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(54) **Device and method for cutting an object under water**

(57) The invention relates to a device for cutting an object under water. The device comprises a support frame, provided with lowering means to bring it to a cutting position under water and with a carrier that is movable relative to the support frame by moving means and that carries cutting means, comprising an abrasive fluid

jet nozzle, attached to a pump for providing the abrasive fluid under pressure and transport means for transporting the pressurized abrasive fluid to the abrasive fluid jet nozzle. The invention also relates to a method for cutting an object under water by using the device, and a jack-up pontoon or barge provided with the device.

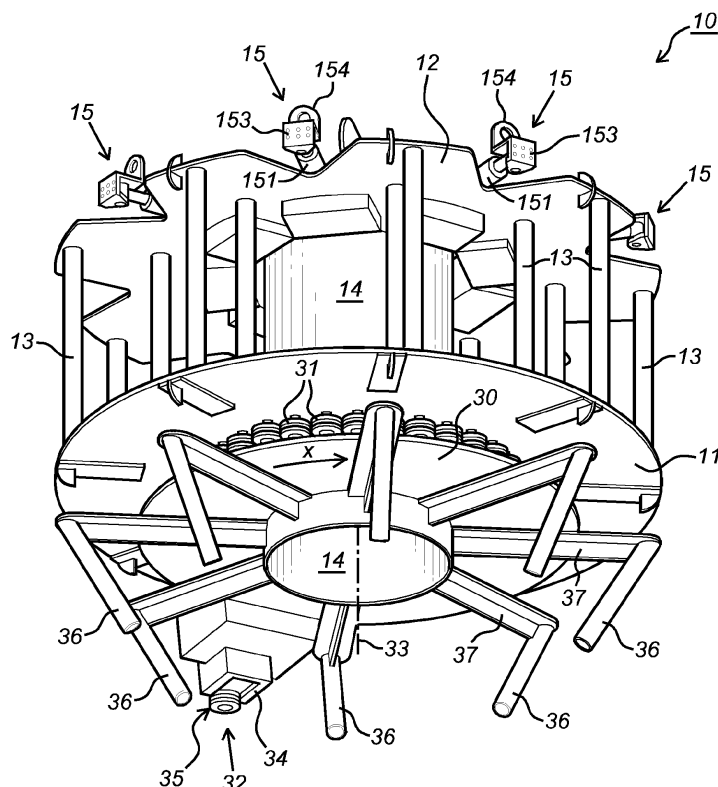


Fig. 3

Description

[0001] The invention relates to a device for cutting an object under water. The invention in particular relates to a device for cutting a hollow pile that has been partly provided into a substrate, in particular an underwater bottom. The invention also relates to a method for cutting an object under water, and to a jack-up platform or barge provided with the device.

[0002] The supporting structure for an offshore windmill typically comprises a tubular upper portion and a lower portion in the form of a trussed structure, referred to as a jacket. A large part of the jacket extends under water where it takes support onto a substrate, which in this example constitutes the underwater bottom.

[0003] The foundation of the jacket is formed by a plurality of hollow and open-ended piles that are hydraulically driven into the underwater bottom by a hydraulic hammer, provided on an off-shore platform, brought to the envisaged location for this purpose. In this process, the inside of the hollow piles fills with underwater bottom material. When all piles have been provided into the substrate according to the desired geometrical pattern, thereby forming the foundation, the jacket is installed onto the foundation formed by the plurality of piles by inserting legs of the jacket into the piles. After removal of the bottom material present inside the piles, the hollow piles receive the legs of the jacket, which legs are then secured to the hollow piles by grouting, i.e. by providing grout in the space between the legs and the inner surface of the piles.

[0004] The above described process requires a relatively accurate positioning of the upper end of the piles with respect to the under water bottom. It is in other words important that the piles stuck out of the underwater bottom over a known length. This is not so easily achieved by hammering or any other process, largely due to variable and sometimes unknown underwater bottom properties. It is for this reason that piles that have been provided into the underwater bottom over part of their length, are frequently cut off to the desired length above underwater bottom level.

[0005] The known method which involves using a cutting torch is cumbersome and relatively inaccurate.

[0006] The invention has for its object to provide a device and method for cutting an object under water, and in particular hollow piles that have been partly provided into an underwater bottom, which device and method overcome the above mentioned and other drawbacks of the state of the art.

[0007] The invention provides for this purpose a device, comprising a support frame, provided with lowering means to bring it to a cutting position under water and with a carrier that is movable relative to the support frame by moving means and that carries cutting means, comprising an abrasive fluid jet nozzle, attached to a pump for providing the abrasive fluid under pressure and transport means for transporting the pressurized abrasive fluid

to the abrasive fluid jet nozzle.

[0008] The support frame of the device according to the invention allows to accurately position the fluid jet nozzle with respect to the object from a position that is preferably remote from the actual cutting position. Once the support frame is installed vis-à-vis the object to be cut, the movable carrier allows to move the abrasive fluid jet nozzle along a surface to be cut. Since the position of the carrier relative to the support frame is known beforehand and the support frame is adapted to be positioned accurately relative to the object to be cut, an accurate cut may be achieved in an object under water by the device according to the invention. The use of an abrasive fluid jet does not require the exertion of large forces in order to make a cut, which further improves accuracy. Since the position of the abrasive fluid jet nozzle(s) on the carrier can be defined for each specific cutting job, the distance between the mouth of the abrasive fluid jet nozzle(s) and the surface to be cut can be determined accurately. This distance is preferably as small as possible since an abrasive fluid jet will quickly diverge under water and loose part of its cutting energy. The device according to the invention allows such accurate positioning of the abrasive fluid jet(s) relative to the surface to be cut that a clean cut is easily obtained in an economical amount of time.

[0009] In an embodiment of the invention, the object is a hollow pile provided at least over part of its length into an underwater bottom, and the support frame is shaped such that it can be lowered into or around the pile by the lowering means until the cutting means are at the desired cutting height, wherein the support frame comprises means for stabilizing it in or around the pile. A device having a support frame shaped such that it can be lowered into a pile by the lowering means, and further comprising means for stabilizing it in the pile is preferred. The lowering means are preferably provided on a jack-up platform or barge, and may comprise well known equipment, such as a crane, gripping means, winches and the like. The support frame is typically attached to the platform or barge by a number of cables that are lengthened to lower the support frame under water to the object to be cut.

[0010] The invention also relates to a method for cutting an object under water, comprising providing a device comprising a support frame, provided with lowering means to bring it to a cutting position under water and with a carrier that is movable relative to the support frame by moving means and that carries cutting means, comprising an abrasive fluid jet nozzle, attached to a pump for providing the abrasive fluid under pressure and transport means for transporting the pressurized abrasive fluid to the abrasive fluid jet nozzle; bringing the cutting means to the desired cutting position; and emitting the abrasive fluid under pressure against a wall of the object to make a cut in the wall.

[0011] In particular, a method is provided wherein the object is a hollow pile that has been provided into an

underwater bottom over at least part of its length, and wherein the support frame is lowered into or around the pile until the cutting means are at the desired cutting height, where after the support frame is stabilized in or around the pile and the abrasive jet is moved against the inner or outer wall of the pile. This embodiment allows to divide a predetermined length of pile from the pile provided in the underwater bottom, by lowering the support frame - provided with carrier and abrasive fluid jet nozzle (s) - into or around the pile over a distance that covers the desired length of pile to be divided, hold the support frame in this position and emit abrasive fluid under pressure against the inside or outside wall of the pile to produce a clean cut at the desired cross-section.

[0012] A pile cut by the method according to the invention is particularly useful as a foundation for the jacket of a windmill or other large structure since it has the right length above seabed level to allow inserting the legs of a jacket into a plurality of such hollow piles and secure the legs to the hollow piles by grouting, i.e. by providing grout in the space between the legs and the inner surface of the piles. Providing piles with the right length above seabed level and with a clean cutting edge allows to establish a good connection between the jacket and the foundation piles.

[0013] According to an embodiment of the invention, the device is provided with means for stabilizing the support frame in or around the pile. Such an embodiment allows to accurately position and fixate the support structure relative to the pile, which improves the accuracy of cutting, and to absorb the forces generated by the emitting abrasive fluid jet(s).

[0014] Another embodiment of the invention relates to a device, wherein the means for stabilizing comprise pressure arms, configured to extend and retract in the radial direction of the pile and to take support against the inside or outside wall of the pile in the extended position. In a particularly preferred embodiment of the device wherein the carrier comprises a rotation symmetric body and the moving means of the carrier are adapted to rotate the carrier around its longitudinal axis, the pressure arms may for instance comprise a number of hydraulic cylinders that are connected to the carrier and may be extended outwards in the radial direction (perpendicular to the longitudinal direction) of the carrier to take support against the inside or outside wall of the pile. This embodiment is advantageous in that after a circumferential cut has been made in the pile, the divided piece of pile is firmly gripped from the inside by the pressure arms, which allows to remove said piece of pipe together with the support frame (to which it is attached) by lifting the support frame with the lowering means to the jack-up platform or barge. Once above the water level the divided piece of pile may be disconnected from the support frame by retracting the hydraulic cylinders from the surface of the divided pile section in the radial direction.

[0015] An embodiment of the device according to the invention wherein the moving means of the carrier are

adapted to rotate the carrier around its longitudinal axis allows covering a substantial circumferential surface of the piles with a limited number of abrasive fluid jet nozzles. The rotating means may be arranged to provide a continuous rotation in one direction over for instance 360°, or they may be arranged to provide a back and forth rotation over a limited angle, such as 180° for instance. All other cutting angles are possible however.

[0016] As mentioned above, a predetermined length of pile can readily be divided from a pile by lowering the support frame into the pile over a predetermined distance and holding it in a fixed height position during cutting. In a useful embodiment of the device according to the invention, the support frame comprises limiting means adapted to take support on the upper rim of the pile thereby limiting the distance over which the support frame may be lowered into or around the pile. Such limiting means may be formed for instance by a plate with dimensions that exceed the transverse dimensions of the pile, which plate is positioned above the support frame and attached to it by a plurality of suspension cables of known length. When lowering the support frame into or around a pile, the plate will touch the upper rim of the pile and rest on it like a lid on a pot. To allow accurate positioning, the plate is preferably at its underside (the side facing the pile) provided with a number of cross plates with bevelled edges at the outside perimeter of the plate. The cross plates may be distributed over the circumference of the plate and when positioned on the pile take support on the upper rim of the pile with their bevelled edges. The length of the suspension cables may be selected such that the desired cutting depth is reached. The legs of a jacket are usually of different length to facilitate inserting the legs into the piles. Indeed, the longer leg is inserted first in a pile and thereafter serves as a pivot point for inserting the next longer leg in a second pile. The present embodiment allows to adjust the cutting distance for each pile separately by adjusting the limiting means accordingly.

[0017] In another preferred embodiment according to the invention, a device is provided wherein the support frame at its underside comprises guiding means for guiding the frame to, into or around an object to be cut. Such an embodiment facilitates the positioning and fixation of the support frame vis-à-vis the object to be cut.

[0018] According to an embodiment of the invention, the abrasive fluid jet nozzles are positioned such that they act on the inner or outer wall of the pile to make a cut into or through the wall of the pile. The abrasive fluid may comprise any substance that is readily ejected from a high pressure jet nozzle and that is adapted to cut the surface or wall of an object under water, in particular of a pile, typically made of steel. A particularly suitable abrasive fluid comprises water to which additives, such as for instance abrasive agents, jet converging agents and/or air are added preferably.

[0019] The jet nozzles of a preferred embodiment of the device are positioned substantially at a right angle to

the object surface to be cut, in particular to the longitudinal axis of the tube. In such a position, the abrasive fluid jets originating from the nozzles strike the inside wall surface of the pile at a right angle, which maximizes the cutting force.

[0020] The abrasive fluid jet nozzles are configured to eject fluid jets at a high pressure. Thereto, the fluid jets are at one end connected to transport means for transporting the pressurized fluid to the fluid jet nozzle in the form of a pressure hose for instance, which at the other end connects to pressure means for providing the fluid under high pressure, for instance in the form of a pressure plunger pump. This equipment is conveniently provided on a jack-up platform or barge for instance, from which the support frame is lowered into the water. The pressure used for the purpose must be large enough to yield a jet that effectively cuts the material of the object under water. Suitable pressure exceed 1000 bar, and abrasive fluid jet nozzle(s) configured for emitting the fluid under a pressure of at least 2000 bar and more preferably at least 3000 bar are preferred.

[0021] The method according to the invention makes use of the above described device. Preferred features of the method are described in the appended claims. Other details and advantages of the invention will appear from the following detailed description of the method and the device. This description is given by way of example only, without limiting the invention in any way. The reference numbers relate to the accompanying figures, in which:

figure 1 schematically shows a representation of an assembly of a jack-up platform and a particular embodiment of the device according to the invention;
figure 2 schematically shows a more detailed perspective view from above of an embodiment of the device according to the invention;
figure 3 schematically shows a more detailed perspective view from below of the embodiment shown in figure 2; and
figure 4 schematically shows a perspective view from above of the embodiment of figure 1 in a stabilized position within a pile.

[0022] Referring to figure 1, an assembly of a jack-up platform 2 and a device 1 according to one embodiment of the invention is shown. Device 1 is adapted for cutting a circumferential part of the inside surface 3a of a hollow pile 3 that has been driven hydraulically in an underwater bottom 200. Bottom 200 may comprise any material including clay, silt, sand, and even rock. The pile 3 is part of a foundation for a structure to be erected at sea, such as a windmill. A typical diameter of such a pile 3 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.

[0023] In an embodiment of the invention, the object is a hollow pile provided at least over part of its length into an underwater bottom, and the support frame is shaped such that it can be lowered into the pile by the

lowering means until the cutting means are at the desired cutting height, wherein the support frame comprises means for stabilizing it in the pile.

[0024] Jack-up platform 2 comprises a working deck 22 and is anchored in the bottom 200 by means of four support legs 21 (only two of which are visible) and generally height-adjustable. A lowering means 20 is situated on the jack-up platform 2 for manipulating a cutting device 1 according to the invention. Lowering means 20 may for instance take the form of a crane as shown, but may also be any other lifting device suitable for the purpose, such as winches for instance. In the embodiment shown, lowering means 20 comprise a carrier boom 23, rotatably fastened to pivot point 27 and at the other outer end provided with a pulley 24, over which runs a lifting cable 25 that operates a hook 26. A cutting device 1 is attached to hook 26 via a cable 29. The crane is able to lower (or hoist) the cutting device 1 by unwinding (winding up) lifting cable 25 over pulley 24 and/or by pivoting carrier boom 23 in the direction opposite to direction R (in direction R) by slackening (tensioning) cable 28.

[0025] As further shown in figure 1, cutting device 1 is lowered into the pile 3 over a predetermined distance. To achieve an accurate height positioning of the device 1 vis-à-vis the pile 3, device 1 is equipped with limiting means adapted to take support on the upper rim 3b of the pile 3. In the embodiment shown in figure 1, the limiting means comprise a plate 4 with dimensions that exceed the transverse dimensions of pile 3. Plate 4 is attached to a support frame of the device 1 (see below for further details) by a plurality of suspension cables 6 of known length. When lowering the cutting device into the pile 3, the plate 4 will touch the upper rim 3b of pile 3 and take support on it. To allow accurate positioning, the plate 4 is preferably at its underside (the side facing the pile 3) provided with a number of cross plates 5 with bevelled edges at the outside perimeter of the plate 4. Cross plates 5 are regularly distributed over the circumference of plate 4 and take support on the upper rim 3b of the pile 3 with their bevelled edges. An accurate positioning of device 1 on pile 3 is thus achieved in a simple way.

[0026] The length of the suspension cables may be selected such that the desired cutting depth is reached.

[0027] Figure 2 shows an embodiment of device 1 in more detail. Device 1 comprises a support frame 10, comprising a central tube 14 to which are attached two spaced apart annular plates (11, 12). The upper plate 12 and lower plate 11 are mutually connected through a plurality of paired steel cross members 13. Upper plate 12 comprises a number of recesses around its circumference, at which recesses plate 12 is provided with means for stabilizing the support frame 10 in the pile 3. The means for stabilizing comprise pressure arms 15, configured to extend and retract in the radial direction of frame 10 (and pile 3) and to take support against the inner wall 3a of pile 3 in the extended position. Pressure arms 15 in the embodiment shown comprise a number of hydraulic cylinders 151 that are connected to the central tube 14

through pressure blocks 152 and at the other free may extended outwards in the radial direction of plate 12 by pushing out its piston. The pistons are at there free end provided with pressure pads 153 that, in the extended position, take support against the inner wall 3a of pile 3. In this position, support frame 10 is accurately positioned and fixated relative to pile 3, as show in figure 4. Pressure arms 15 are further provided with hoisting eyes 154 to which cables 6 (see figure 1) are attached in operation.

[0028] With reference to figure 3, support frame 10 is further provided with a carrier plate 30 that is rotatable in the circumferential direction X relative to the support frame 10 around its longitudinal axis 33. The relative rotation is achieved by a plurality of cylindrical bearings 31 provided between under plate 11 of frame 10 and carrier plate 30. The bearings 31 are arranged to provide a continuous rotation in two directions (back and forth) over a circumferential angle of 360°. According to the invention, carrier plate 30 further carries cutting means 32, that co-rotate with carrier 30. Cutting means 32 comprise an (x, y)- frame 34 provided with an abrasive fluid jet nozzle 35. The (x-y) frame allows in a known manner to move nozzle 35 radially outwards towards the pile 3 or radially inwards away from the pile 3. Circumferential movements may also be allowed over limited distances if desired. The abrasive fluid jet nozzle is positioned on carrier 30 with its ejection opening facing radially outwards such that it acts on the inner wall 3a of pile 3, i.e it ejects a fluid jet radially outwards such that it strikes the inside wall 3a surface of the pile 3 at a substantially right angle and makes a cut into or through the wall of the pile 3.

[0029] Attached to cutting means 32, and typically provided on the jack-up platform 2 or barge, is a pump 40 for providing the abrasive fluid under pressure and transport means in the form of a high pressure hose 41 for carrying the pressurized abrasive fluid to the abrasive fluid jet nozzle 35. Hose 41 and other umbilicals conveniently extend through the central tube 14 of frame 10 for attachment to nozzle 35 and other utilities.

[0030] As shown in figure 3, support frame 10 of device 1 may also be provided at its underside with guiding means in the form of a number of slanting beams or tubes 36. Tubes 36 are supported by arms 37 that are connected to the central tube 14 and extend radially outward. The radial distance between two opposite tubes 36 is considerably smaller than the diameter of the pile 3 which allows to guide the frame 10 into the upper opening of pile 3 easily when lowering it from platform 2.

[0031] The above described device 1 allows to cut a pile 3 under water accurately and fast. Thereto, the frame 10 is lowered into the pile until the cutting means 32 are positioned at their correct height in the desired cutting position. To allow an accurate cut, support frame 10 is first stabilized within the pile 3 by extending pressure arms 15. Carrier 30 is then brought into rotation which will move the fluid jet nozzle 35 along a circular path of inner wall 3a. It is also possible to simultaneously lower the frame 10 and rotate carrier 30 to produce a spiral cut,

if this is desired. The abrasive fluid emitted against the inner wall 3a of pile 3 under a high pressure provides a cut in the wall and divides the pile 3 when a complete rotation of 360° has been achieved.

[0032] If a cut has to be made in pile 3 at a limited height, i.e. very close to the upper rim 3b of pile 3, frame 10 may be turned around whereby upper plate 12 becomes the lower plate and lower plate 11 becomes the upper plate. Cables 6 are in this position attached to hoist eyes 155 and led through central tube 14 to the attachment hook 26 of crane 20.

[0033] As shown in figure 4, after a circumferential cut has been made in pile 3, the divided piece of pile with inner surface 3a, upper rim 3b, and cut lower rim 3c is firmly gripped from the inside by the pressure arms 15, which allows to remove said piece of pipe together with support frame 10 to which it is attached by lifting this assembly with crane 20 to the jack-up platform 2. Once above water level 100, the divided piece of pile 3 is disconnected from support frame 10 by retracting the hydraulic cylinders 151 radially inwards which loosens the pressure applied by pressure pads 153 and frees frame 10 from pile 3.

[0034] The invention as described by the above embodiment provides a device and an efficient method for cutting a hollow pile that has been partly provided into a substrate, in particular an underwater bottom. The parts of the pipes that remain in the underwater bottom are preferably used as a foundation for a windmill.

Claims

1. Device for cutting an object under water, the device comprising a support frame, provided with lowering means to bring it to a cutting position under water and with a carrier that is movable relative to the support frame by moving means and that carries cutting means, comprising an abrasive fluid jet nozzle, attached to a pump for providing the abrasive fluid under pressure and transport means for transporting the pressurized abrasive fluid to the abrasive fluid jet nozzle.
2. Device according to claim 1, wherein the object is a hollow pile provided at least over part of its length into an underwater bottom, and wherein the support frame is shaped such that it can be lowered into or around the pile by the lowering means until the cutting means are at the desired cutting height, wherein the support frame comprises means for stabilizing it in or around the pile.
3. Device according to claim 2, wherein the means for stabilizing comprise pressure arms, configured to extend and retract in the radial direction of the pile and to take support against the inside or outside wall of the pile in the extended position.

4. Device according to any one of the preceding claims, wherein the carrier comprises a rotation symmetric body and the moving means of the carrier are adapted to rotate the carrier around its longitudinal axis.
5. Device according to any one of the preceding claims, wherein the abrasive fluid jet nozzles are positioned on the carrier such that they act about perpendicular to the object to be cut.
6. Device according to any one of the preceding claims, wherein the support frame comprises limiting means adapted to take support on the upper rim of the pile thereby limiting the distance over which the support frame may be lowered into or around the pile.
7. Device according to any one of the preceding claims, wherein the support frame at its underside comprises guiding means for guiding the frame to, into or around an object to be cut.
8. Device as claimed in any one of the preceding claims, wherein the abrasive fluid jet nozzle is configured for emitting the fluid under a pressure of at least 1000 bar, preferably at least 2000 bar, and most preferably at least 3000 bar.
9. Jack-up pontoon or barge, provided with a device as claimed in any one of the preceding claims.
10. Method for cutting an object under water, comprising providing a device comprising a support frame, provided with lowering means to bring it to a cutting position under water and with a carrier that is movable relative to the support frame by moving means and that carries cutting means, comprising an abrasive fluid jet nozzle, attached to a pump for providing the abrasive fluid under pressure and transport means for transporting the pressurized abrasive fluid to the abrasive fluid jet nozzle; bringing the cutting means to the desired cutting position; and emitting the abrasive fluid under pressure against a wall of the object to make a cut in the wall.
11. Method according to claim 10, wherein the object is a hollow pile that has been provided into an underwater bottom over at least part of its length, and wherein the support frame is lowered into or around the pile until the cutting means are at the desired cutting height, where after the support frame is stabilized in or around the pile and the abrasive jet is moved against the inner or outer wall of the pile.
12. Method according to claim 11, wherein the carrier comprises a rotation symmetric body and the abrasive jet nozzle is moved by rotating the carrier around its longitudinal axis.
13. Device according to any one of claims 10-12, wherein the abrasive fluid jet acts about perpendicular to the object to be cut.
14. Method according to any one of claims 10-13, wherein the abrasive fluid is emitted under a pressure of at least 1000 bar, preferably at least 2000 bar, and most preferably at least 3000 bar.

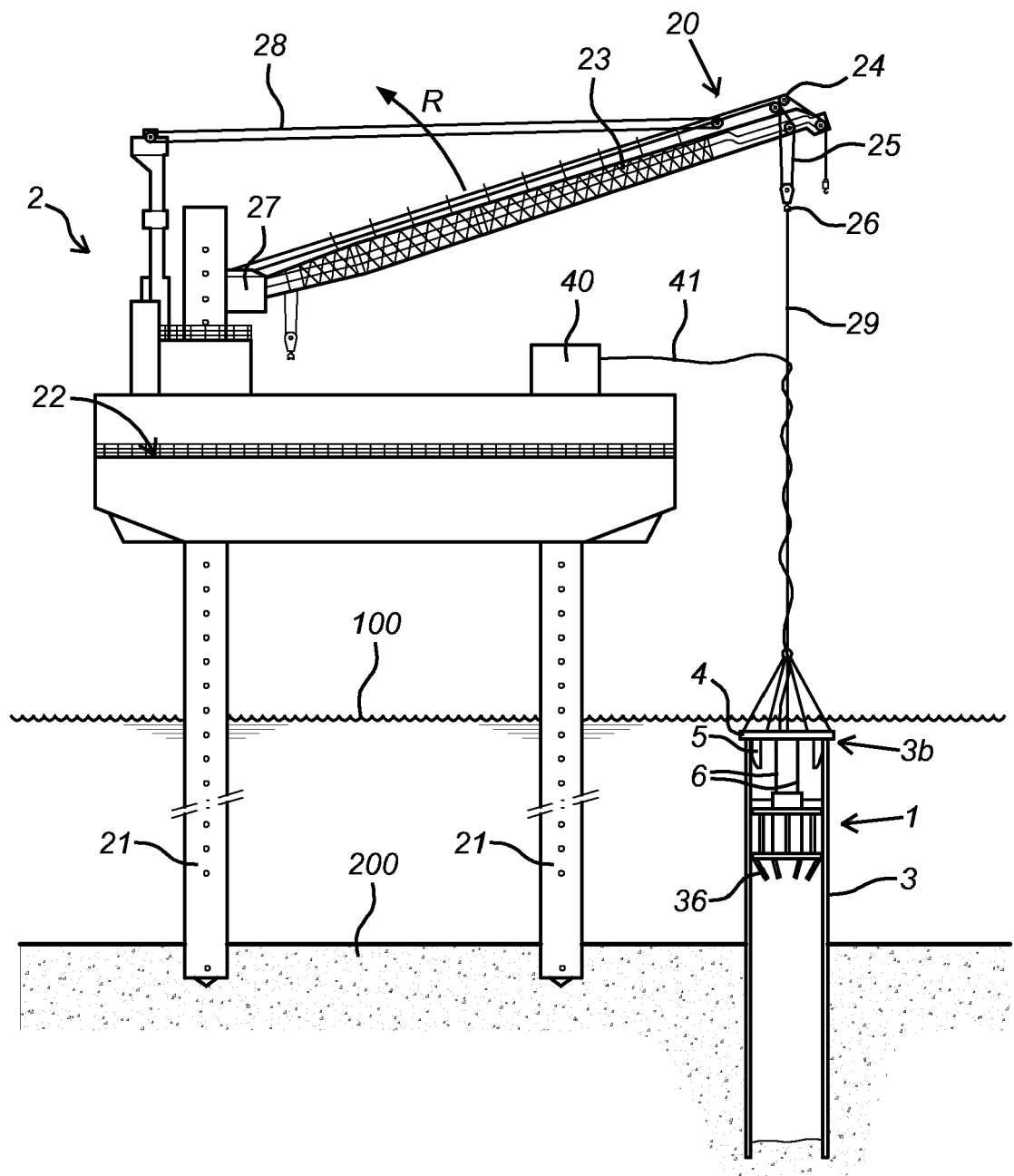


Fig. 1

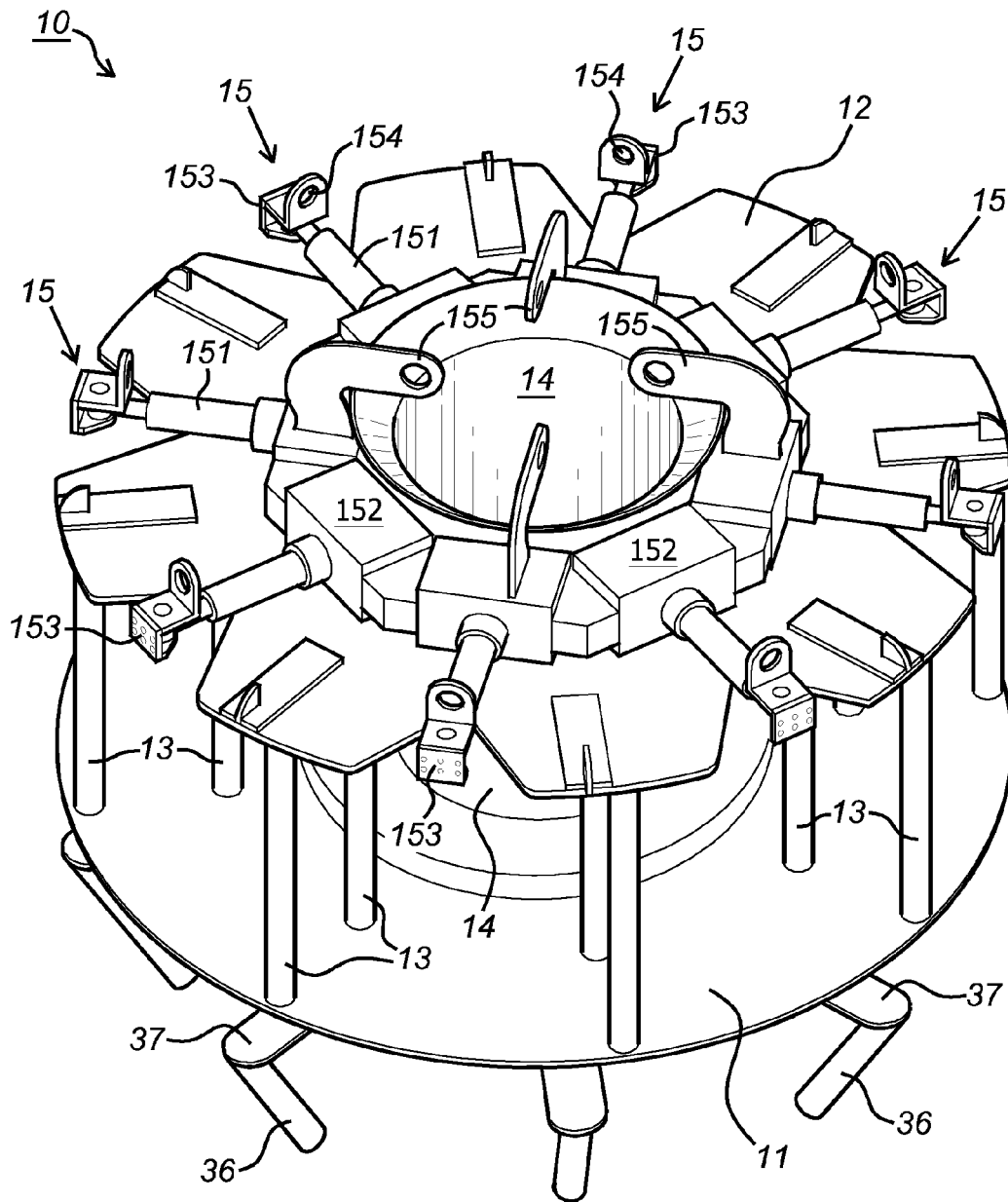


Fig. 2

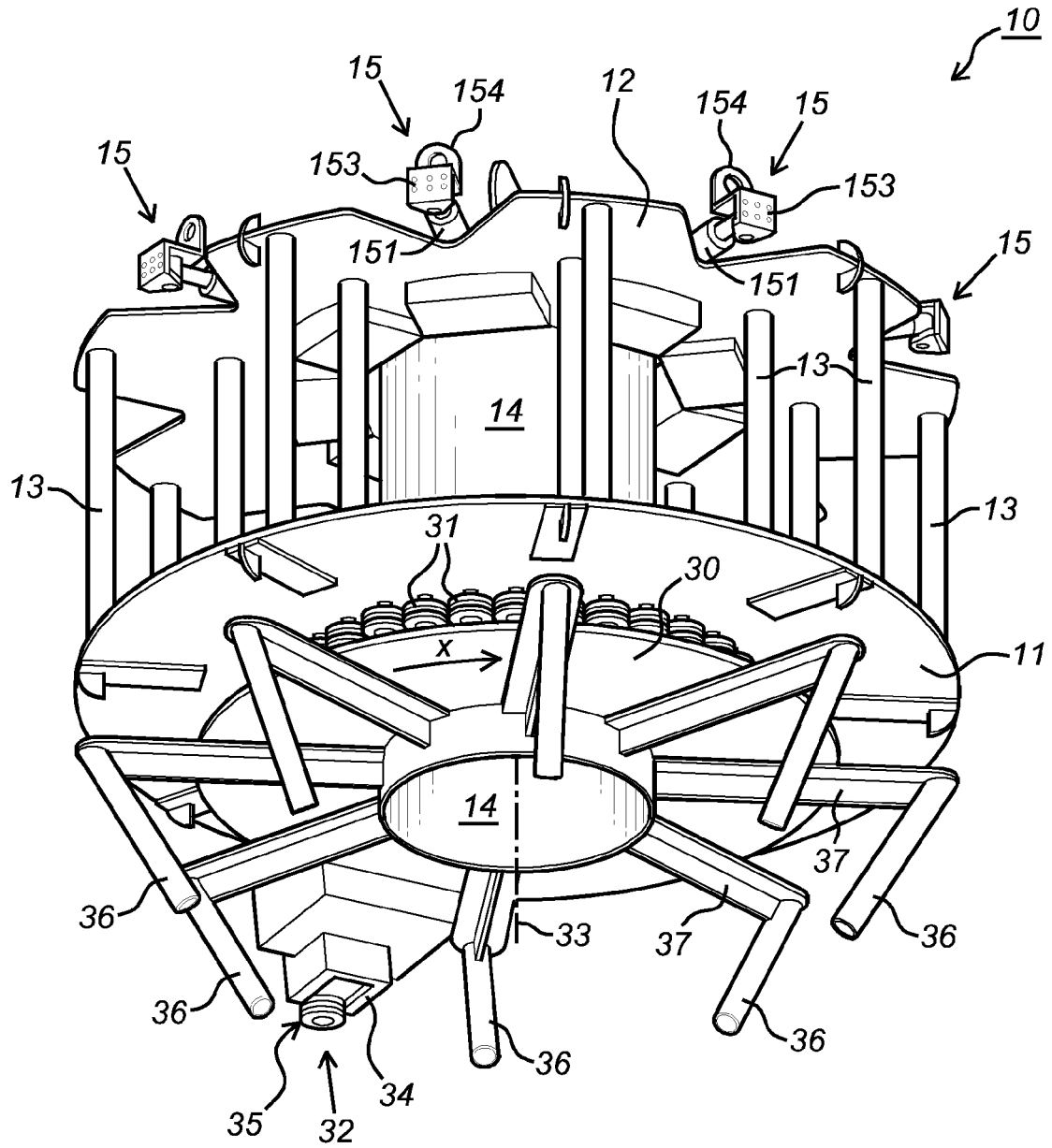


Fig. 3

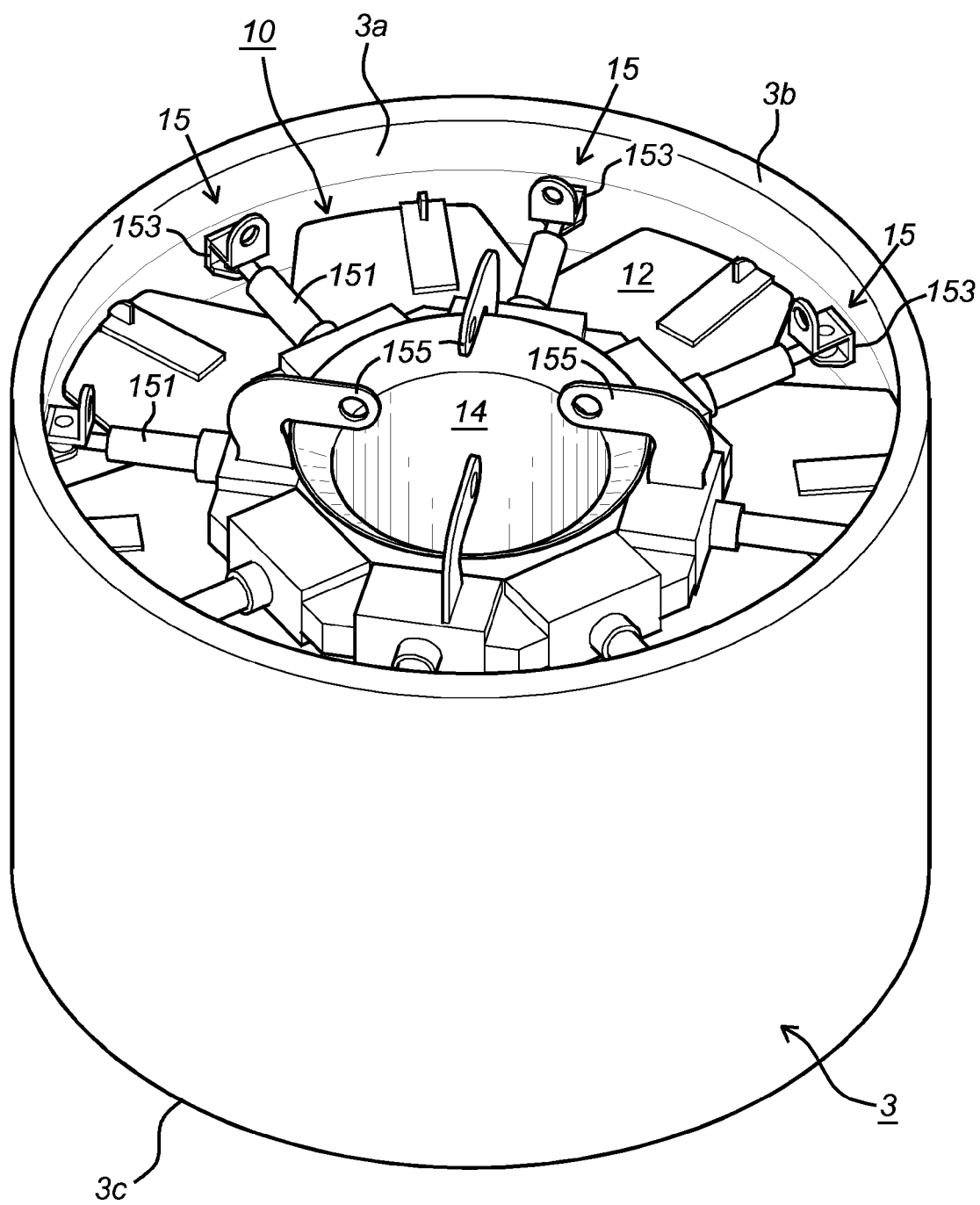


Fig. 4



EUROPEAN SEARCH REPORT

Application Number
EP 11 15 2681

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 23 May 2011	Examiner Eder, Raimund
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 11 15 2681

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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