(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 June 2013 (06.06.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/081455 Al

(51) International Patent Classification:
E02D 5/44 (2006.0 1) *E02D 7/28* (2006.0 1)

(21) International Application Number:
PCT/NL20 12/05083 1

(22) International Filing Date:
22 November 2012 (22.1 1.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2007882 28 November 201 1 (28. 11.201 1) NL

(71) Applicant: **BALLAST NEDAM OFFSHORE B.V.** [NL/NL]; 71, Ringwade, NL-3439 LM Nieuwegein (NL).

(72) Inventor: **VAN LEEUWEN, Anton Dirk, jr.;** 14, Breudijk, NL-3481 LP Harmelen (NL).

(74) Agent: **HOLLAAR, C ;** Postbus 3241, NL-2280 GE Rijswijk (NL).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available):* AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available):* ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on nextpage]

(54) Title: EXCAVATOR

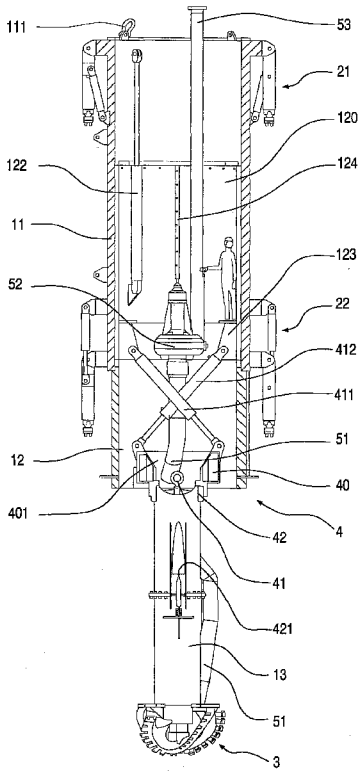

Fig.4

(57) Abstract: Excavator (1) for excavating bottom parts from a bottom floor at a distal end of a hollow ground structure, comprising a framework (10), a radial positioning mechanism (21) for positioning the framework in the hollow ground structure, a discharge unit (50) comprising a release head (3) connected at an end of a release arm (13). The excavator comprises a steering mechanism (4) for steering the release arm (3) from a first position to a second position. The steering mechanism (4) is mounted to a distal end of the framework. The steering mechanism (4) comprises a cardan joint for connecting the release arm (13) to the frame work (10).

WO 2013/081455 A1

Published:

— *with international search report (Art. 21(3))*

Title: EXCAVATOR

The present invention relates to an excavator device for excavating bottom parts from a bottom floor inside a ground structure. The ground structure is for example a vertical access shaft or a foundation pile. In particular, the present invention relates to an excavator as a submergible dredge device for discharging bottom parts from a water floor. Further, the invention relates to a use of the submergible dredge device for installing an off shore foundation pile.

US 4.742.876 discloses a device for submarine foundation drilling. A drilling unit is disclosed which is linked by a series of boring rods to an operating vessel. The rod string is suspended from the vessel with the aid of a handling winch. The vessel has a hydraulic power station able to furnish hydraulic fluid by way of a control board. The lower end of the rod string is linked to the top of the drilling unit. The drilling unit is disposed inside a casing. The drilling unit is completely confined in the casing so that when the apparatus reaches the ocean bottom, the drilling unit lower part enters the earth where the drilling will take place. Clamps and shoe brakes are subsequently used to link and unlink the drilling unit to the casing. Thus, the casing descends with the drilling unit until a desired depth has reached.

The drilling unit has an open front surface. Two counterwards drivable roller cutters are provided to dig into the water bottom and release bottom parts. The roller cutters are rotatable about a horizontal axis and are swingable arranged to increase the reach of the roller cutters. Released bottom parts are pulled towards an opening of a suction pipe which is positioned adjacent the roller cutters. A dredging pump and a discharge conduit are provided to discharge the released bottom parts away from the drilling unit over a limited distance, but not upwards to the vessel.

A problem to the disclosed drilling unit is that the drilling unit is only suitable to be used with hollow structures which have a substantially constant inner diameter. During operation the drilling unit interacts with the casing to lower the casing into the ocean bottom. It is not possible to introduce hollow structures into a water bottom which has a e.g. a tapered inner space portion, because the drilling unit cannot pass through that smaller portion. For that reason many foundation piles are assembled in at least two portions after introducing a base portion with a constant inner diameter in the water bottom. An assembled transition portion which provides a transition of a large diameter of e.g. 7meters of the base portion to a smaller diameter of e.g. 4meters of the top portion can be assembled and connected in a later step by using a grout mixture. In practise it has appeared that those

grout connections fail after a period of some years. Expensive repair operations are necessary to strengthen the grout connections and stabilise the foundation piles.

Other publications like WO2010139380 and JP62-284818 disclose an excavating device which can be introduced into a foundation pile for excavating ground at a bottom of the foundation pile. A problem to the disclosed excavating devices is that these devices are in fact designed only for a land-operation and not for installing a foundation pile in an offshore environment. The disclosed devices are vulnerable to damages and failures when they are used under severe offshore conditions.

It is an object of the present invention to at least partially eliminate the above mentioned drawbacks and/or to provide a useable alternative. In particular, it is an object of the invention to provide a submergible dredge device which is capable to achieve a fast release and discharge of bottom parts from a water bottom. Additionally, it is an object of the invention to provide an excavator as a submergible dredge device, wherein the device is arranged to pass through a hollow elongated structure having at least one inner portion of a substantial smaller diameter.

According to the invention this object is achieved by an excavator as defined in claim 1.

According to the invention an excavator is provided for discharging bottom parts from a bottom floor at a distal end of a hollow ground structure. During a release operation in which bottom parts are released, the excavator is positioned inside the hollow ground structure. The ground structure is for example a foundation pile or a vertical access shaft to a tunnel. The ground structure may be a concrete or steel structure. The excavator comprises a framed work for supporting excavator components. The framework has a longitudinal axis which extends from a proximal end to a distal end. In particular, in a system of a framework and the ground structure, the longitudinal axis of the framework coincidences with a longitudinal axis of the ground structure.

Further, the excavator comprises a radial positioning mechanism, also called a clamping mechanism, for positioning the framework in a radial direction with respect to an inner wall of the ground structure. The clamping mechanism positions the framework with respect to the ground structure in a radial direction. The clamping mechanism may be arranged to withstand transmitted rotational forces during a release operation to prevent the excavator from rotating about the longitudinal axis.

The excavator further comprises a discharge unit which comprises a release head for releasing bottom parts. The release head is connected to an end of a release arm. The release arm is movable connected to the distal end of the framework. The discharge unit further comprises a discharge pump which is connected to a discharge conduit for discharging released bottom parts from a bottom floor. The discharge conduit extends from

the release head to the proximal end of the framework for discharging released bottom parts away from the release head.

Further, the excavator comprises a steering mechanism for steering the release arm from a first position to a second position with respect to the framework. The steering mechanism is mounted to a distal end of the framework.

The excavator according to the invention is improved in that the steering mechanism comprises a cardan joint for connecting the release arm to the frame work.

The connection of the release arm to the framework provided by the cardan joint allows a rotational movement of the release arm in two directions. The cardan joint itself is pivottable in a first direction with respect to the framework about a first axis. Additionally, the release arm is pivottable in a second direction with respect to the cardan joint about a second axis. In particular, the first and second axes are perpendicular. Herewith, the release head which is mounted to the distal end of the release arm may extend in two directions. Advantageously, a fast release operation may be performed by releasing along the two-directional surface. The presence of the cardan joint makes a rotation table to provide a rotational movement of the release arm redundant. In comparison with a rotation table, a cardan joint provides an advantage in that the cardan joint is less vulnerable for failures caused by a wear of components. The cardan joint provides a more robust configuration. In particular, seal components are better resistant. Present sand, clay and stone parts provide severe conditions for the components of the excavator. In particular, an off shore working environment of the excavator arranged as a submergible dredge device during a dredging operation is a highly abrasive environment. Advantageously, the cardan joint of the excavator according to the invention makes the excavator suitable to operate under these severe conditions.

In an embodiment of the excavator according to the invention, the cardan joint includes a cardan body. The cardan body is positioned in between the framework and the release arm. The cardan body is pivotally about the first axis connected with the distal end of the framework. The cardan body is actuable by a cardan body actuator to rotate the cardan body about the first axis with respect to the framework about a first pivot angle. The cardan body is pivotally about the second axis connected with the release arm. The release arm is actuable by a release arm actuator to rotate the release arm about the second axis. The release arm is rotatable with respect to the cardan body about a second pivot angle. Seen in the longitudinal direction of the dredge device, the first and second axis are positioned above each other. Seen in a cross-sectional projection, the first and second axis are positioned crosswise to obtain a universal joint. In particular, the first axis and second axis are positioned substantially perpendicular. Advantageously, the cardan body actuator and the release arm actuator are controllable to obtain a travel of the release head along a

surface which extends in two radial directions. Advantageously, the release arm which positions the release head is symmetrically swingable about the longitudinal axis. This allows a large reach of the release head in a single swing. Advantageously, the distal end of the release arm is movable along a circular release path, such that the release head can follow the inner wall of the ground structure, in particular the foundation pile.

In an embodiment of the excavator according to invention, the cardan body is actuable about the first axis about a first pivot angle of at least 45°, in particular at least 60°, more in particular at least 70°.

In an embodiment of the excavator according to the invention, the cardan body actuator comprises at least one hydraulical cylinder. Preferably, the cardan body actuator comprises two hydraulical cylinders. The two hydraulical cylinders are positioned side-by-side. Advantageously, the two hydraulical cylinders provide an improved stability when moving the cardan body.

In a further embodiment of the excavator according to the invention, the two hydraulical cylinders are positioned in a crosswise arrangement. In contrast to a parallel arrangement, a first hydraulical cylinder is positioned opposite another hydraulical cylinder in the cross-wise arrangement. In the crosswise arrangement, the hydraulical cylinder may be a single acting cylinder. A single-acting cylinder is a cylinder in which a hydraulic working fluid acts on one side of a piston only. This is in contrast to a double-acting cylinder, in which the working fluid acts alternately in both directions. The single-acting cylinder in the crosswise arrangement relies on the opposite positioned cylinder to push the piston back in the other direction. Advantageously, the crosswise arrangement allows a more simplified configuration and control of the cardan joint.

In an embodiment of the excavator according to the invention, the release arm actuator comprises at least one hydraulical cylinder. The hydraulical cylinder is arranged to move the release arm about the second axis. In a further embodiment of the excavator according to invention, the release arm actuator comprises two hydraulical cylinders. The two hydraulical cylinders maybe mounted opposite each other at both sides of the release arm. The release arm is positioned in between the two hydraulical cylinders. The two hydraulical cylinders maybe single-acting cylinders. The single acting cylinder at one side of the release arm relies on the opposite positioned single acting cylinder to be returned. Advantageously, this arrangement provides a simple and reliable configuration to control the movements of the release arm.

In an embodiment of the excavator according to invention, the cardan body has a passageway for enabling a passage of the discharge conduit. The passageway is preferably centrally positioned in the cardan body. The release arm is preferably a hollow release arm. The passageway and the hollow release arm allows the discharge conduit to be introduced

into the release arm at a proximal end of the release arm. The discharge conduit may extend from the proximal end of the release arm to a distal end of the release arm to reach the release head. Advantageously, the arrangement of the discharge conduit inside the release arm provides a protection for the discharge conduit against damages caused by e.g. sharp stony bottom parts.

In an embodiment of the excavator according to invention, the cardan body is window shaped. In particular, the cardan body has a rectangular shape which is open worked in a middle region to form the passageway. The enclosed shape of the cardan body provides rigidity of the cardan body to withstand heavy loads doing a release operation of releasing bottom parts form a bottom floor.

In an embodiment of the excavator according to invention, the framework is a telescopically framework. The framework has a first framework part which is telescopically connected to a second framework part for moving the second framework part along the longitudinal axis. A rotational blockage element may be provided in between the first and second framework part to prevent a rotational movement of the second framework part with respect to the first framework part about the longitudinal axis. The first and second framework part are furthermore connected to each other by at least one framework actuator for extending the framework in the longitudinal direction. In particular, the framework actuator is a hydraulic cylinder. The hydraulic cylinder may extend in parallel with the longitudinal direction. The hydraulic cylinder may be a double acting cylinder to extend and shorten the framework.

Advantageously, the telescopically framework improves the release operation. During the release operation, the first framework part is clamped to an inner wall of an off shore foundation pile. The second framework part is linear movable with respect to the first framework part. During the release operation, the second framework part may extend with respect to the first framework part to press the release head into the bottom floor. Advantageously, a plurality of layers of bottom parts may be released during one release operation, wherein the first framework part remains clamped to the inner wall of the off shore foundation pile.

In contrast to a telescopically arranged release arm, the telescopically framework provides a simple configuration for lowering the release head during a release operation. The framework may house a discharge pump which moves together with the release head which advantageously prevents a structural complexity in which the discharge conduit has to extend together with the release arm when and the release arm extends.

In an embodiment of the excavator according to invention, the framework actuator comprises two hydraulic cylinders. The two hydraulical cylinders are single-acting cylinders in which a first hydraulic cylinder is arranged upside down with respect to an opposite

second hydraulic cylinder. Advantageously, the single acting cylinders provide a simple configuration of the excavator according to the invention.

In an embodiment of the excavator according to the invention, the first and second framework part have a tubular shape. The first framework part encloses at least partially the second framework part. The second framework part is arranged inside the first framework part. The framework actuator is positioned inside the first framework part. At a proximal end the framework actuator is connected to an inner wall of the first framework part. At a distal end, the framework actuator is connected to the second framework part. Advantageously, the inner positioned framework actuator is protected by the first framework part from damages.

In an embodiment of the excavator according to the invention, the tubular framework provides an enclosed inner space which can serve as a housing for components. In particular, the housing is provided in the second framework part. The housing can be watertight sealed from the environment. The discharge pump maybe situated in the housing. Herewith, the discharge pump maybe protected in the housing from the severe environment during a dredging operation. In a particular embodiment, the inner space provides sufficient space to provide access for a human being. Advantageously, the inner space of the framework maybe accessible to service components e.g. the discharge pump of the excavator.

In an embodiment of the excavator according to the invention, in the clamping mechanism comprises at least one set of clamping members for clamping the excavator to an inner wall of an off shore foundation pile. The clamping members are movable connected to an outer wall of the framework. In particular, a reinforcing ring may be provided at the outer wall of the framework to mount the clamping members. The at least one set of clamping members are movable in radial direction to transform the excavator from a compact configuration to an extended configuration. In the compact configuration, the excavator has an extreme outer diameter which is sufficient small to let the excavator pass along a narrowing portion of the foundation pile. In the extended configuration, the excavator has an extreme outer diameter which is sufficient large to clamp the dredge device to the inner wall at a distal end of the ground structure, in particular a foundation pile. The distal end of the ground structure may have an enlarged portion which has an increased diameter. An off shore foundation pile may have for example a cylindrical top region having an inner diameter of about four metres, a tapered middle region which provides a transformation from a small diameter to an enlarged diameter, and a bottom region having an inner diameter of about eight metres. In particular, the excavator comprises a clamping mechanism which is able to overbridge a variation of an inner diameter of a foundation pile

of at least two metre e.g. from about four to six metres, in particular at least three metres, but preferably at least four metres.

In an embodiment of the excavator according to invention, the clamping members when positioned in the extended configuration enlarge an outer diameter of the excavator to at least 8, in particular to at least lOmetres, more in particular to at least 15metres. Advantageously, the excavator as a submergible dredge device is usable to install off shore foundation piles of the largest type.

In an embodiment of the excavator according to the invention, the outer dimensions of the dredge device are adjustable to and fro a compact configuration to change radial outer dimensions of the device, wherein a maximum radial outer dimension is variable from 100% in an extreme extended configuration to at least 80%, in particular at least 60%, but preferably at least 50% in an extreme compact configuration. Herewith, the device may be adjustable to and fro outer dimensions from about 7 meters to about 4 meters and vice versa. Advantageously, the excavator is suitable to introduce a foundation pile which has a tapered transition portion. It is no longer necessary to split up the implementation of a foundation pile, wherein in a first step a base portion with a constant diameter is introduced, after which a transition portion is mounted to the base portion. Now, it is possible to introduce a structure already including a base and transition portion.

In an embodiment according to the invention, the excavator comprises a control platform, which control platform is mountable to a proximal end of the off shore foundation pile. The control platform may be provided with a winch to lower and lift the excavator into the inner space of the off shore foundation pile. Advantageously, the control platform which is installed at the proximal end of the structure provides a stationary location which is not influenced by swelling of the sea.

Further, the invention relates to a use of the excavator for installing an off shore ground structure. In particular, the ground structure is an off shore foundation pile. The excavator in a marine application can also be called a marine excavator or a submergible dredge device. The marine excavator can be used with a dredge head for dredging, in particular when releasing bottom parts from a soft soil water floor containing sand, clay and/or peat or with a cutter head for drilling, cutting or milling when releasing rocky bottom parts from a rocky water floor.

In a particular use, the excavator is used for installing an off shore foundation pile, wherein the off shore foundation pile has a narrowing portion having a small diameter at a proximal end and a widening portion having a large diameter at a distal end. The small diameter is for example at most 4meters, in which the large diameter at the distal end is for example at least 6meters. In use, the excavator can pass the narrowing portion in a compact

configuration, wherein the excavator can clam at the wide portion in the extended configuration.

Further preferred embodiments are defined in the sub claims.

The invention will be explained in more detail with reference to the appended drawings. The drawings show a practical embodiment according to the invention, which may not be interpreted as limiting the scope of the invention. Specific features may also be considered apart from the shown embodiment and may be taken into account in a broader context as a delimiting feature, not only for the shown embodiment but as a common feature for all embodiments falling within the scope of the appended claims, in which:

Fig. 1 shows in a perspective view an excavator arranged as a submergible dredge device according to the invention;

Fig. 2a shows in a schematic front view the submergible dredge device of Fig. 1 in an extended configuration;

Fig. 2b shows in a schematic top view the submergible dredge device of Fig. 2a;

Fig. 3a shows in a schematic side view the submergible dredge device of Fig. 1 in a compact figuration;

Fig. 3b shows in a schematic top view the submergible dredge device of Fig. 3a; and

Fig. 4 shows in a longitudinal cross view arrangement of an inner space of the submergible dredge device.

Identical reference numbers are used in the figures to indicate identical or similar components of the excavator according to the invention.

Figure 1 shows in a perspective view an embodiment of an excavator 1 according to the invention. In particular, the excavator is a marine excavator, more in particular a submergible dredge device. The marine excavator is arranged for use underwater. The marine excavator is arranged for use in an off shore environment. The submergible dredge device is arranged for dredging a soft soil bottom floor. In particular, the soft soil bottom floor contains sand, clay or the like.

The excavator 1 is configured to be lowered through a hollow elongated ground structure like a vertical access shaft or a foundation pile towards a bottom floor. The foundation pile may be a concrete or steel pile. In particular, the foundation pile is an off shore foundation pile, more in particular a wind turbine foundation pile. The wind turbine foundation pile may have a constant diameter. In particular, the wind turbine foundation pile has a varying diameter. The wind turbine foundation pile may have a top region and a base region, wherein the base region includes a larger inner diameter than the inner diameter of the top region.

The submergible dredge device comprises a framework 10. The framework 10 has a tubular shape. The framework 10 has an inner space which forms a support, in particular a housing for several components of the excavator 1.

At the proximal end, the framework 10 is provided with hoisting means 111, in particular hoisting eyes for connecting a hoisting cable to the framework 10 of the submergible dredge device. Herewith, the excavator can be suspended from a control board. Preferably, the control board is positioned on top of the ground structure. In contrast to a control board at a barge or vessel at water level which has inherent swell, the control board on top of the foundation casing does not move relatively to the submergible dredge device. The positioning of the control board on top of the foundation pile provides a stable work position.

The framework 10 includes a first framework part, also called a first casing 11 and a second framework part, also called a second casing 12. The casings 11,12 are elongated and cylindrical shaped and have a central axis which defines a longitudinal axis.

The first casing 11 is an outer casing. The second casing 12 is an inner casing. The first and second casing are telescopically connected to each other. The first casing is hollow. The first casing has a proximal and distal end. The first casing has a cylindrical wall. The first casing has a length of at least 5m, in particular at least 10 m. the first casing has an outer diameter of at most 3 m, in particular at most 4 m, more in particular at most 4.5 m. Herewith, the first casing can pass through a narrow portion of an off shore foundation pile.

The second casing 12 is at least partially receivable into a distal end of the first casing 11. The second casing 12 is linearly movable with respect to the first casing 11. At least one framework actuator 122, in particular a hydraulic cylinder, is provided to move the second casing 12 with respect to the first casing 11. As shown, a set of two hydraulic cylinders 122 are provided to move the second casing 12 with respect to the first casing 11 along the longitudinal axis. A rotation blockage 121 is provided to prevent a rotational movement of the second casing 12 about the longitudinal axis with respect to the first casing 11. Regarding a release process, the first casing 11 may also called a stationary casing and the second casing may also called a dynamic casing. During a releasing operation, the first casing is kept stationary with respect to the foundation pile and the second casing moves downwardly towards a bottom floor.

The excavator 1 is provided with a release arm 13 at the distal end of the framework 10. The release arm 13 is elongated and has a proximal and distal end. At the proximal end of the release arm, the release arm 13 is movable connected to the second framework part 12. At a distal end, the release arm is provided with a release head 3 for releasing bottom parts from a bottom floor. Here, the release head 3 is a dredge head for dredging bottom parts. A dredging operation can be performed when the bottom floor is situated in a water

environment. The bottom floor is a soft soil which contains sand, clay, peat or the like. The dredge head 3 is rotatable about the longitudinal axis of the release arm 13. The dredge head 3 is open worked and is dome shaped. The dredge head 3 comprises a plurality of dredge members 31 which are positioned at bar shaped dredge member holders 32 at an outer circumference of the dredge head 3. The bar shaped dredge member holders 32 provide the open worked property of the dredge head 3.

Fig. 2a shows in a front view the excavator, in particular the submergible dredge device, in an extended configuration. Figure 3a show in a side view the submergible dredge device in a compact configuration. Fig. 2b and Fig. 3b show a top view of the submergible dredge device in respectively the extended and compact configuration.

At least one clamping mechanism 21,22 is provided at the outer wall of the first casing 11 for clamping the framework 10 of the excavator 1 to an inner wall of a hollow structure. By operating the clamping mechanism 21, the first casing 11 of the framework 10 can be stationary positioned relative to a foundation pile. The clamping mechanism is provided with a clamping member 213,223 for contacting an inner wall of the foundation pile.

The clamping mechanism comprise a lever member 211 for overbridging a distance to and fro an inner wall of a foundation pile. The lever member 211 of the clamping mechanism is pivotally connected to the outer wall of the first casing. The clamping mechanism comprises at least one clamping member 213 which is positioned at a free end of the lever member. The clamping mechanism 21 comprises further a clamping actuator 212 to actuate the lever member 211 to and fro the first casing 11. In a movement from the compact to the extended configuration, the lever member may overbridge a distance of at least 0.5, in particular at least 1 m, more in particular at least 2 m.

Herewith, the submergible dredge device can be transformed from a compact configuration to an extended configuration. In the compact configuration, the clamping mechanism is positioned close to the outer wall of the first casing. In the extended configuration, the clamping mechanism is moved away from the first casing and may extend several metres from the first casing to the inner wall of the foundation pile. In the extended configuration, the clamping mechanism may increase the outer diameter of the framework 1 to at most 10m. Advantageously, the submergible dredge device can pass a narrowed portion of about 4m of an inner space of a foundation pile in the collapsed position and can be clamped at a wide portion of about 7 m to the foundation pile in the extended configuration of the clamping mechanism.

As shown in Fig. 2a and 3a, the submergible dredge device has a first and second clamping mechanism 21,22. The first clamping mechanism 21 is positioned in an upper region of the framework 1. The second clamping mechanism 22 is positioned below the first clamping mechanism in a lower region of the framework 10. By operating the first clamping

mechanism 21 and the second clamping mechanism 22 in an alternating manner, the submergible dredge device can be lowered in a controlled manner along the inner wall of the foundation pile.

Fig. 4 shows the excavator in a cross-sectional view about the longitudinal axis.

The second casing 12 has an inner space 120 which forms a housing. The housing 122 is water tightly sealed from the environment. The housing is accessible for an operator. An operator may access the second casing to inspect or service inner arranged components. At a proximal end, the housing of the second casing has an access opening to allow an operator to enter the inner space. A stair 124 and a platform 123 are provided to provide a safe working environment.

At a middle region, the second casing 12 comprises a discharge unit 50 for discharging release bottom parts. The discharge unit 50 comprises a discharge pump 52. The discharge pump 52, here a dredge pump, is arranged to pump released bottom parts away from the framework 10. The discharge pump is a centrifugal pump. The discharge pump 52 has a discharge pump housing with a central inlet and a tangential outlet. An outlet conduit 53 is connected to the tangential outlet of the discharge pump 52. An inlet conduit 51 is connected to the inlet of the discharge pump 52. The inlet 51 and outlet conduit 53 form a discharge conduit which extends from the release head 3 to the proximal end of the framework 10. Via the discharge conduits, released bottom parts from the bottom floor are pumped away in upwards direction. The discharge conduit of the discharge unit 50 extends over a length of at least 30 meter, in particular at least 50 meter, but more in particular at least 100 meter. Herewith, the discharge conduit may extend upwards from the water bottom to a water level. The discharge conduit may extend upwards to a control platform at the water level. A barge may be provided at the water level to collect released bottom parts.

Fig. 4 shows the release arm 13 of the excavator 1 in further detail. The release arm is elongated and has a longitudinal axis. The release arm has a proximal and distal end. A release head 3 is rotationally connected to the release arm 13. The release head 3 is rotational about the longitudinal axis of the release arm. In particular, the release arm 13 has a length of at least 2m, more in particular at least 4m. The release arm 13 is hollow and comprises at least one release arm casing.

At a distal end, the frame work 10 comprises a steering mechanism 4 which includes a cardan joint. The cardan joint has a cardan body 40 which has an open worked frame. The cardan body 40 has a central opening 401.

The release arm is movable connected to the distal end of the second casing by the cardan joint. The release arm 13 is movable in at least two degrees of freedom with respect to the framework 10 of the excavator 1. A first degree of freedom is provided by a pivotal connection which includes a first axis 41 of the cardan body arm to the framework 10. The

cardan body is subsequently movable in at least one degree of freedom relative to the release arm 13 which provides a second degree of freedom to the release arm. The second degree of freedom is provided by a pivotal connection which includes a second axis 42 of the cardan body to the release arm 13.

Herewith, the release arm 13 has at least two degrees of freedom to move relative to the distal end of the second casing.

At least one cardan body actuator 411 is provided to move the cardan body 40 relative to the second casing 12 about the first axis 41. As shown, two hydraulic cylinders 411, 412 are provided to swing the cardan body 40 relative to the second casing 12. Herewith, the cardan body 40 is pivotally movable connected to the second casing 12. The two hydraulic cylinders are arranged in a cross wise arrangement.

The pivotal connection of the release arm 13 to the cardan body 40 comprises at least one release arm actuator 421 to move the release arm 13 relative to the cardan body 40 about the second axis 42. As shown, the release arm actuator 421 includes a set of two hydraulic cylinders 421 ,422 for rotating the release arm 13.

As shown in Fig. 3a, the release arm is symmetrically rotatable about the first axis 41 with respect to the longitudinal axis 'L' of the framework 10 in a first direction. The release arm 13 is rotatable about the first axis 41 in a direction transversal the longitudinal axis about a pivot angle a of at least 30°, in particular at least 60°, more in particular at least 70°. In the first direction, the release head 3 at the distal end of the release arm 13 is movable from a first extreme position A to a second extreme position B. A distance in between the first and second extreme positions A, B may be at least 6 metres.

As shown in Fig. 2a, the release arm 13 is symmetrically rotatable with respect to the longitudinal axis 'L' of the framework 10 in a second direction about the second axis 42. The release arm 13 is rotatable about the second axis 42 in a direction transversal the longitudinal axis about a pivot angle β of at least 30°, in particular at least 60°, more in particular at least 70°. In the second direction, the release head 3 at the distal end of the release arm 13 is movable from a third extreme position C to a fourth extreme position D. A distance in between the third and fourth extreme positions C, D may be at least 6 metres.

Numerous variants are possible in addition to the embodiment shown.

In addition to the shown embodiments, the dredge head may be arranged as a cutter.

Although the invention has been disclosed with reference to particular embodiments, from reading this description those of skilled in the art may appreciate changes and modification that may be possible from a technical point of view but which do not depart from the scope of the invention as described above and claimed hereafter. It will be understood by those of skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention.

Modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiments disclosed in the above detailed description, but that the invention will include all embodiments falling within the scope of the appended claims.

CLAIMS

1. Excavator (1) for excavating bottom parts from a bottom floor at a distal end of a hollow ground structure, comprising

- a framework (10) for supporting components of the excavator, wherein the framework has a longitudinal axis (L) which extends from a proximal end to a distal end;
- a radial positioning mechanism (21) for positioning the framework in the hollow ground structure;
- a discharge unit (50) comprising a release head (3) for releasing bottom parts, wherein the release head is connected at an end of a release arm (13), wherein the release arm (13) is connected to the distal end of the framework (10), wherein the discharge unit (50) further comprises a discharge pump (52) which is connected to a discharge conduit (51 ,53) which extends from the release head (3) to the proximal end of the framework (10) for discharging released bottom parts away from the release head (3);
- a steering mechanism (4) for steering the release arm (3) from a first position to a second position, wherein the steering mechanism (4) is mounted to a distal end of the framework,

characterised in that the steering mechanism (4) comprises a cardan joint for connecting the release arm (13) to the frame work (10).

2. Excavator according to claim 1, wherein the cardan joint comprises a cardan body (40), which cardan body is pivotally about a first axis (41) connected with the distal end of the framework (10) and pivotally about a second axis (42) connected with the release arm (13), the cardan body (40) being actuable by at least one cardan body actuator (41 1) to rotate the cardan body (40) about the first axis (41), wherein the release arm (13) is actuable by at least one release arm actuator (421) to rotate the release arm (13) about the second axis (42).

3. Excavator according to claim 1 or 2, wherein the cardan body actuator comprises two hydraulical cylinders (41 1,412) which are positioned in a crosswise arrangement, wherein the hydraulical cylinders are single-acting cylinders.

4. Excavator according to claim 2 or 3, wherein the cardan body (40) has a passageway (401), wherein the discharge conduit extends through the passageway.

5. Excavator according to any of the preceding claims, wherein the framework has a first framework part (11) which is telescopically connected to a second framework part (12) for a movement of the second framework part along the longitudinal axis (L), wherein the

first and second framework part are furthermore connected to each other by at least one framework actuator for extending the framework in the longitudinal direction.

6. Excavator according to any of the preceding claims, wherein the framework (10) has a tubular shape which include an enclosed inner space (120), wherein the discharge pump (52) is located in the inner space.

7. Excavator according to any of the preceding claims, wherein the clamping mechanism (21) comprises at least one set of clamping members (213), wherein the clamping members are movable connected to the framework, wherein the clamping members are movable in a radial direction between a retracted and extended position, and by movement from the retracted to the extended position transform the excavator in radial direction from a compact configuration to an extended configuration, wherein the clamping members enlarges an outer diameter of the excavator in the compact configuration from an outer diameter of at most 5metres, in particular at most 4metres, to an outer diameter in the extended configuration in which the outer diameter is at least 6metres, in particular at least 6.5metres.

8. Excavator according to claim 7, wherein the clamping members (21) when positioned in the extended configuration enlarge an outer diameter of the excavator to at least 8, in particular at least lOmetres, more in particular at least 15metres.

9. Use of the excavator (1) as a submergible dredge device for installing an off shore foundation pile.

10. Use according to claim 9, wherein the off shore foundation pile has a narrowing portion and a wide portion, wherein the excavator passes the narrowing portion in a compact configuration and wherein the excavator clamps to an inner wall at the wide portion in an extended configuration of the excavator.

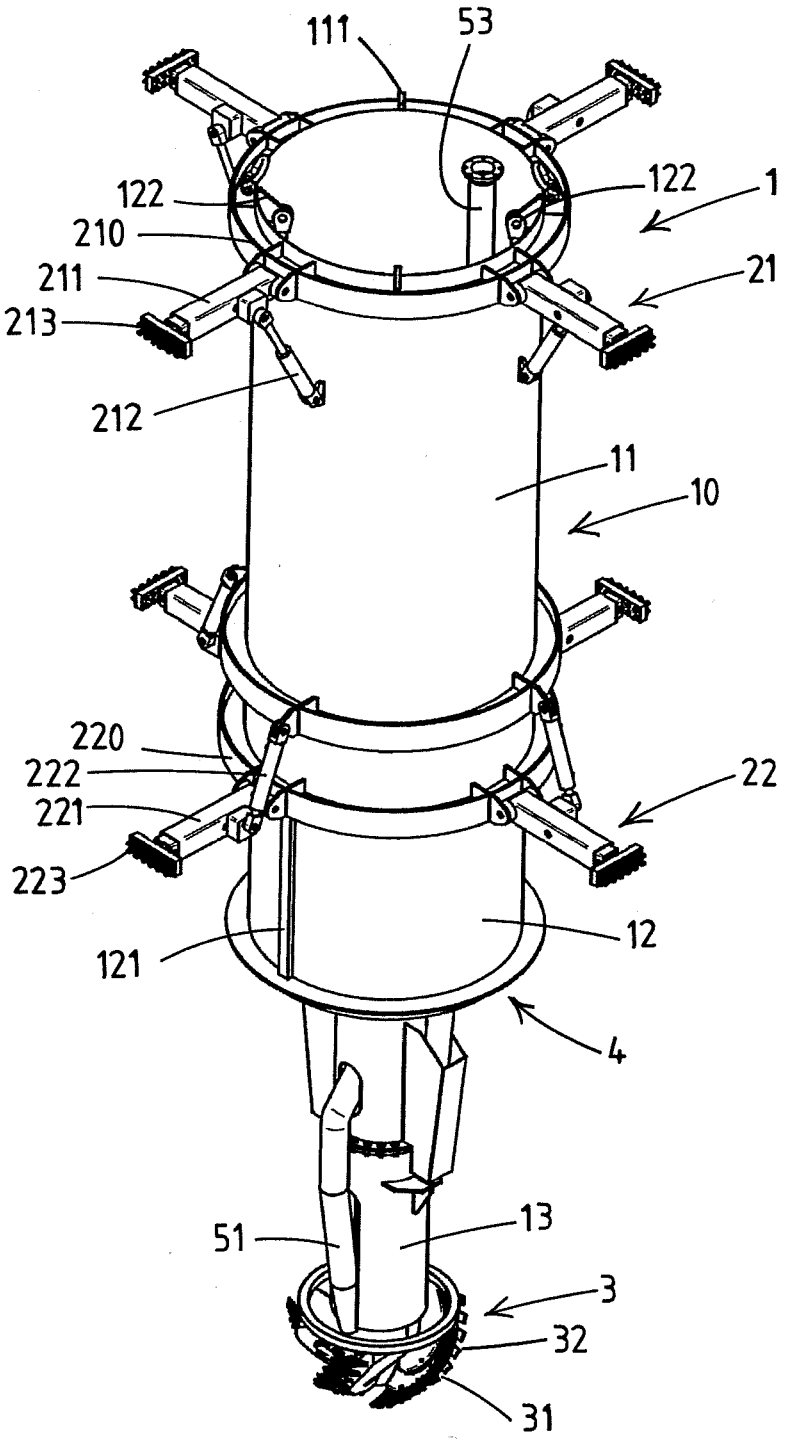
111
53
122
122
1
210
211
21
213
212
11
10
220
222
221
22
223
12
121
4
51
13
3
32
31

Fig.1

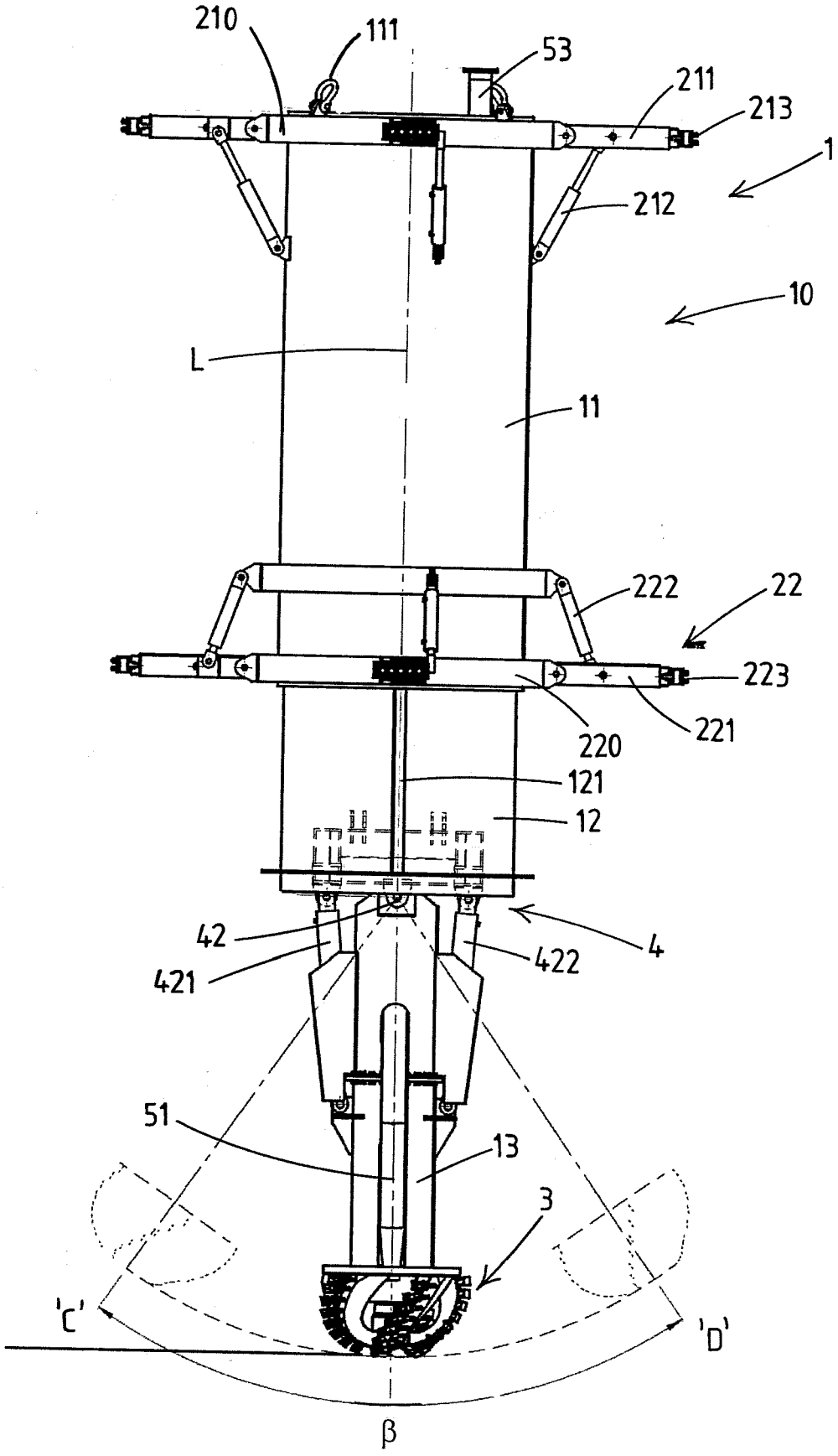
210
111
53
211
213
1
212
10
L
11
222
22
223
221
220
121
12
42
421
422
4
51
13
3
'C'
'D'
β

Fig.2a

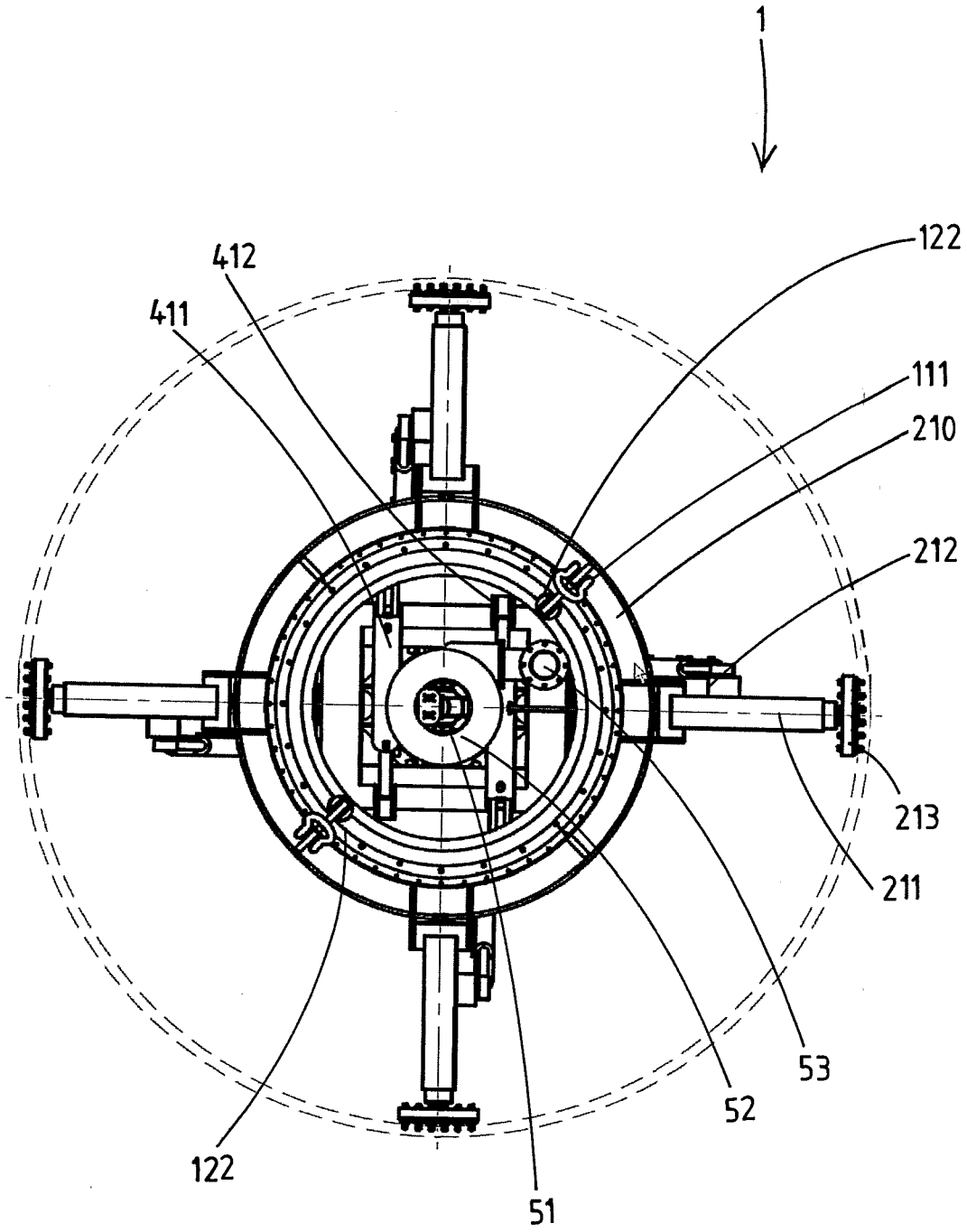

Fig.2b

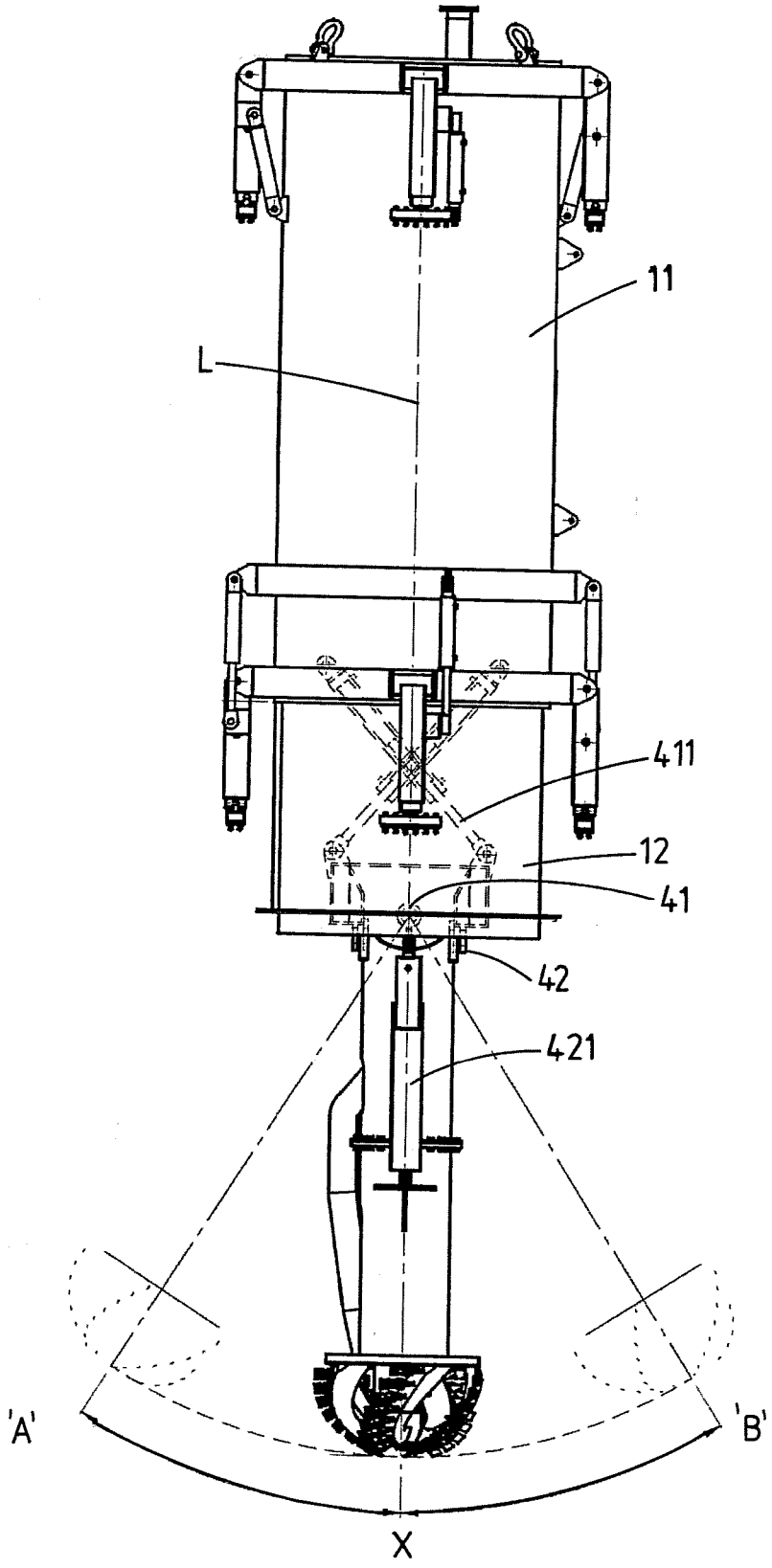

Fig.3a

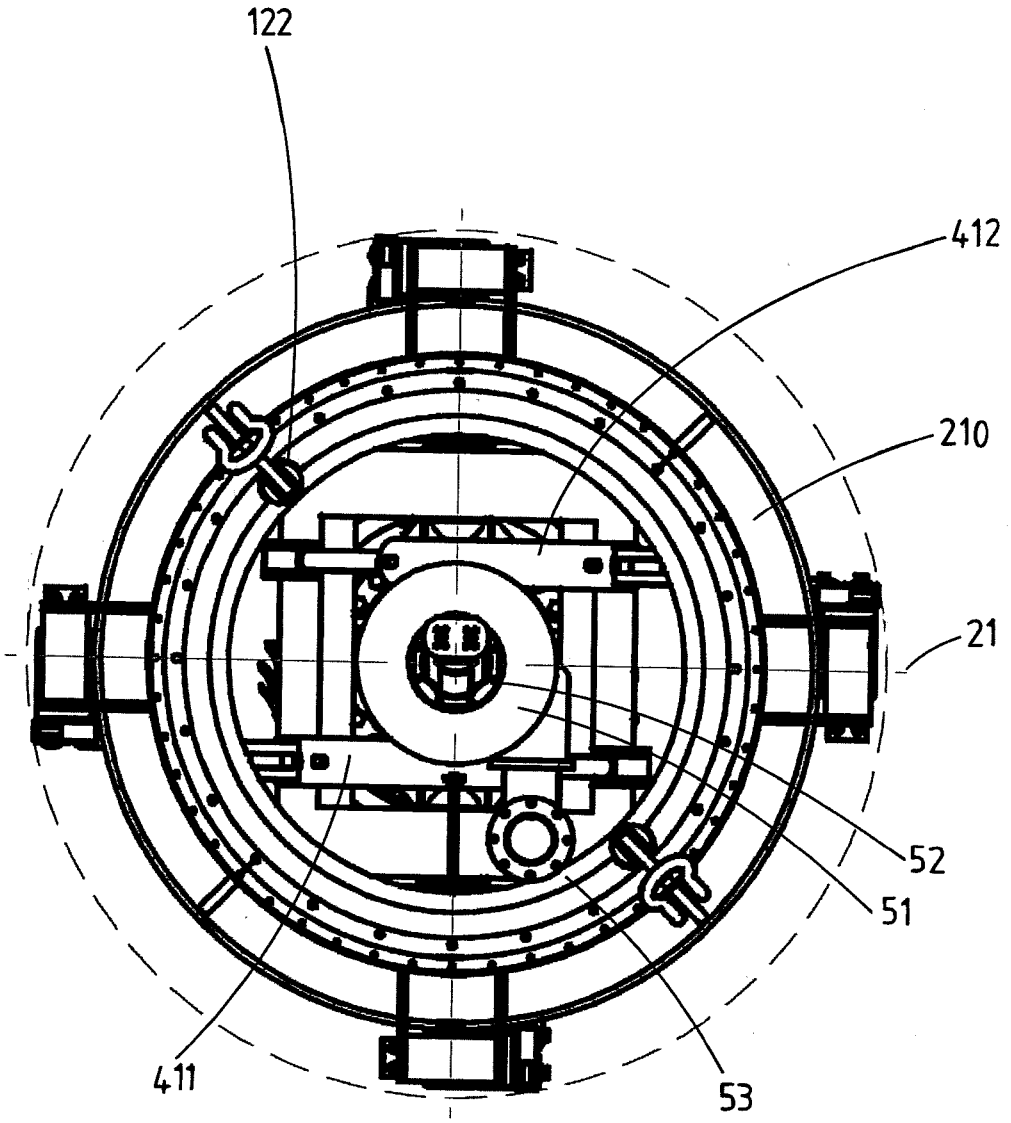

Fig.3b

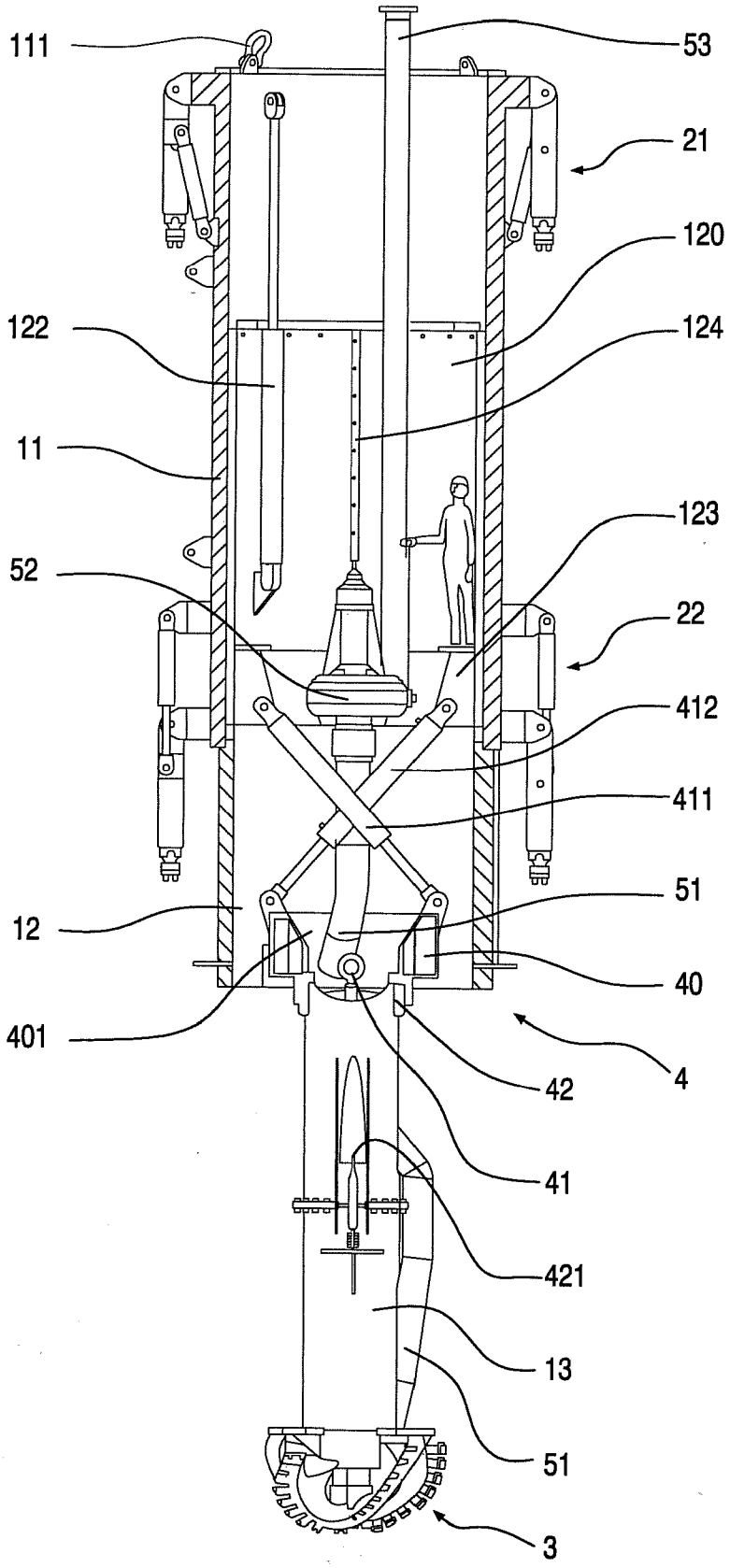
111
53
21
120
122
124
11
123
52
22
412
411
51
12
40
401
42
4
41
421
13
51
3

Fig.4

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2012/050831

A. CLASSIFICATION OF SUBJECT MATTER
INV. E02D5/44 E02D7/28
ADD.

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)
E02D

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

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

EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2010/139380 AI (HERRENKNECHT AG; PETERS MARK [DE]) 9 December 2010 (2010-12-09) the whole document	1-10
A	W0 2008/072950 A2 (VERTICAL DEV B V [NL] ; VAN LEEUWEN MARINUS TEUNIS J R [NL]) 19 June 2008 (2008-06-19) the whole document	1-10

☐ 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 claimfs) orwhich 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
26 February 2013	19/03/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+3 1-70) 340-3016	Geiger, Haral d

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NL2012/050831

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010139380 A1	09-12-2010	CN 102803616 A	28-11-2012
		DE 102009023466 A1	05-01-2011
		EP 2417303 A1	15-02-2012
		EP 2423390 A1	29-02-2012
		US 2012076591 A1	29-03-2012
		WO 2010139380 A1	09-12-2010
WO 2008072950 A2	19-06-2008	EP 2102418 A2	23-09-2009
		EP 2102419 A2	23-09-2009
		NL 1033050 C2	16-06-2008
		WO 2008072950 A2	19-06-2008
		WO 2008072951 A2	19-06-2008