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(54) **CONSTRUCTION METHOD FOR UNDERWATER PIPE PILE FOUNDATION AND UNDERWATER PIPE PILE FOUNDATION**

(57) The disclosure relates a construction method for an underwater pipe pile foundation and the underwater pipe pile foundation, wherein the method comprises the following steps: disposing construction interlayers (20) on a side wall of a hollow steel pipe pile body (3) in an axial direction, disposing a plurality of construction holes (17) in the sides, away from an inner cavity of the pipe pile body (3), of the construction interlayers (20) in the axial direction, the plurality of construction interlayers (20) being disposed at intervals in the circumferential direction of the pipe pile body (3), and covering the construction holes (17) with plugging plates (2), hoisting and

sinking the pipe pile body (3) on a position to be constructed, and sinking the pipe pile body (3) to a predetermined elevation; respectively disposing explosive impact apparatuses (5) at the plurality of construction holes (17), detonating the explosive impact apparatuses (5) to bomb out the plugging plates and form soil body cavities (7) in soil bodies on positions corresponding to the construction holes (17); laying down a grouting pipe (15) to the bottom of the pipe pile body (3) along the construction interlayers (20) and grouting the pile tip and the soil body cavities (7).

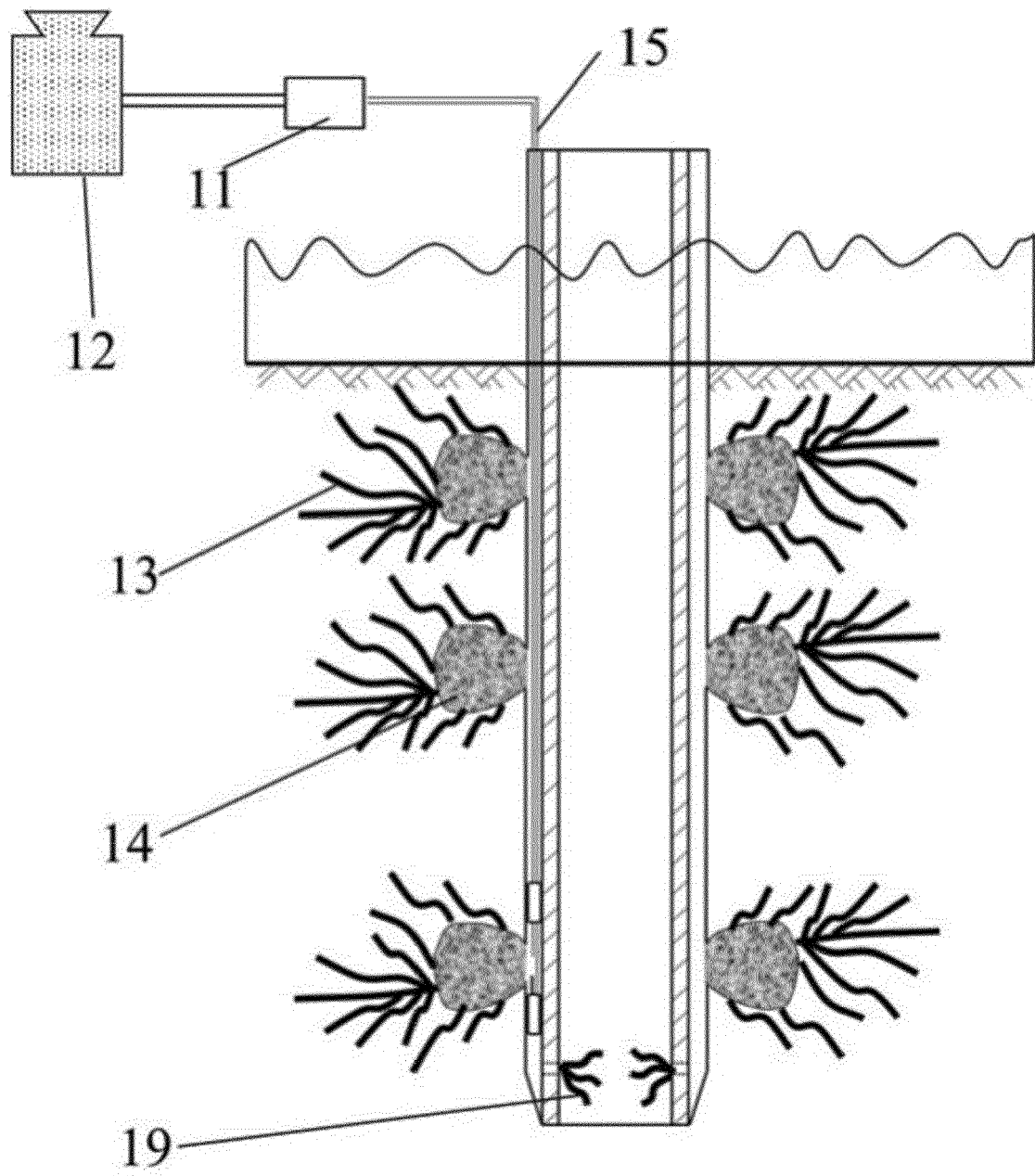


Fig. 6

Description

TECHNICAL FIELD

[0001] The present disclosure relates to the technical field of underwater pipe pile foundations, and particularly relates to a construction method for an underwater pipe pile foundation and the underwater pipe pile foundation.

BACKGROUND

[0002] With the development of offshore wind power towards deep and open sea, in order to more effectively utilize offshore wind power resources to increase the power generation efficiency, high-megawatt wind generator sets are to be developed and applied gradually, which will obviously increase the overall load on the upper parts of wind generators and causes the problem that the wind generators may collapse laterally after being mounted due to the increment of bearing capacity required on the bottoms of the wind generators, thereby affecting the smooth operation of the wind generators. The requirement on the bearing capacity can be met by means of increasing the size of an offshore wind power pile foundation, which can undoubtedly increase the production and transportation costs of the pile foundation greatly.

[0003] In order to reduce the device cost, a post-grouting construction method is frequently adopted as a construction method for a pile foundation in the prior art. During construction, firstly, a pipe pile foundation is driven into a soil body under a water body by a pile vibrosinking device, then, cement slurry is injected into the bottom of the pipe pile foundation from the inner side of a pipe pile by pressurization, and cement slurry is squeezed into the soil body, so that the strength of the soil body below the pipe pile foundation is enhanced, and the pipe pile foundation is prevented from sinking. However, during post-grouting construction, the soil body under the water body is higher in density, the diffusion volume of the cement slurry in the soil body is smaller, and the soil body may play a role in filtering the cement slurry in the process of injecting the cement slurry by pressurization, so that solid and liquid in the concrete may be separated to greatly reduce the strength of the cement slurry, which weakens the bearing capacity enhancement for the pipe pile foundation, and may still cause the problem that the pipe pile is inclined laterally during actual use.

SUMMARY

[0004] Therefore, the technical problem to be solved by the present disclosure is to overcome the defect in the prior art that the bearing capacity enhancement of a pipe pile foundation constructed by using a post-grouting construction method for an underwater pipe pile foundation is weakened, thereby providing a construction method for an underwater pipe pile foundation and the under-

water pipe pile foundation.

[0005] In order to solve the above-mentioned technical problem, the present disclosure provides a construction method for an underwater pipe pile foundation, including the following steps:

[0006] disposing construction interlayers on a side wall of a pipe pile body in an axial direction, disposing a plurality of construction holes in the sides, away from an inner cavity of the pipe pile body, of the construction interlayers in the axial direction, and covering the construction holes with plugging plates;

hoisting and sinking the pipe pile body on a position to be constructed, and sinking the pipe pile body to a predetermined elevation;

respectively disposing explosive impact apparatuses at the plurality of construction holes along the construction interlayers, and detonating the explosive impact apparatuses to bomb out the plugging plates and form soil body cavities in soil bodies on positions corresponding to the construction holes; and

injecting cement slurry into the soil body cavities along the construction interlayers via the construction holes to complete the construction.

[0007] Optionally, before the step of injecting cement slurry into the soil body cavities, the construction method further includes: injecting the cement slurry into soil bodies on the bottom of the pipe pile body via the construction interlayers to complete pile tip grouting.

[0008] Optionally, the step of pile tip grouting includes: laying down a grouting pipe to the bottom of the pipe pile body along the construction interlayers, isolating the construction interlayer at a slurry outlet of the grouting pipe, and injecting the cement slurry at a predetermined pressure via the grouting pipe.

[0009] Optionally, the step of injecting cement slurry into the soil body cavities includes: forming the slurry outlet in the side wall of the grouting pipe, laying down the grouting pipe to the slurry outlet and a certain construction hole along the construction interlayers, isolating two sides of the slurry outlet in the axial direction of the grouting pipe in the construction interlayers, enabling the slurry outlet, the construction holes and the soil body cavities to form an isolated sealed space, and injecting the cement slurry into the soil body cavities via the grouting pipe.

[0010] Optionally, the slurry outlet is disposed in the side wall of the grouting pipe, and isolation air sacs are mounted on two sides of the slurry outlet in the axial direction of the grouting pipe; and the step of isolating two sides of the slurry outlet in the axial direction of the grouting pipe includes: by inflating the pair of isolation air sacs disposed on the two sides of the slurry outlet in the grouting pipe, expanding the isolation air sacs until horizontal spaces on positions where the isolation air sacs in the

construction interlayers are located are fully filled.

[0011] Optionally, each of the explosive impact apparatuses includes a pair of isolation plates and an explosive box disposed between the pair of isolation plates; and when the explosive impact apparatuses are disposed at the plurality of construction holes, the explosive boxes are aligned to the construction holes, and the pair of isolation plates is respectively disposed on the upper and lower sides of the construction hole.

[0012] Optionally, the step of disposing construction interlayers includes: disposing the plurality of construction interlayers at intervals in the circumferential direction of the pipe pile body.

[0013] The present disclosure further provides an underwater pipe pile foundation constructed by applying the construction method for the underwater pipe pile foundation in the present disclosure.

[0014] Optionally, the bottom of the underwater pipe pile foundation extends into a soil body, and the underwater pipe pile foundation includes: a pipe pile body; and soil body cavities formed in soil bodies surrounding the pipe pile body, the soil body cavities being filled with cement structural bodies, and the cement structural bodies being connected to the pipe pile body.

[0015] Optionally, the underwater pipe pile foundation further includes a plurality of pile side slurry veins dispersively extending from the soil body cavities to a direction away from the pipe pile body, the pile side slurry veins being connected with the cement structural bodies into a whole.

[0016] The technical solutions of the present disclosure have the following advantages.

1. The construction method for the underwater pipe pile foundation provided by the present disclosure includes the following steps: disposing the construction interlayers on the side wall of the pipe pile body in the axial direction, disposing the plurality of construction holes in the sides, away from the inner cavity of the pipe pile body, of the construction interlayers in the axial direction, and covering the construction holes with the plugging plates; hoisting and sinking the pipe pile body on the position to be constructed, and sinking the pipe pile body to the predetermined elevation; respectively disposing the explosive impact apparatuses at the plurality of construction holes along the construction interlayers, and detonating the explosive impact apparatuses to bomb out the plugging plates and form the soil body cavities in the soil bodies on the positions corresponding to the construction holes; and injecting the cement slurry into the soil body cavities along the construction interlayers via the construction holes to complete the construction.

Firstly, explosive compact is performed on the soil bodies surrounding the pipe pile body; the plugging plates on the construction interlayers are vibrated to be smashed by impact waves generated by explo-

sion; the soil bodies on the outer side form the soil body cavities due to the impact waves, and the soil bodies at the peripheries of the cavities are squeezed to be more compact; then, the soil body cavities formed on a pile side at intervals are grouted in a high-pressure grouting manner; and thus, the horizontal resistance and the vertical bearing capacity of pile side soil bodies can be effectively enhanced, the ability of the pipe pile body resisting horizontal displacement under the action of a lateral load and a bending moment is improved, and the risk that the pile foundation is inclined towards one side under the impact action of water flow, sea waves and the like can be reduced greatly.

2. In the construction method for the underwater pipe pile foundation provided by the present disclosure, before the step of injecting cement slurry into the soil body cavities, the construction method further includes: injecting the cement slurry into the soil bodies on the bottom of the pipe pile body via the construction interlayers to complete pile tip grouting. By injecting the cement slurry in the soil bodies on the bottom of the pipe pile body in advance, pile tip grouting stone bodies are formed on a pile tip of the pipe pile body, so that the soil plugging effect of a pipe pile is improved, and the bearing capacity of the pipe pile is comprehensively improved. Meanwhile, the pipe pile is prevented from settling during construction to prevent the construction holes from being mismatched with the soil body cavities, so that the construction precision is improved, and the horizontal resistance and vertical bearing capacity of the pile side soil bodies are effectively enhanced.

3. In the construction method for the underwater pipe pile foundation provided by the present disclosure, by inflating the pair of isolation air sacs disposed on the two sides of the slurry outlet in the grouting pipe, the isolation air sacs expand until the horizontal spaces on the positions where the isolation air sacs in the construction interlayers are located are fully filled. The horizontal spaces on heights where the isolation air sacs are located are fully filled by the isolation air sacs, so that the slurry outlet, the construction holes and the soil body cavities form an isolated sealed space; then, the cement slurry is injected into the soil body cavities via the grouting pipe, an injection pressure is increased when the cement slurry is injected, and due to the injection of the cement slurry by pressurization, the penetration depth of the cement slurry in the soil bodies and the compaction degree of the cement slurry inside the soil body cavities can be effectively improved.

4. In the construction method for the underwater pipe pile foundation provided by the present disclosure, each of the explosive impact apparatuses includes

the pair of isolation plates and the explosive box disposed between the pair of isolation plates; and when the explosive impact apparatuses are disposed at the plurality of construction holes, the explosive boxes are aligned to the construction holes, and the pair of isolation plates is respectively disposed on the upper and lower sides of the construction holes. When the soil body cavities are formed by explosion construction, by mounting the explosive box between the two isolation plates, explosive impact waves in a vertical direction are obstructed by the isolation plates when the explosive box is detonated, so that the impact waves can only move to the plugging plates and form impact in the soil bodies on corresponding positions after bombing out the plugging plates to form the soil body cavities. By directionally moving the explosive impact waves, the compaction degrees of the soil bodies surrounding the soil body cavities formed by explosive impact are enhanced, and the bearing capacity of the soil bodies surrounding the pile foundation to the pile foundation is improved.

5. The underwater pipe pile foundation provided by the present disclosure extends into the soil body and includes: the pipe pile body; and the soil body cavities formed in the soil bodies surrounding the pipe pile body, the soil body cavities being filled with the cement structural bodies, and the cement structural bodies being connected to the pipe pile body. By disposing the cement structural bodies connected to the pipe pile body in the soil bodies surrounding the pipe pile body and enhancing the bearing capacity surrounding the pipe pile body, the risk that the pipe pile body is inclined to laterally collapse can be reduced effectively.

6. The underwater pipe pile foundation provided by the present disclosure further includes the plurality of pile side slurry veins dispersively extending from the soil body cavities to a direction away from the pipe pile body, and the pile side slurry veins are connected with the cement structural bodies into a whole. By outwards extending the pile side slurry veins from the cement structural bodies, the overall movement resistance of the cement structural bodies is increased, the cement structural bodies are prevented from settling, the cement structural bodies can be stably connected to the periphery of the pipe pile body, and the long-term stable operation of the underwater pipe pile foundation is guaranteed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] To describe the technical solutions in the specific implementations of the present disclosure or the prior art more clearly, the accompanying drawings required for describing the specific implementations or the prior

art will be briefly introduced below. Apparently, the accompanying drawings in the following description show only some implementations of the present disclosure, and those of ordinary skill in the art may still derive other accompanying drawings from these accompanying drawings without creative efforts.

Fig. 1 is a top view showing a pipe pile body provided in an implementation of the present disclosure;

Fig. 2 is a schematic diagram showing that a pipe pile body provided in an implementation of the present disclosure sinks to a predetermined elevation on the seabed;

Fig. 3 is a schematic diagram showing a step that explosive impact apparatuses are disposed and detonated in an implementation of the present disclosure;

Fig. 4 is a schematic structural diagram showing an explosive impact apparatus provided in an implementation of the present disclosure;

Fig. 5 is a schematic diagram showing working states of isolation air sacs provided in an implementation of the present disclosure; and

Fig. 6 is a schematic diagram showing a step of pile side grouting construction provided in an implementation of the present disclosure.

[0018] Descriptions for reference numerals in the accompanying drawings: 1, channel steel; 2, high-strength plastic plate; 3, pipe pile body; 4, pile tip grouting hole; 5, explosive impact apparatus; 6, steel wire rope; 7, soil body cavity; 8, explosive box; 9, explosion starter; 10, isolation plate; 11, grouting pump; 12, slurry agitation and storage device; 13, pile side slurry vein; 14, cement slurry; 15, grouting pipe; 16, slurry outlet; 17, construction hole; 18, isolation air sac; 19, pile tip grouting stone body; and 20, construction interlayer.

DETAILED DESCRIPTION

[0019] The technical solutions of the present disclosure will be described clearly and completely below with reference to the accompanying drawings. Apparently, the described embodiments are only a part, but not all, of the embodiments of the present disclosure. Based on the embodiments in the present disclosure, all other embodiments obtained by those of ordinary skill in the art without creative effects shall fall within the protection scope of the present disclosure.

[0020] In the description of the present disclosure, it should be noted that directional or positional relationships indicated by terms such as "center", "upper", "lower", "left", "right", "vertical", "horizontal", "inner" and "out-

er" are directional or positional relationships based on the accompanying drawings, are merely intended to facilitate the description of the present disclosure and the simplification of the description, rather than to indicate or imply that the appointed apparatus or element has to be located in a specific direction or structured and operated in the specific direction so as not to be understood as restrictions on the present disclosure. In addition, terms "first", "second" and "third" are only for the purpose of description, but cannot be understood as indicating or implying the relative importance.

[0021] In the description of the present disclosure, it should be noted that the terms "mount", "link", and "connection" should be understood in a broad sense unless otherwise specified and defined, for example, "connection" may be fixed connection or detachable connection or integral connection, may be mechanical connection or electrical connection, may be direct connection or indirect connection through an intermediate medium, and may be internal connection of two elements. For those of ordinary skill in the art, the specific meanings of the above-mentioned terms in the present disclosure may be understood according to specific situations.

[0022] In addition, the technical features involved in the different implementations of the present disclosure described below may be combined with one another without any conflict.

Embodiment 1

[0023] As shown in Fig. 1 to Fig. 6, the present embodiment provides a construction method for an underwater pipe pile foundation, which is applicable to construction of a pipe pile foundation in a water body such as a river, a lake, and the sea, and includes the following steps.

[0024] Construction interlayers 20 are disposed on a side wall of a pipe pile body 3 in an axial direction, and four construction interlayers 20 are disposed at intervals in the circumferential direction of the pipe pile body 3. A plurality of construction holes 17 are disposed in the sides, away from an inner cavity of the pipe pile body 3, of the construction interlayers 20 in the axial direction, and the construction holes 17 are covered with high-strength plastic plates 2 serving as plugging plates. In the present embodiment, firstly, holes serving as the construction holes 17 are formed at intervals in a web plate of channel steel 1 in a length direction, and the high-strength plastic plates 2 are fixed to inner sides of rectangular holes in a manner of epoxy resin glue or bolt connection. After the connection between the channel steel 1 and the high-strength plastic plates 2 is completed, the channel steel 1 is welded on an outer wall of a steel pipe pile. By welding two wing plates of the channel steel 1 on the outer side wall of the steep pipe pile, the construction interlayers 20 are formed between the channel steel 1 and the steel pipe pile.

[0025] The pipe pile body 3 on which the construction

interlayers 20 are mounted is shipped to a construction machine station by a transport ship; the pipe pile body 3 is hoisted, firstly, the pile sinks by means of the dead weight of the pipe pile body 3, and then, a pile hammer is mounted to hit and sink the pile to a predetermined elevation.

[0026] A plurality of explosive impact apparatuses 5 are hoisted into the construction interlayers 20 by means of steel wire ropes 6. Each of the explosive impact apparatuses 5 includes a pair of steel isolation plates 10 and an explosive box 8 disposed between the pair of isolation plates 10; and when the explosive impact apparatuses 5 are disposed at the plurality of construction holes 17, the explosive boxes 8 and the construction holes 17 are correspondingly consistent in height, and the pair of isolation plates 10 is respectively disposed on upper and lower sides of the construction holes 17. After the preparatory work is ready, explosion starters 9 are started to complete energy release of all explosive boxes 8 inside a single piece of channel steel 1, so that the plugging plates are bombed out, and soil body cavities 7 are formed in soil bodies on positions corresponding to the construction holes 17. Then, residues obtained after the explosive impact apparatuses 5 in the pile side soil bodies are taken out and stored. The explosive impact apparatuses 5 are hoisted by the steel wire ropes 6, leading wires are disposed inside the steel wire ropes 6, one end of each leading wire is sequentially connected to each of the plurality of explosive boxes 8, and the other end of each leading wire is connected to each of the explosion starters 9. When the explosion starters 9 are started, the explosive boxes 8 are detonated to generate explosive impact waves by which the high-strength plastic plates 2 are bombed out, and thus, the soil body cavities 7 are formed outside. The pair of isolation plates 10 is used to provide a reliable limited space so that explosive impact energy is mainly propagated to the high-strength plastic plates 2.

[0027] Before cement slurry 14 is injected into the soil body cavities 7, the cement slurry 14 is injected into soil bodies on the bottom of the pipe pile body 3 via the construction interlayers 20 to complete pile tip grouting. A grouting pipe 15 is laid down to the bottom of the pipe pile body 3 along the construction interlayers 20, the construction interlayer 20 at a slurry outlet 16 of the grouting pipe 15 is isolated, and the cement slurry 14 is injected at a predetermined pressure via the grouting pipe 15. Specifically, pile tip grouting holes 4 for communicating the construction interlayers 20 to the inner cavity of the pipe pile body 3 are formed in the side wall on the end, close to the bottom, of the pipe pile body 3. The slurry outlet 16 is disposed in the side wall of the grouting pipe 15, and isolation air sacs 18 are mounted on two sides of the slurry outlet 16 in the axial direction of the grouting pipe 15. An outer surface of the grouting pipe 15 is provided with height marks. Firstly, the grouting pipe 15 is laid down to a pile tip, and the slurry outlet 16 in the grouting pipe 15 is enabled to align to the pile tip grouting

holes 4 and face the pile tip grouting holes 4. An inflation apparatus is started to inflate the isolation air sacs 18 to expand the isolation air sacs 18 on the upper and lower sides of the slurry outlet 16, and after the two isolation air sacs 18 on the upper and lower sides are closed, a sealed space is formed for the slurry outlet 16 of the grouting pipe 15. Then, a grouting pump 11 is started, a pressure gauge is adjusted to a set grouting strength, and the cement slurry 14 is injected into a soil core inside the pile tip via the grouting pipe 15 to form pile tip grouting stone bodies 19, thereby completing pile tip grouting. The slurry is injected into the soil core inside the pile tip of the pipe pile body 3 from the slurry outlet 16 of the grouting pipe 15 via the pile tip grouting holes 4 to form the pile tip grouting stone bodies 19, so that the strength of the soil core is enhanced, and the bearing capacity of the pile tip is increased.

[0028] Air in the isolation air sacs 18 is released, and the grouting pipe 15 is uplifted to the slurry outlet 16 of the channel steel 1 on the bottommost end of a pile side; the inflation apparatus is restarted, and after the inflation for the two isolation air sacs 18 on the upper and lower sides is completed, the isolation air sacs 18 expand until horizontal spaces on positions where the isolation air sacs 18 in the construction interlayers 20 are located are fully filled, and the slurry outlet 16, the construction holes 17 and the soil body cavities 7 are enabled to form an isolated sealed space; high-pressure grouting starts, and the slurry rushes into the soil body cavities 7 and spread to the surrounding soil bodies; and grouting is stopped when the grouting rate is reduced sharply. The above-mentioned step that the grouting pipe 15 is uplifted is repeated, and the slurry outlet 16 is enabled to sequentially correspond to the soil body cavities 7 on different heights until all pile side grouting constructions are completed. The grouting construction processes in the plurality of construction interlayers 20 may be performed at the same time or alone, and the specific construction manner may be determined according to situations on construction sites. During grouting, the cement slurry 14 in a slurry agitation and storage device 12 is injected into the slurry outlet 16 of the grouting pipe 15 via a slurry suction pipe and a grouting and delivering pipe under a pressure generated by the grouting pump 11. The annular isolation air sacs 18 are disposed on the upper and lower sides of the slurry outlet 16 of the grouting pipe 15, and the isolation air sacs 18 expand by inflation before grouting to form a sealed space, which ensures that the cement slurry 14 smoothly enters the soil body cavities 7 formed by explosive impact under the action of high pressure and also enters the soil bodies at the peripheries of the soil body cavities 7 in a manner of permeation, compaction or cleavage to form irregular pile side slurry veins 13 extending vertically and horizontally.

[0029] The present disclosure provides a post-grouting bearing capacity improving technology applicable to explosive impact on an offshore wind power steel pipe pile. By adding the explosive impact apparatuses 5, the plastic

plugging plates on the channel steel 1 are vibrated to be smashed by impact waves generated by explosion; the soil bodies on the outer side form the soil body cavities 7 due to the impact waves; and the soil bodies at the peripheries of the cavities are squeezed to be more compact, so that the void ratio of the soil bodies is reduced. The soil body cavities 7 formed on the pile side at intervals are grouted in a high-pressure grouting manner, and thus, the horizontal resistance and the vertical bearing capacity of pile side soil bodies can be enhanced as a whole. In addition, the soil core inside the pipe pile body 3 can be reinforced by the grouting holes formed near the pile tip, so that the soil plugging effect of the steel pipe pile is further improved, and the bearing capacity of the pipe pile body 3 is comprehensively improved.

[0030] As an alternative implementation, when the wall thickness of the pipe pile body 3 meets design strength, the construction interlayers may be directly formed in the side wall of the pipe pile body 3 when the pipe pile body 3 is formed.

[0031] As an alternative implementation, when the internal diameter of the pipe pile body 3 meets a construction requirement, the construction interlayers may be formed by welding the channel steel 1 on the inner side wall of the pipe pile body 3, and the construction holes 17 are reserved in the side wall when the pipe pile body 3 is formed or the construction holes 17 are formed by cutting on corresponding positions after the construction of the construction interlayers is completed.

Embodiment 2

[0032] The present embodiment provides an underwater pipe pile foundation constructed by applying the construction method for the underwater pipe pile foundation in embodiment 1.

[0033] The bottom of the underwater pipe pile foundation extends into a soil body. The underwater pipe pile foundation includes a pipe pile body and soil body cavities. The soil body cavities are formed in soil bodies surrounding the pipe pile body, and are filled with cement structural bodies, and the cement structural bodies are connected to the pipe pile body. The underwater pipe pile foundation further includes a plurality of pile side slurry veins dispersively extending from the soil body cavities to a direction away from the pipe pile body, and the pile side slurry veins are connected with the cement structural bodies into a whole. By outwards extending the pile side slurry veins from the cement structural bodies, the overall movement resistance of the cement structural bodies is increased to prevent the cement structural bodies from settling, so that the cement structural bodies can be stably connected to the periphery of the pipe pile body, thereby guaranteeing the long-term stable operation of the underwater pipe pile foundation. An inner cavity at the bottom of the pipe pile body is further provided with pile tip grouting stone bodies, so that the soil plugging effect is improved. By disposing the soil body cavities, the ce-

ment structural bodies, the pile side slurry veins, and the pile tip grouting stone bodies, the horizontal and vertical bearing capacity of the pipe pile body are comprehensively enhanced, and the risk that the pipe pile body is inclined to laterally collapse during use can be reduced greatly.

[0034] Apparently, the above-mentioned embodiments are merely intended to clearly describe examples, rather than to limit the implementations. Those of ordinary skill in the art can further make other variations or alterations in different forms on the basis of the above-mentioned description. It is unnecessary and impossible to exhaustively list all the implementations herein. Apparent variations or alterations derived therefrom still fall within the protection scope of the present disclosure.

Claims

1. A construction method for an underwater pipe pile foundation, comprising the following steps:

disposing construction interlayers (20) on a side wall of a pipe pile body (3) in an axial direction, disposing a plurality of construction holes (17) in the sides, away from an inner cavity of the pipe pile body (3), of the construction interlayers (20) in the axial direction, the plurality of construction interlayers (20) being disposed at intervals in the circumferential direction of the pipe pile body (3), and covering the construction holes (17) with plugging plates, the pipe pile body (3) being a hollow steel pipe pile; hoisting and sinking the pipe pile body (3) on a position to be constructed, and sinking the pipe pile body (3) to a predetermined elevation; respectively disposing explosive impact apparatuses (5) at the plurality of construction holes (17) along the construction interlayers (20), each of the explosive impact apparatuses (5) comprising a pair of isolation plates (10) and an explosive box (8) disposed between the pair of isolation plates (10); aligning the explosive boxes (8) to the construction holes (17), respectively disposing the pair of isolation plates (10) on the upper and lower sides of the construction holes (17), detonating the explosive impact apparatuses (5) to bomb out the plugging plates and form soil body cavities (7) in soil bodies on positions corresponding to the construction holes (17); laying down a grouting pipe (15) to the bottom of the pipe pile body (3) along the construction interlayers (20), isolating the construction interlayer (20) at a slurry outlet (16) of the grouting pipe (15), forming pile tip grouting holes (4) for communicating the construction interlayers (20) to the inner cavity of the pipe pile body (3) in the

side wall on the end, close to the bottom, of the pipe pile body (3), and injecting slurry into a soil core inside a pile tip of the pipe pile body (3) from the slurry outlet (16) of the grouting pipe (15) via the pile tip grouting holes (4) to complete pile tip grouting; and injecting cement slurry (14) into the soil body cavities (7) along the construction interlayers (20) via the construction holes (17) to complete the construction.

2. The construction method for the underwater pipe pile foundation of claim 1, wherein the step of injecting cement slurry (14) into the soil body cavities (7) comprises: forming the slurry outlet (16) in the side wall of the grouting pipe (15), laying down the grouting pipe (15) to the slurry outlet (16) and a certain construction hole (17) along the construction interlayers (20), isolating two sides of the slurry outlet (16) in the axial direction of the grouting pipe (15) in the construction interlayers (20), enabling the slurry outlet (16), the construction holes (17) and the soil body cavities (7) to form an isolated sealed space, and injecting the cement slurry (14) into the soil body cavities (7) via the grouting pipe (15).
3. The construction method for the underwater pipe pile foundation of claim 2, wherein isolation air sacs (18) are mounted on two sides of the slurry outlet (16) in the axial direction of the grouting pipe (15); and the step of isolating two sides of the slurry outlet (16) in the axial direction of the grouting pipe (15) comprises: by inflating the pair of isolation air sacs (18) disposed on the two sides of the slurry outlet (16) in the grouting pipe (15), expanding the isolation air sacs (18) until horizontal spaces on positions where the isolation air sacs (18) in the construction interlayers (20) are located are fully filled.
4. An underwater pipe pile foundation, constructed by applying the construction method for the underwater pipe pile foundation of any one of claims 1 to 3.
5. The underwater pipe pile foundation of claim 4, wherein the bottom of the underwater pipe pile foundation extends into a soil body, and the underwater pipe pile foundation comprises:

a pipe pile body (3); and

soil body cavities (7) formed in soil bodies surrounding the pipe pile body (3), the soil body cavities (7) being filled with cement structural bodies, and the cement structural bodies being connected to the pipe pile body (3).
6. The underwater pipe pile foundation of claim 5, further comprising a plurality of pile side slurry veins (13) dispersively extending from the soil body cavi-

ties (7) to a direction away from the pipe pile body (3), the pile side slurry veins (13) being connected with the cement structural bodies into a whole.

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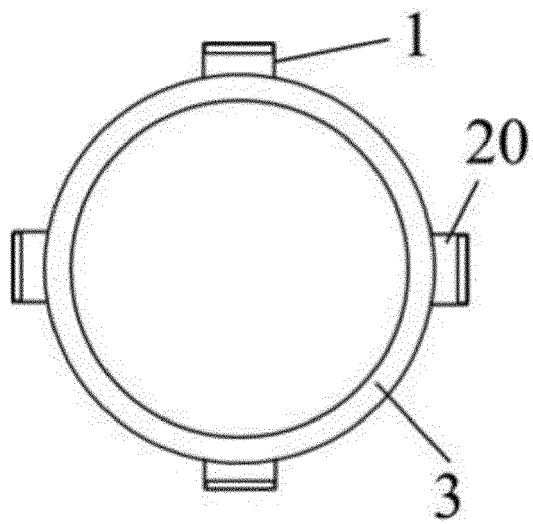


Fig. 1

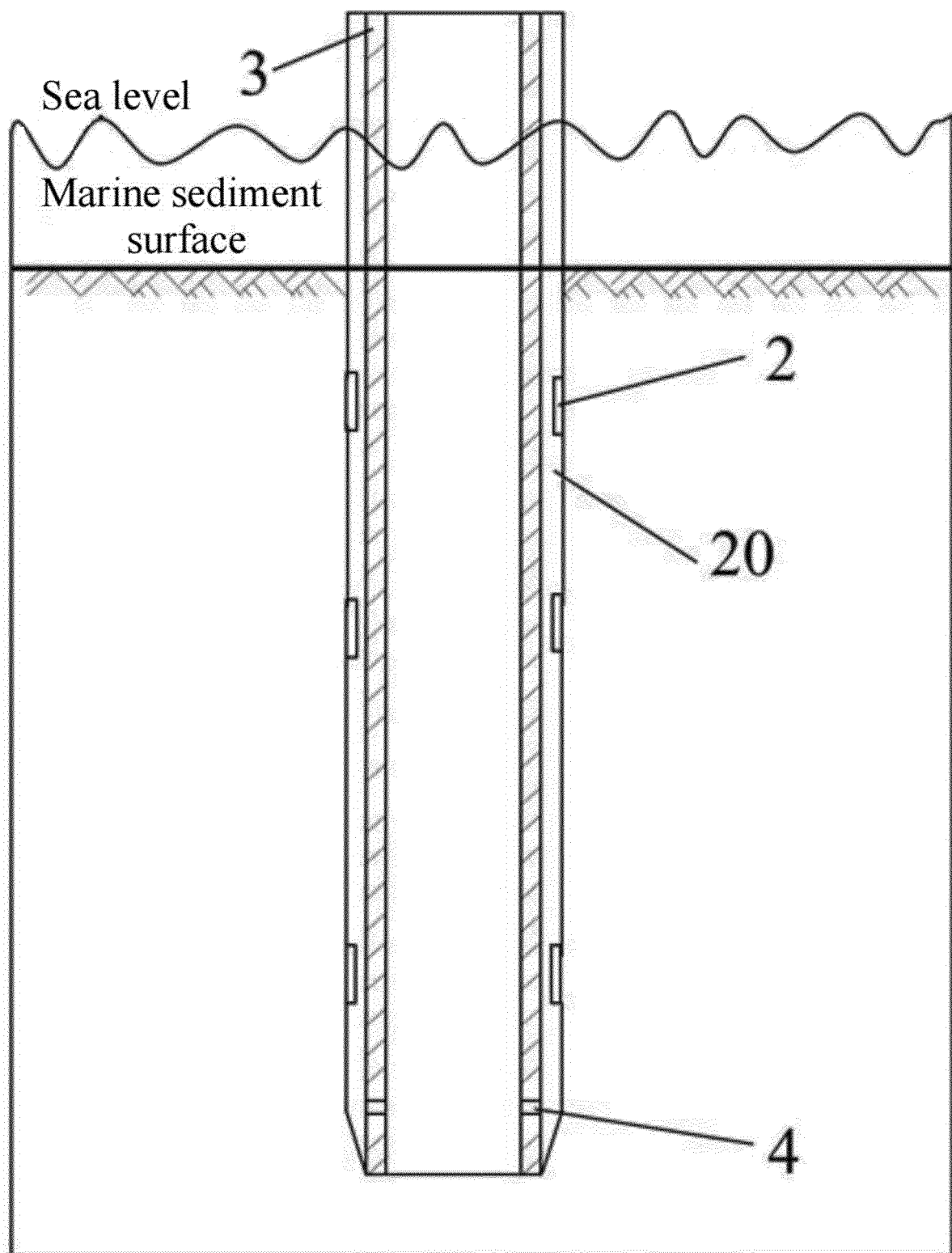


Fig. 2

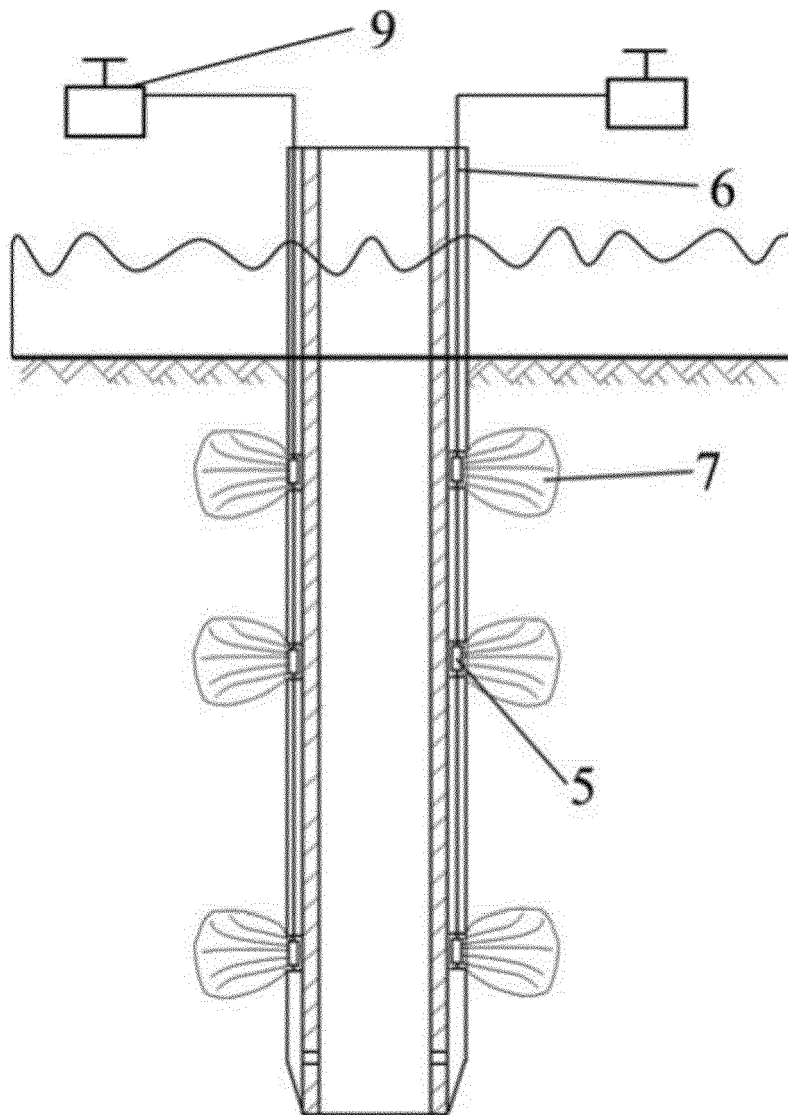


Fig. 3

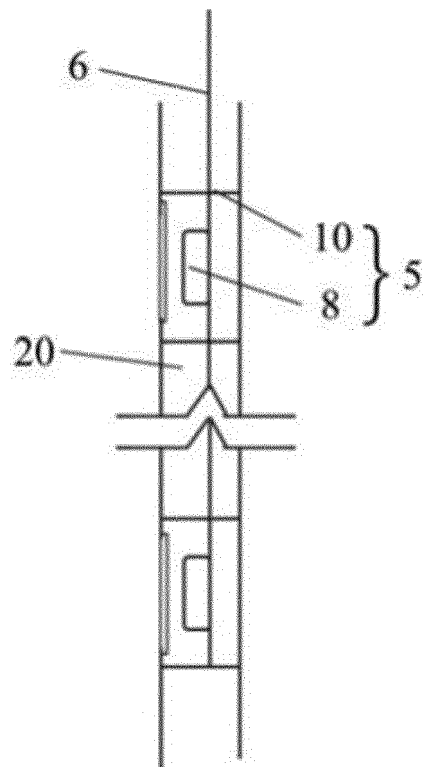


Fig. 4

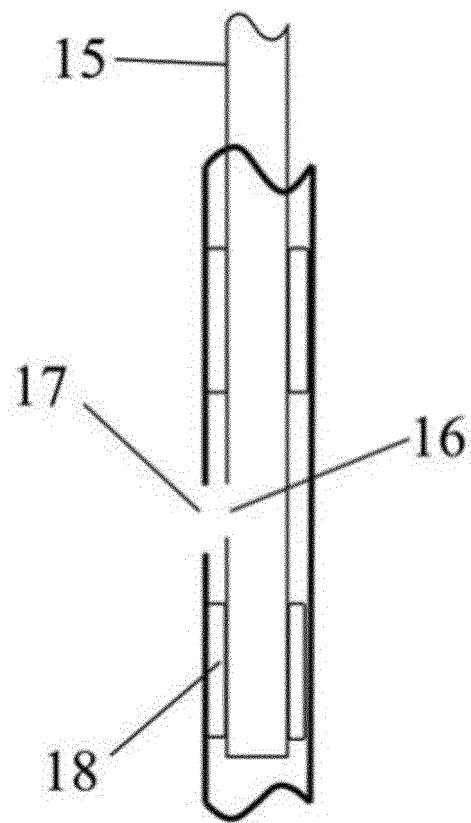


Fig. 5

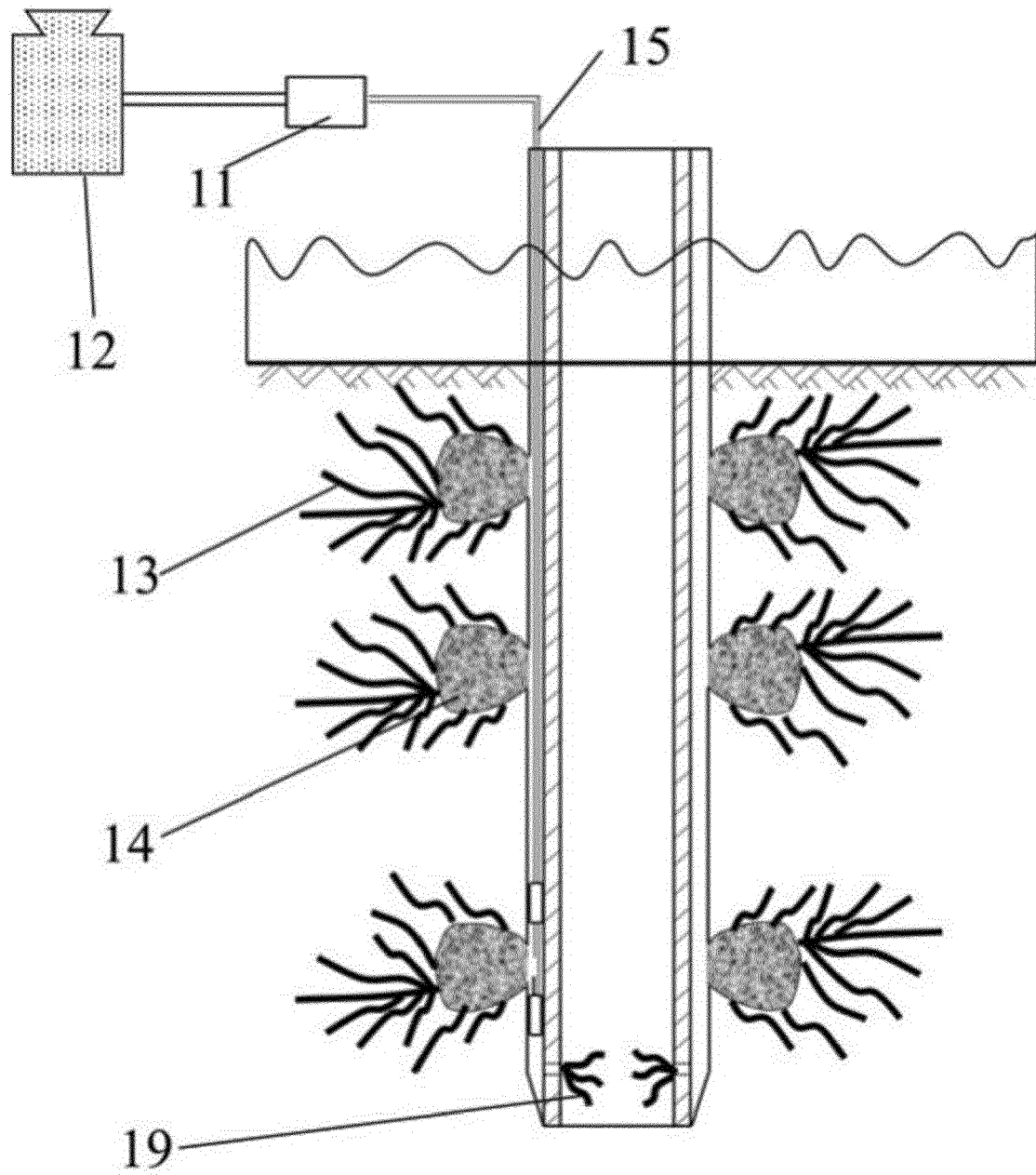


Fig. 6



EUROPEAN SEARCH REPORT

Application Number

EP 22 20 7297

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			E02D E02B
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Place of search		Date of completion of the search	Examiner
Munich		21 July 2023	Koulo, Anicet
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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