubbles in drill string 5, whereby the upward flow is supported. The drilling efficiency is hereby increased.

[0037] Drill head 7 of device 1 according to the invention can further be provided with nozzles directed outward in radial direction 21 for injecting a first fluid, preferably water, under a first pressure into ground layers 3 at the position of drill head 7. The device is provided for this purpose with feed lines (not shown) for feeding the first fluid to the nozzles. The lines are connected to pressure means such as a pump or compressor for bringing the first fluid under pressure. The nozzles are preferably mounted on drill head 7 so that they co-rotate with the drill head, although mounting on for instance the peripheral surface of housing 9 of drilling means 10 is likewise possible. Nozzles 25 are preferably suitable for injecting the water under a first pressure of at least 200 bar, more preferably at least 350 bar, still more preferably at least 500 bar and most preferably at least 650 bar. Because the nozzles are directed substantially radially outward, the water jets are injected into ground layer 3 at a greater depth than the lower outer end of borehole casing 4. Extra ground material is hereby removed or at least weakened at the position of the underside of borehole casing 4, whereby borehole casing 4 can move deeper into the ground 3.

[0038] The feed lines for the first and second fluid can be long, particularly in the case of drilling at great depth. These lines are preferably carried substantially without bends from the upper side of device 1 to the lower part of drill string 5 and/or drill head 7. Pressure losses are hereby prevented as far as possible.

[0039] Referring to figures 7 and 8, a lifting platform 30 is shown which is provided with a device 1 according to the invention. Such an embodiment is particularly suitable for arranging pile foundations, on which jackets and/or monopiles for wind turbines can be placed, in underwater bottoms.

[0040] The shown lifting platform 30 is anchored in the underwater bottom by means of spud piles 31 and can be further provided with a crane 32 and, if desired, other auxiliary means. Lifting platform 30 further comprises an outrigger 33. Outrigger 33 is provided with means for arranging borehole casing 4 in ground 3, which means comprise in the shown embodiment an oscillator 34 which, if desired, is adapted to arrange borehole casing 4 in the ground at an angle 35 to the vertical direction 40 other than zero, as shown in figure 8. Frame 33 also allows positioning of borehole casing 4 within the required tolerance.

[0041] Referring to figures 5A-5C and 6A-6D, a number of steps are shown of an embodiment of the method according to the invention. The jacks (109, 110) are not shown in the figures for the sake of clarity. From the platform 30 shown in figure 7 and/or 8 a borehole casing 4 is first driven into ground 3 to a first depth, which corresponds for instance to the depth of overburden 3a (see figure 5A). The borehole casing preferably admits substantially no water on its underside. The depth to which borehole casing 4 can be carried into ground 3 typically depends on the chosen arranging technique and on the properties of the ground at this depth. At the insertion depth of borehole casing 4 the ground 3 is preferably a hard layer such as rock, limestone, hard clay or highly compacted sand. Overburden 3a usually comprises more easily penetrable soil such as for instance weathered rock, clay, peat, loosely compacted sand.

[0042] The drilling means 10 suspended from a flexible cable 26 is then lowered by means of crane 32 into borehole casing 4 from the position shown in figure 1 to a position as shown in figure 5A, in which the underside of drill head 7 lies at the level of the underside of borehole casing 4. In order to reach this level it may be necessary to have drill head 7 rotate in order to crush a ground material plug formed in borehole casing 4 and discharge it via the hollow drill shaft 5 and discharge line 14. As shown in figure 5A, drilling means 10 is secured in borehole casing 4 by relative translation of the peripheral parts 11, 12, as already described above. Drill string 5 is then set into rotation in borehole casing 4 with rotary motor 13 so that ground material 3 is dislodged by the cutting action of cutting tools 8, wherein drill head 7 moves in the longitudinal direction 20 of borehole casing 4 into ground 3 to a depth at which collar 15 makes contact with upper part 16 of drilling means 10 (figure 5B). The loosened ground material 3 is discharged during drilling via the flexible discharge hose 14 connected to the hollow drill string 5, if desired using a water column arranged in borehole casing 4 and by introducing air into discharge cavity 6, this as described in more detail above.

[0043] Drill head 7 is subsequently retracted by rotary motor 13 to a position in which the underside of drill head 7 lies slightly above the level of the underside of borehole casing 4 (figure 5C), for instance over a distance roughly equal to the thickness of overburden 3a. At this moment a shaft 2 has been created with a depth corresponding to the stroke length 17 of collar 15.

[0044] In order to further deepen the formed shaft 2, borehole casing 4 is then moved to a second depth greater than the first depth as shown in figure 6A using oscillator 34 on platform 30 or using another suitable pile-driving means. Lowering of borehole casing 4 into ground 3 is facilitated here by the presence of shaft 2. As shown in figures 6B and 6C, drill head 7 is then moved deeper into borehole casing 4 and drill string 5 is rotated so that further ground material 3 is dislodged by the cutting action of cutting tools 8 and discharged via the discharge hose 14 connected to the hollow drill string 5. In order to reach the desired depth it may be necessary to uncouple drilling means 10 from borehole casing 4 by deactivating the securing means 11, 12, lowering drilling means 10 into borehole casing 4 to the desired height, and subsequently securing drilling means 10 once again by activating the securing means 11, 12 as described in more detail above.

[0045] Drill head 7 is then once again retracted into borehole casing 4 by rotary motor 13 to a position in which the underside of drill head 7 lies slightly above the level of the underside of borehole casing 4, after which borehole casing 4 is driven together with drill head 7 further into the ground to a greater depth as shown in figure 6D. The above described sequence can then be repeated any number of times until the desired depth of shaft 2 has been reached. At that moment, drilling means 10 is released from borehole casing 4 by deactivating the securing means, and the drilling means is raised by means of crane 32.

[0046] The invented device and method are particularly suitable for drilling shafts of relatively large diameters in composite grounds so as to enable forming and/or arranging of foundation piles therein, wherein any desired depth can be reached without the drilling having to be interrupted at any time for assembly purposes.

[0047] The invention is not limited to the embodiment described here, and many modifications could be made thereto, to the extent these modifications fall within the scope of the appended claims.

Claims

1. Device (1) for drilling shafts (2) in a ground (3) consisting of rock, clay and/or related materials, comprising a borehole casing (4) and means for arranging the borehole casing (4) in the ground (3); and a drilling means (10) which can be lowered into the borehole casing (4) by means of a flexible suspension; wherein the drilling means (10) comprises a hollow drill string (5) provided with a drill head (7) with cutting tools (8) and means (13) for setting the drill string (5) into rotation, and wherein the drilling means (10) is further provided with securing means with which the drilling means (10) can be secured in the borehole casing; wherein the device is further provided with discharge means for dislodged ground material (21) connected to the hollow drill string and with translation means (109) for displacing the drill head (7) over a determined stroke length in the longitudinal direction of the borehole casing (4), wherein the drilling means (10) is in secured state.

2. Device as claimed in claim 1, wherein the translation means (109) are adapted to provide for a stroke length such that the drill head (7) can extend deeper than a lower edge of the borehole casing (4).

3. Device as claimed in claim 1 or 2, wherein the translation means comprise jacks slidable into each other and/or hydraulic cylinders.

4. Device as claimed in any of the foregoing claims, further comprising means for maintaining a water column (11) in the borehole casing (4), which water column maintains a flow in the hollow drill string (5) for the purpose of discharging the dislodged ground material (21).

5. Device as claimed in any of the foregoing claims, wherein the securing means comprise wedge-like peripheral parts (11, 12) which run in the longitudinal

direction of the borehole casing and co-act such that a relative translation of the peripheral parts (11, 12) in the longitudinal direction (20) provides for a radial clamping force between the drilling means (10) and the borehole casing (4).

6. Device as claimed in claim 5, wherein the securing means comprise jacks for the relative translation of the wedge-like peripheral parts (11, 12) in the longitudinal direction (20) of the borehole casing (4).

7. Device as claimed in any of the foregoing claims, wherein the flexible suspension (26) of the drilling means (10) comprises the discharge means (14) for dislodged ground material (21) connected to the hollow drill string (5).

8. Device as claimed in any of the foregoing claims, wherein the means for arranging the borehole casing (4) in the ground (3) comprise an oscillator (34).

9. Device as claimed in any of the foregoing claims, wherein the drill head (7) is provided with nozzles which are connected to feed lines and directed substantially radially outward and which are adapted to inject a first fluid into the ground (3) at the position of the drill head (7) under a first pressure of at least 200 bar, more preferably at least 350 bar, and most preferably at least 500 bar.

10. Device as claimed in any of the foregoing claims, wherein the device comprises means connected to feed lines and adapted to inject a second fluid into the hollow drill string (5) of the drilling means (10) at the position of the drill head (7) under a second pressure of a maximum of 50 bar, more preferably a maximum of 30 bar, and most preferably a maximum of 20 bar.

11. Lifting platform provided with a device as claimed in any of the claims 1-10.

12. Lifting platform as claimed in claim 11, comprising an adjustable outboard frame (outrigger) provided with the means for arranging the borehole casing (4) in the ground (3).

13. Lifting platform as claimed in claim 11 or 12, wherein the means for arranging the borehole casing (4) in the ground (3) are adapted to arrange the borehole casing in the ground at an angle to the vertical direction other than zero.

14. Method for drilling shafts (2) in a ground (3) consisting of rock, clay and/or related materials, comprising of providing a device as claimed in any of the foregoing claims, arranging the borehole casing (4) in the ground (3) at a first depth, this such that it admits substantially no water on its underside, lowering the drilling means (10) into the borehole casing (4) by means of a flexible suspension, securing the drilling means (10) in the borehole casing, then setting the drill string (5) into rotation in the borehole casing (4) so that ground material (21) is dislodged by the cutting action of the cutting tools (8), moving the borehole casing (4) to a second depth greater than the first depth, displacing the drill head (7) over a determined stroke length to a greater depth in the borehole casing (4) by means of the translation means (109), wherein the drilling means (10) is in secured state, rotating the drill string so that ground material (21) is dislodged by the cutting action of the cutting tools (8) and discharging the dislodged ground material (21) via discharge means connected to the hollow drill string (5).

15. Method as claimed in claim 14, wherein the stroke length is such that the drill head (7) extends deeper than a lower edge of the borehole casing (4).

16. Method as claimed in claim 14 or 15, wherein a lifting platform is provided which is provided with an outrigger, and wherein the borehole casing (4) is arranged from the frame into the ground at an angle to the vertical direction other than zero.

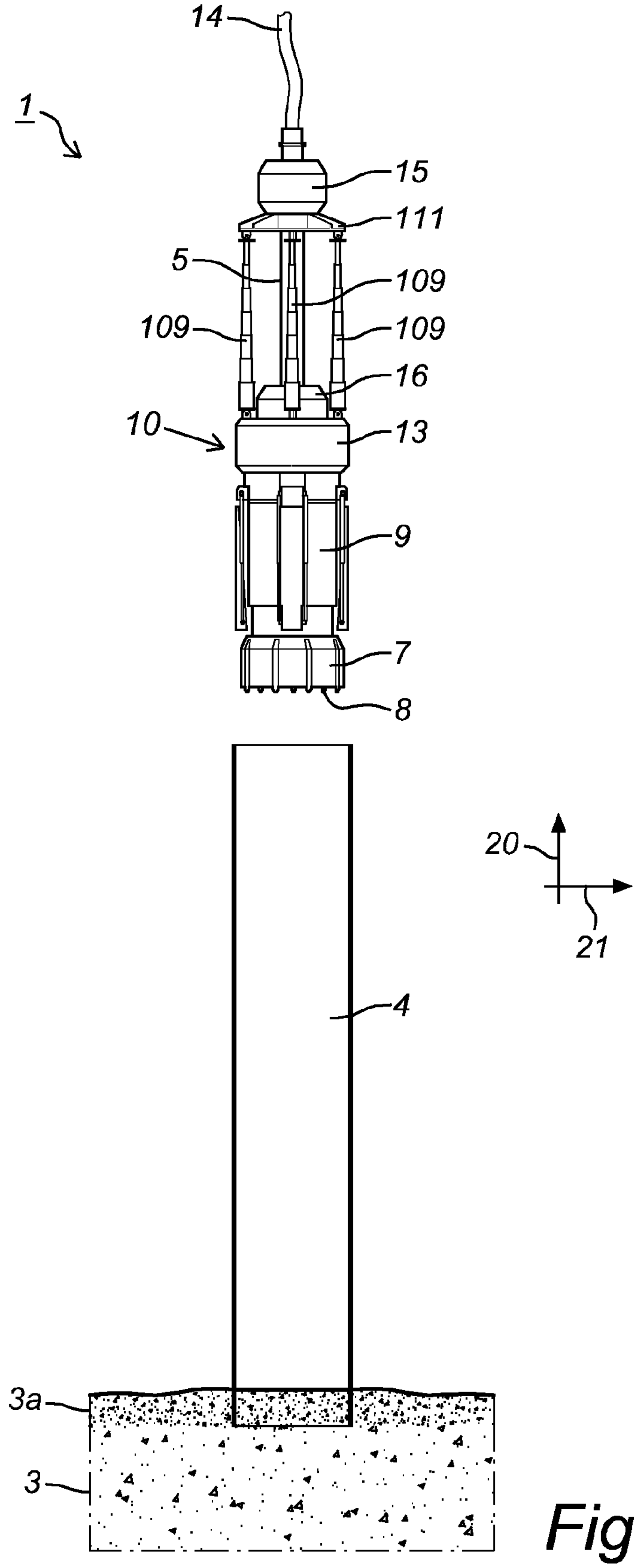

Fig. 1

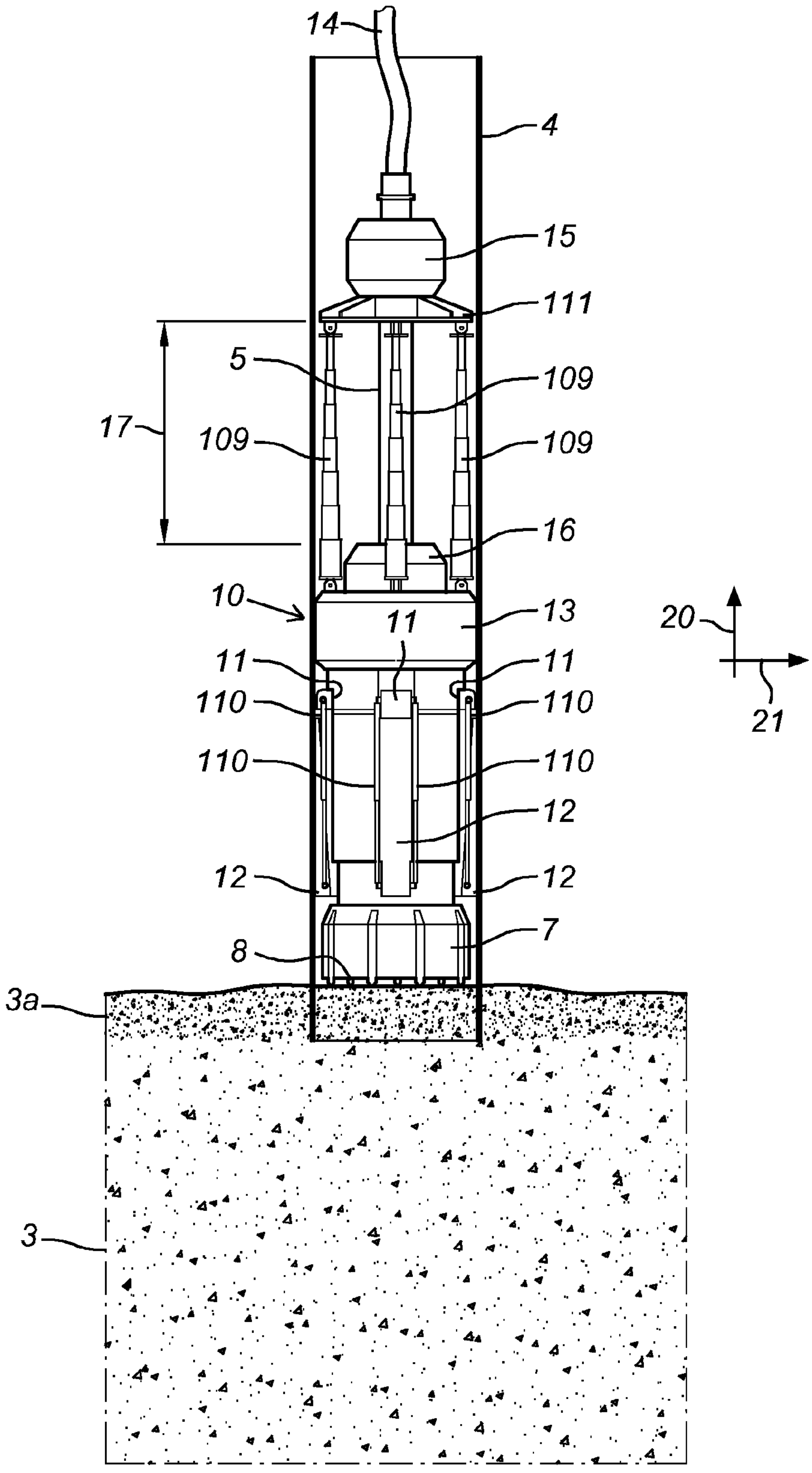
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Fig. 2

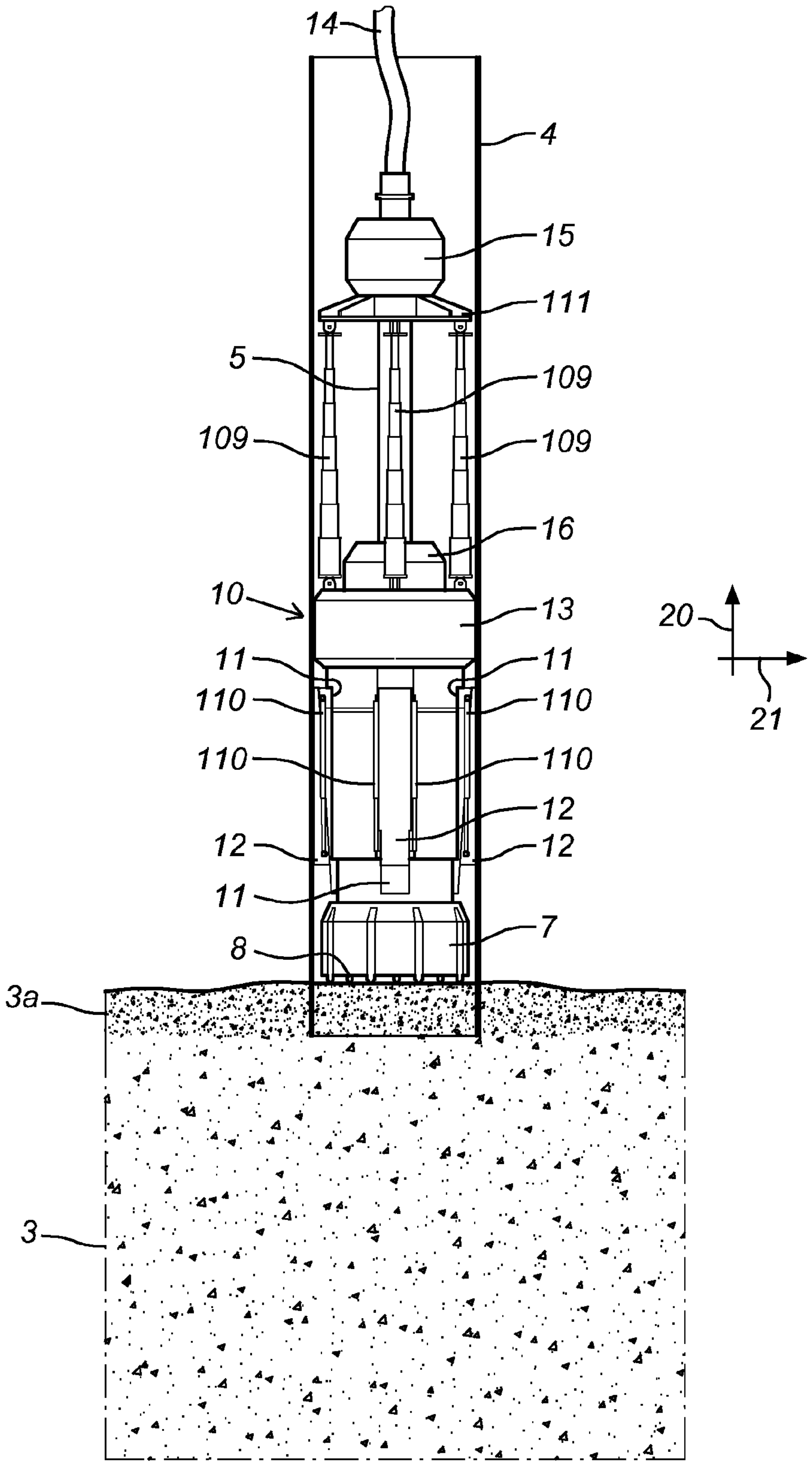
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Fig. 3

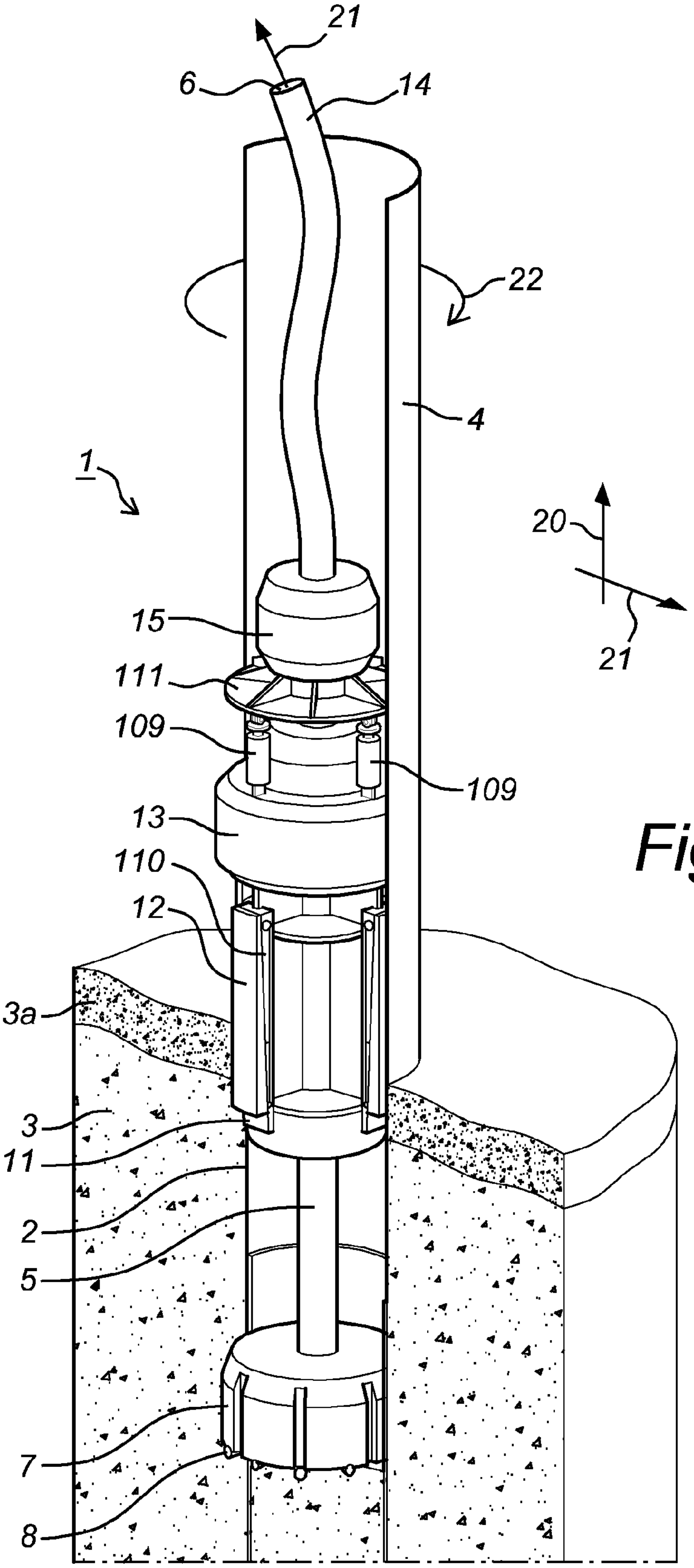


Fig. 4

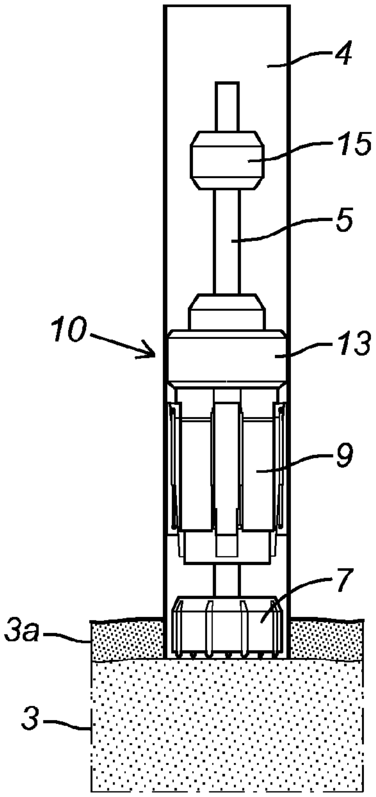


Fig. 5A

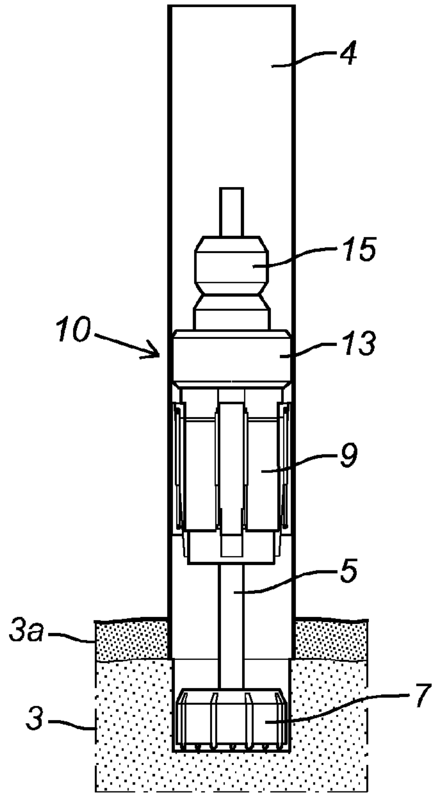


Fig. 5B

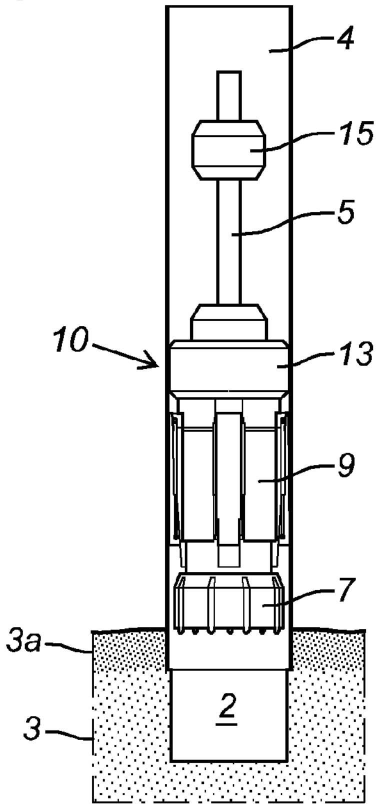


Fig. 5C

Fig. 6A

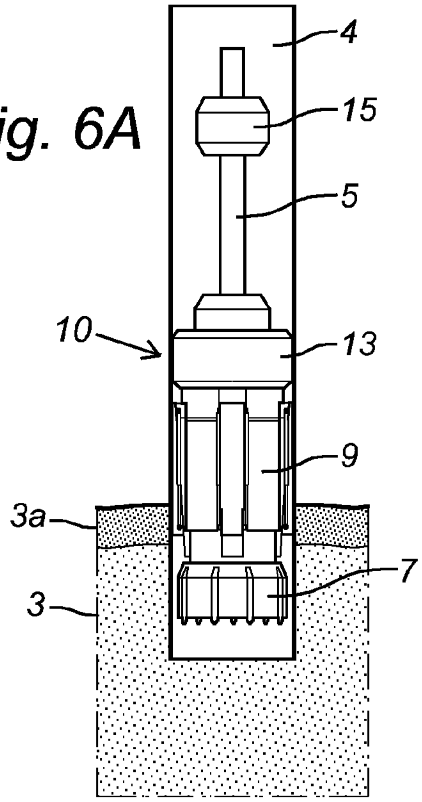


Fig. 6B

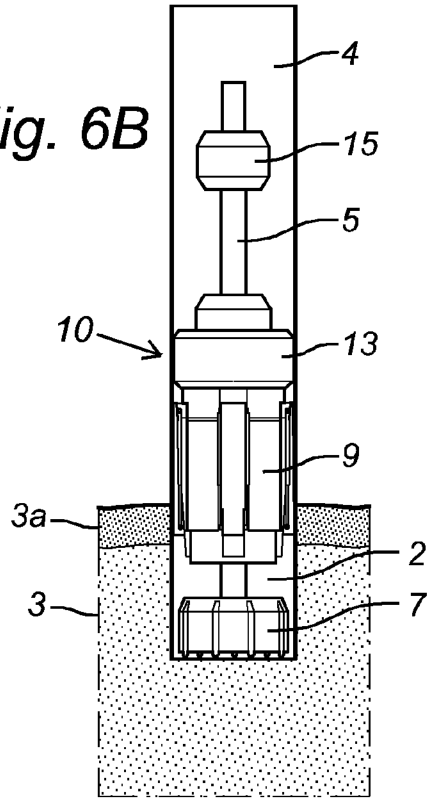


Fig. 6C

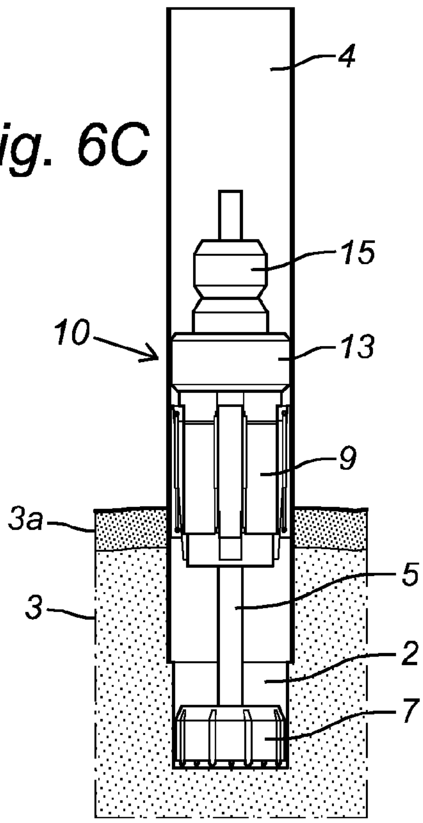
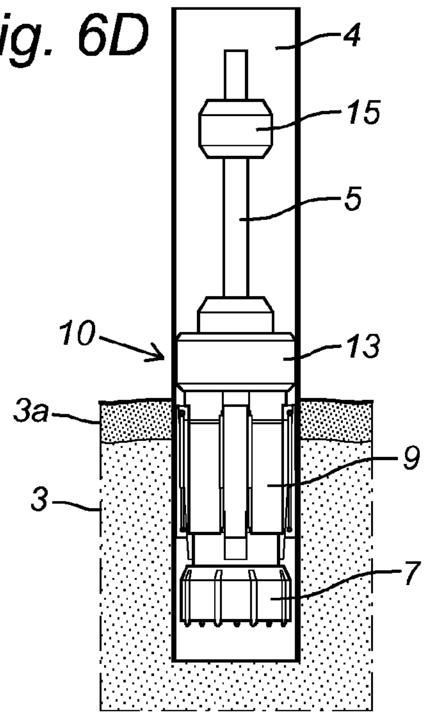


Fig. 6D



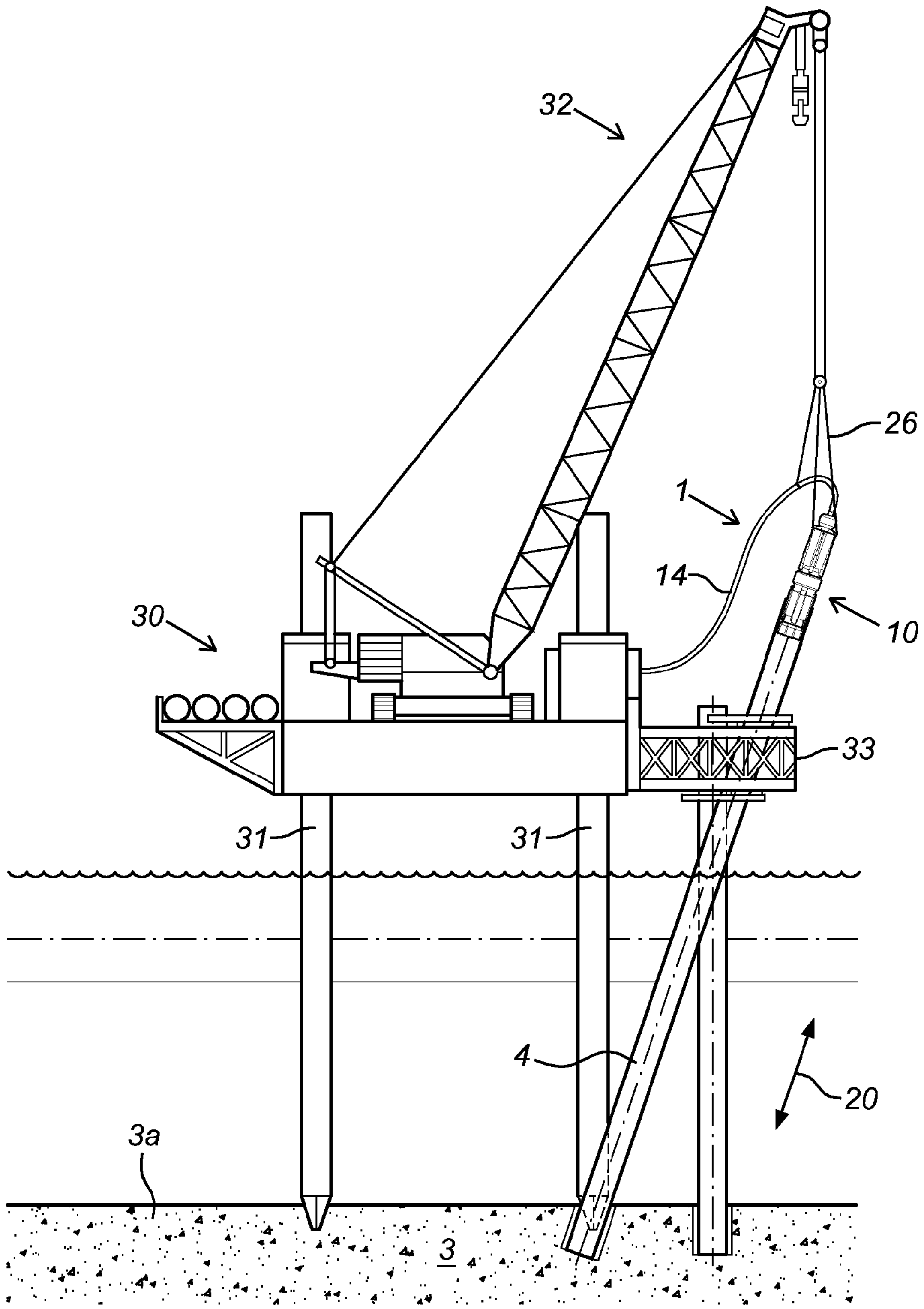


Fig. 7

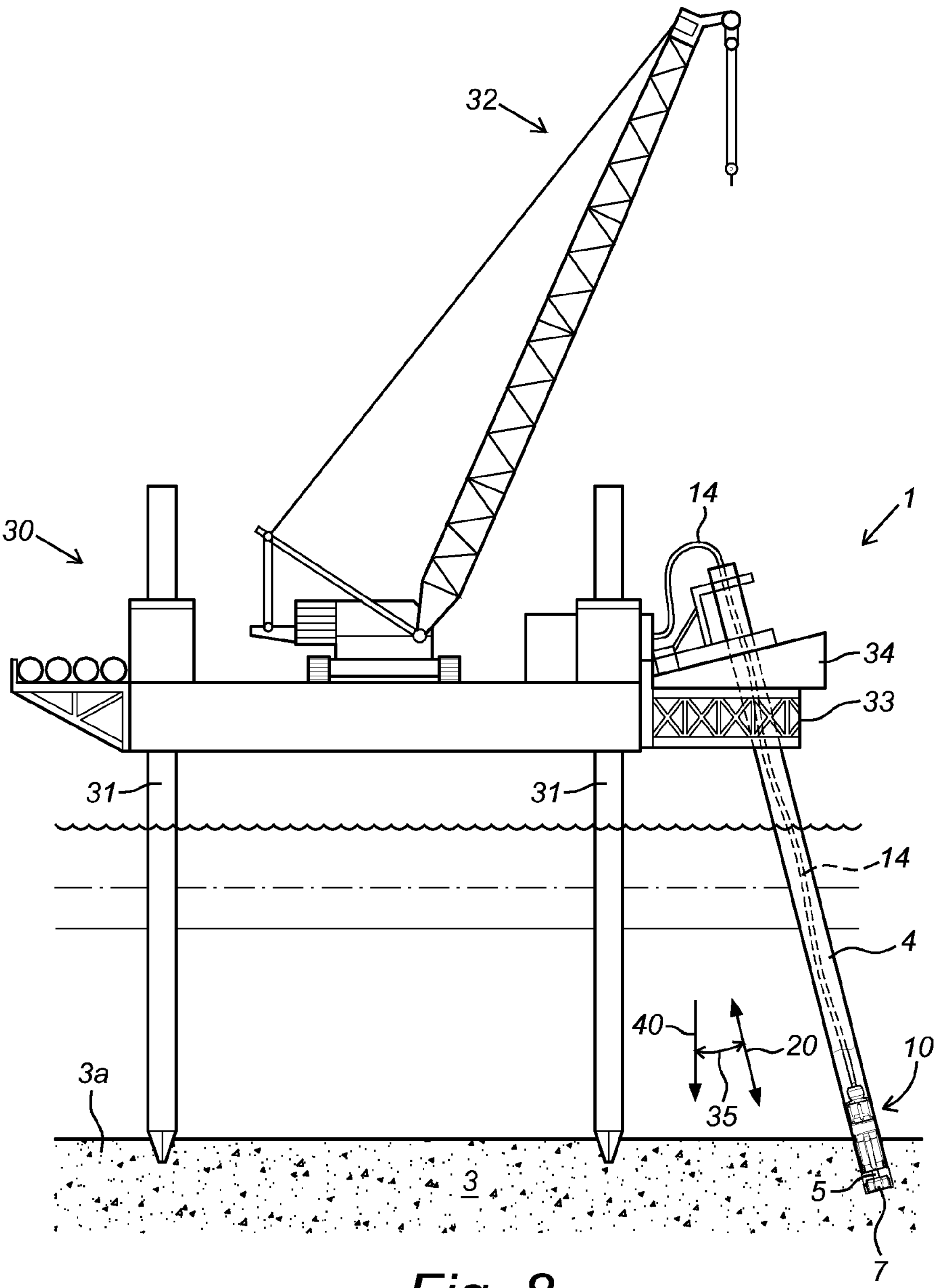


Fig. 8

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Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	3 June 2013	Dantinne, Patrick

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Place of search	Date of completion of the search	Examiner
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