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(54) **PILE FOUNDATION AND METHOD FOR INSTALLING A PILE FOUNDATION**

(57) The invention relates to a pile foundation and a method for installing a pile having an elongated body structure, comprising a tapered shape and a hollow channel extending between a first and a second end of the pile for injecting cement grouts or mortars through said foundation and into a cavity between said first end part and said soil, where the hole has a diameter smaller than the largest width/diameter of the pile and a diameter larger than the smallest width/diameter of the pile.

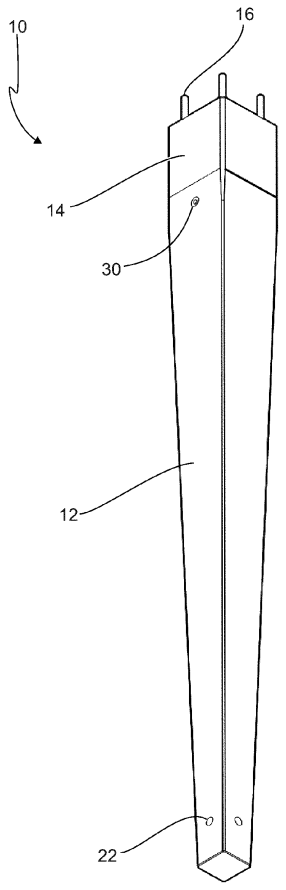

FIG. 1A

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Description

TECHNICAL FIELD

[0001] The present invention relates to a pile foundation and a method for installing a pile foundation.

BACKGROUND OF THE INVENTION

[0002] Concrete pile foundations are typically used for deep piling foundations, which are used when the upper soil layers are not suitable for accommodating a shallow foundation. Concrete piles are often preferred over shallow foundations when the bearing capacity of the ground is weak in relation to the construction which the foundation should support. Especially when the construction to be erected is a power line mast, overhead mast, etc., a shallow foundation is not suitable, and by using a pile foundation, the load from the construction may be transferred from the weaker upper layers of the soil to lower stronger layers, which are typically found at a deeper level in the ground.

[0003] The concrete piles are typically manufactured as reinforced concrete piles and cast in standardized lengths, such as approx. 6 meters.

[0004] By using a pile foundation, the load from the construction, such as a mast, may be transferred from the weak upper layers of the soil to stronger layers, which are typically found deeper in the ground.

[0005] The foundation must be able to absorb a bending moment and a shear force from the construction, e.g., a mast, where the bending moment is usually greatest 2-3 meters below the ground surface, and the shear force is greatest at the lower part of the pile foundation, which is embedded into the ground.

[0006] Such pile foundations may be used as part of a larger foundation construction or the pile foundations themselves may define the foundation.

[0007] The piles are preferably driven into the ground by using a pile driver or hammer or the like such that the soil which surrounds the pile is compressed in a lateral direction compared to the pile foundation, which compression increases the stability of the pile for better accommodating the bending moment and a shear force. However, hammering pile foundations into the ground generates huge vibrations and loud sounds to the surroundings, which when the pile foundation is installed in an urban area is problematic, as the vibrations may destroy nearby constructions, and the generated sounds which are problematic in the cities need to be below certain values in order to prevent a health risk for the persons installing the piles and to avoid any discomfort for the nearby residents. In general, it is advisable to avoid noise loads above approximately 85 dB or peak values of pulses above approximately 137 dB.

[0008] In order to avoid the above-defined problematic issues in relation to pile foundations that are driven/hammered into the ground, it is known to grout-in pile foundations into the ground. A hole having a diameter substantially larger than the width or diameter of the pile foundation is drilled into the ground, whereafter the pile foundation is lowered into the hole and kept in a desired vertical position before a grout or cement mortar is poured or injected into the cavity between the pile and the wall of the hole. Hereby the pulsating vibration of the hammer, which drives in the pile foundation is avoided. However, as the soil around the pile foundation has not been exposed to a compression from the pile, the surrounding soil has not been compacted, which provides a less strong support of the pile foundation compared to the hammered/driven-in pile foundation.

[0009] Both methods for installing the foundations and the concrete piles used have their strength and weaknesses, but none of the methods provides a compromise between the structural capabilities of the installed pile foundation and the inconvenience generated by the installation.

[0010] It is therefore an object of the present invention to overcome the above-defined problems and provide a pile foundation and a method for installing the pile foundation in which the necessary structural strength of the foundation is sufficient and the installation results in the least vibration and sound pollution.

[0011] The above object and advantages, together with numerous other objects and advantages, which will be evident from the description of the present invention, are according to a first aspect of the present invention obtained by:

A pile foundation for a mast, such as a power line mast, overhead mast, etc.,

the pile foundation comprising an elongated body structure, having a first end part with a first end, and a second end part with a second end, reinforcement elements, such as steel reinforcement elements, extending between the first end part and the second end part, and connectors arranged at the second end, such as threaded bolt connectors, for interconnection with the mast,

the pile foundation comprising a tapered shape, such that when driving the pile foundation into the ground in a vertical direction, the surrounding soil is compacted in a lateral direction compared to the pile foundation, for stabilizing the pile foundation,

the pile foundation further comprising a hollow channel extending between the first and second end for injecting cement grouts or mortars through the pile foundation and into a cavity between the first end part and the soil.

[0012] The pile foundation is preferably premanufactured from reinforced concrete, which reinforcement is embedded into the pile for arranging sufficient strength and lifespan of the pile. The pile comprises a first end part with a first end, which represents the lower end of the pile when installing the pile, and a second end part

with a second end, which after installation projects from the ground surface and arranges the point of connection for the construction. For that purpose, the second end is arranged with connectors, such as threaded bolt connectors, for interconnection with the above construction, such as a mast. It should be noted that the pile foundation may be part of a larger foundation construction or may define the foundation in itself.

[0013] The pile foundation may be manufactured up to 6 meters or more, and comprises a tapered shape, such as the first part being tapered, whereby the pile foundation is suitable for being driven/hammered into the ground in order to compress the surrounding soil and establish increased stability of the pile.

[0014] Besides the tapered shape, the pile foundation comprises a hollow channel for injecting a cement grout or mortar through the pile foundation and into a cavity between the first end part and the soil.

[0015] Hereby is it possible to drill a hole into the ground, which hole has a diameter smaller than the widest width/diameter of the pile, but larger than the smallest (and lower) diameter/width of the pile, such that the lower part (the narrow part of the first tapered shape) of the pile will extend into the hole with a cavity between the pile and the wall of the hole, and the upper part of the pile (the wide part of the tapered shape), which part has a width/diameter greater than the diameter of the hole, needs to be driven/hammered into the hole. However, as soil has been removed in order to arrange the hole, the upper part needs not be driven/hammered into the hole with the same force as if when the hole has not been arranged. Therefore, a limited driving/hammering force is required to drive/hammer the pile foundation into the desired depth. It is understood that the soil around the upper part, which part has a width/diameter larger than the diameter of the hole, is not compressed to the same extent as when the hole has not been arranged, but nonetheless, the soil has been compacted sufficiently in order to arrange a stable position of the pile foundation by using a limited driving/hammering force with the result of less vibration and sound.

[0016] After the pile has been driven into the hole to a desired depth, a cement grout or mortar is injected through the pile foundation via the hollow channel and into a cavity between the first end part and the soil.

[0017] The above defined pile foundation thus provides the possibility of combining the technique of driving/hammering in the pile and the technique of grouting around the pile in a hole.

[0018] According to a further embodiment of the first aspect of the invention, the first end part has a tapered cross section, and the second end part has a primary substantially constant cross section, the first part extending the main part of the elongated body structure.

[0019] The first end part comprises the tapered shape and spans the main part of the length of the pile, and the second end part comprises a substantially constant cross section. Hereby the pile can be made at greater lengths without having the need for driving/hammering in the pile over the entire second end part.

[0020] Alternatively, the first end part may be arranged with a constant cross section, and the second end part may be arranged with a tapered shape. In such a situation, the diameter of the hole is larger than the width/diameter of the first end part and is smaller than the largest width/dimeter of the first end part.

[0021] According to a further embodiment of the first aspect of the invention, the pile further comprises an injection opening in the first end part, the opening being in communication with the hollow channel for injecting the cement grouts or mortars through the opening.

[0022] The pile foundation comprises an injection opening in the first end part, and preferably at the lower end of the first end part, which injection opening is in communication with the hollow channel such that a cement grout or mortar can be injected from the outside, through the hollow channel in the pile, and through the injection opening, such that the mortar/grout may fill the cavity between the pile and the wall of the hole.

[0023] According to a further embodiment of the first aspect of the invention, the openings are arranged at sides of the pile foundation.

[0024] The hollow channel extends inside the pile foundation from the second end towards the first end, and terminates a distance from the first end, wherefrom second hollow channels extend to the sides of the pile foundation and communicate with injection openings in the sides, wherefrom the mortar/grout can be ejected. The pile foundation may comprise injection openings on one or more sides of the pile, preferably at opposite sides of the pile, such as on two opposite sides or on all sides of the pile. The injection openings are arranged a distance from the first end, such that when the pile foundation extends in a drilled hole to the very bottom of the hole, the injection openings are not blocked by the bottom of the hole. Preferably, the holes are arranged approximately 250 mm from the first end and up to approximately 3500 mm from the first end. In some embodiments, the distance from the injection openings may be less than 250 mm. In an even further embodiment, the pile may comprise first opening(s) arranged at a first distance from the first end, and second opening(s) arranged at a second distance from the first end. The injection openings are preferably arranged at the lowermost part of the pile, but in case the lowest opening(s) get blocked by dirt/soil, the second opening(s) are opened for injecting mortar/grout into the cavity between the pile at the wall of the hole.

[0025] According to a further embodiment of the first aspect of the invention, the first end part at the first end comprises a series of open channels/grooves in connection with the hollow channel, for distributing the cement grouts or mortar towards the sides.

[0026] In another embodiment different from the above-described embodiment, the hollow channel extends all the way to the first end and is arranged such that it communicates with a series of open chan-

nels/grooves, such as a number of grooves extending from the end of the hollow channel and terminating at the sides of the pile. When the pile is a four-sided pile, preferably four open channels/grooves are arranged extending from the hollow channel and toward each side of the pile, respectively. The pile may be arranged with open channels/grooves terminating at one or more sides of the pile, preferably all sides of the pile.

[0027] Compared to the embodiment of injection channels being arranged at a distance from the first end, this embodiment provides for a pile which is easier, and thereby cheaper, to manufacture. However, when installing this embodiment of the pile, it must be ensured that the pile is kept at a distance from the bottom of the hole, or at least not driven/hammered into the bottom of the hole, whereby the open channels/grooves will be blocked by dirt/soil.

[0028] According to a further embodiment of the first aspect of the invention, the connectors are connected to the reinforcement elements.

[0029] It is preferred that the connectors are connected to the reinforcing elements by welding the connectors, such as threaded bolt connectors, to the reinforcing elements, such as steel bars. Hereby the structural loads from the construction, such as a mast, can be transferred from the connectors to the reinforcing elements embedded in the pile foundation.

[0030] According to a further embodiment of the first aspect of the invention, the pile foundation at the second end comprises coupling means, such as a screw thread, for connecting a cement grout or mortar injection system to the second end.

[0031] In a further embodiment, the pile foundation is arranged with coupling means, such as a screw thread, preferably an internal screw thread, at the inlet of the hollow channel at the second end of the pile. In order to inject mortar/grout onto the hollow channel, and further out of the injection opening(s) and into the cavity between the pile and the wall of the drilled hole, it is preferred to use a mortar/grout injection system. In order to ensure a proper and strong connection between the injection system and the pile foundation, the upper end of the hollow channel is arranged with coupling means capable of interconnecting with mating coupling means on the injection system.

[0032] According to a further embodiment of the first aspect of the invention the, the pile foundation at said first end comprises pile connection elements for interconnection with corresponding pile connection elements arranged on a second pile foundation.

[0033] The pile foundation will be manufactured with a maximum length, such as up to 6 meters or more. However, if it is needed to install a pile foundation deeper into the ground, e.g., due to excessive load on the pile from an above construction, the length of the single pile foundation is not sufficient.

[0034] Therefore, the pile foundation having the tapered shape is arranged with pile connection elements for interconnection with corresponding pile connection elements arranged on an upper end of a second pile foundation. The second pile foundation will be connected to the first (tapered) pile foundation at the first end of the first pile foundation such that the second pile when installed is arranged below the first pile.

[0035] The defined pile connection means may correspond to the known types of pile connection means which are used as "normal" pile extenders in connection with straight (nontapered) pile foundations. Such pile connection means are thus known from various documents including EP2382357B1.

[0036] In case the tapered pile foundation needs to be connected to a second pile foundation, such as a straight concrete pile, the length of the tapered pile will be less than the standard 6 meters, such as preferably approximate half the maximum length, e.g., such as 3 meters. As the respective interface between the two pile foundations needs to correspond to each other and the tapered shape has the same inclination, the tapered pile foundation is arranged shorter than the standard pile.

[0037] According to a second aspect of the present invention, the above objects and advantages are obtained by:

A pile foundation system for a mast, such as a power line mast or an overhead mast, etc., the pile foundation system comprising a pile foundation having pile connection elements as described above, and a second pile comprising corresponding pile connection elements for the interconnection of the two piles.

[0038] As described above, the maximum length of a single pile may not be large enough in order to drive the pile to a deeper level into the ground, and a system as defined therefore provides the possibility of providing a longer pile. The system may comprise the "tapered" pile and a single second pile, which preferably is a straight concrete pile, but the second pile may further be arranged with second pile connection elements arranged at the opposite (lower) end, for interconnection with another (third) pile foundation, preferably a straight pile foundation having pile connection elements at least at the "upper" end for interconnection with the second pile.

[0039] According to a third aspect of the present invention, the above objects and advantages are obtained by:

A method for installing a pile foundation or a pile foundation system according to the invention into the ground, the method comprising the following steps:

- providing a pile foundation or a pile foundation system according to the invention, and
- driving the pile foundation a predetermined distance into the ground.

[0040] The above defined method provides the possibility of installing the above-defined pile foundation into the ground, preferably into a hole in the ground, the hole having a diameter less than the largest width/diameter of the pile foundation. The pile may be driven/hammered

into the ground by typical pile-driving/hammering equipment known in the art. The pile is lifted into position by the pile-driving/hammering, which via e.g., wires or chains, is connected to hoisting elements arranged at the sides of the pile foundation at the upper end (second end) of the pile. Once the pile is in the correct position, the driving/hammering means, which are commonly known in the art, drives the pile into the ground to a predetermined depth. Before the pile foundation is driven to the predefined depth, and before the hoisting elements are driven below the ground surface, the wires/chains are removed. Thereafter, the pile foundation is driven to the desired depth, whereafter the above construction may be connected to the pile foundation via the connectors.

[0041] According to a further embodiment of the third aspect of the invention, the method comprising the step of drilling a hole into the ground and the step of driving the pile a predetermined distance into the ground comprises the step of driving the pile foundation into the hole, said hole having a diameter less than the largest width of the second end part.

[0042] In order to drive the pile foundation into the ground with minimum force, and thereby with the result of reducing vibrations and sound, a hole is drilled into the ground into which the pile foundation can be driven/hammered.

[0043] Drilling a hole having a diameter with a smaller dimension than the width of the pile significantly reduces the forces needed for driving/hammering the pile into the ground. Besides the benefit of reducing the forces needed for driving/hammering in the pile foundation, the soil around the pile, and mainly the soil around the tapered shape of the pile, that includes the soil around the part of the pile where the dimension (the width) of the pile is larger than the diameter of the hole, is still being compacted, which hereby increases the structural strength of the installed pile foundation.

[0044] Tests have shown that even a hole with a diameter smaller than the smallest width of the pile foundation significantly reduces the forces needed for driving/hammering in the pile foundation.

[0045] According to a further embodiment of the third aspect of the invention, the method further comprising the following step:

- after the pile foundation has been driven into the ground, a cement grout or mortar is injected into the hollow channel from the second end, and out through the first end part.

[0046] As the drilled hole has a diameter larger than the smallest width of the pile, such as the lowest part of the pile, a gap is formed between the pile and the wall of the hole. Therefore, in order to fill the gap and to increase the stability of the pile, and especially increase the stability of the lower area of the pile, which area is subjected to the most shear force from the loads of the above construction, a cement grout or mortar is injected into the hollow channel from the second end, and out through the first end part and into the cavity between the pile and the wall of the hole.

[0047] According to a further embodiment of the third aspect of the invention, the method comprises the step of retracting the pile foundation a predetermined distance before injecting the cement grout or mortar.

[0048] In an embodiment where the lowermost part of the pile penetrates into the soil, such as in the embodiment where the first end part at the first end comprises a series of open channels/grooves in connection with the hollow channel, for distributing the cement grouts or mortar towards the sides the groove, the lower opening of the hollow channel gets blocked by the soil. In order to inject grout/mortar into the cavity between the pile and the wall of the hole, the pile is retracted a distance in vertical direction, hereby lifting the first end free from the bottom of the hole. Hereafter, the grout/mortar can be injected.

[0049] According to a further embodiment of the second aspect of the invention, the hole comprises a diameter less than 2/3 of the average width of the first end part, such as preferably less than ½ of the average width of the first end part.

[0050] As described above, even a hole having a diameter smaller than the smallest width of the pile increases the forces needed for driving the pile foundation into the ground. However, tests have shown that the best results in terms of stability of the pile and the diameter of the hole are achieved with a hole having a diameter less than 2/3 of the average width of the first end part, such as preferably less than ½ of the average width of the first end part.

[0051] According to a fourth aspect of the present invention, the above objects and advantages are obtained by:

A method for installing a pile foundation for a mast, such as a power line mast, an overhead mast, etc., said method comprising the following steps:

- providing a pile foundation comprising an elongated body structure, having a first end part with a first end, and a second end part with a second end, reinforcement elements, such as steel reinforcement elements, extending between the first end part and the second end part, and connectors arranged at the second end, such as threaded bolt connectors, for interconnection with the mast, the pile foundation comprising a tapered shape, such that when driving the pile foundation into the ground in a vertical direction, the surrounding soil is compacted in a lateral direction compared to the pile foundation, for stabilizing the pile foundation,
- drilling a hole into the ground, the hole having a diameter being smaller than the largest width of the pile and/or smaller than the smallest width of the pile, and

- driving the pile foundation a predetermined distance into the ground.

[0052] By the above-defied method is it possible to instal a pile foundation into the ground with a reduction in the forces needed for driving/hammering in the pile foundation compared to a situation where a pile is driven/hammered entirely in the ground. The diameter of the hole is smaller than the largest width of the pile, and if the diameter is smaller than the smallest width of the pile, the need for injecting cement grout or mortar may be avoided.

Fig. 1A is a perspective view of a pile foundation.
Fig. 1B is a perspective view of a cross section of the pile foundation in fig. 1A.
Fig. 2A is a perspective view of a pile foundation.
Fig. 2B is a perspective view of a cross section of the pile foundation in fig. 2A.
Fig. 3 is an enlarged view of an upper end of the pile foundation.
Fig. 4A shows the process of drilling the hole.
Fig. 4B shows the process of arranging the pile in the hole.
Fig. 5A shows the process of driving/hammering in the pile foundation.
Fig. 5B shows the process of grouting around the pile foundation.

[0053] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. The invention may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like reference numerals refer to like elements throughout. Like elements will thus not be described in detail with respect to the description of each figure.

[0054] Fig. 1A is a perspective view of a pile foundation 10. The pile foundation 10 comprises a first part 12 having a tapered shape, and a second part 14, which in the illustrated embodiment is arranged having a substantially constant cross section.

[0055] The pile foundation comprises four connectors 16 arranged at the upper end of the second part 14 for interconnection with an above construction, such as a power line mast, an overhead mast, etc. once the pile foundation 10 has been driven/hammered into the ground.

[0056] The pile foundation comprises hoisting elements 30 arranged for interconnection with hoisting means, such as wires or chains. The pile foundation 10 is lifted via the hoisting elements 30 into the position in which the pile foundation 10 is to be installed.

[0057] The pile foundation 10 comprises at the lower end, i.e. at the lower end of the first part 12, injection openings which are in communication with a hollow channel 18, which extends in the longitudinal direction of the pile foundation (see fig. 1B). The hollow channel 18 and the injection openings 22 are arranged such that a cement grout or mortar can be injected from the upper end of the pile foundation, through the pile foundation 10, and out through the injection openings 22 and into a cavity 40 (see 4B & 5A) between the pile 10 and the wall of a hole.

[0058] Fig. 1B is a perspective view of a cross section of the pile foundation 10 in fig. 1A. It is from figure 1B apparent that the hollow channel 18 extends in the longitudinal direction of the pile foundation 10 from the upper end (the second end) of the pile foundation 10 and towards the lower end (the first end) of the pile foundation 10.

[0059] The hollow channel 18 terminates a predefined distance from the lower end, wherefrom injection openings 22 extend to the surfaces of the pile foundation. The injection openings may be arranged in relation to one or more of the side surfaces, and preferably all of the side surfaces.

[0060] The injection openings 22 are provided a predefined distance from the lower end, preferably between 250 mm and 3500 mm from the lower end, such that it is ensured that the injection openings are not blocked by the soil if the pile foundation 10 penetrates the bottom of the drilled hole.

[0061] Fig. 2A-B are a perspective view of a pile foundation 10, and a perspective view of a cross section of the pile foundation 10, respectively. The shown embodiment corresponds to the embodiment shown in figure 1A, except that the pile foundation 10 does not comprise injection openings at the sides. In the illustrated embodiment, the hollow channel 18 (see fig. 2B) extends from the upper end to the lower end, where it terminates in a series of open channels/grooves 28, which are in connection with the hollow channel 18. The series of open channels/grooves 28 are shown arranged as a cross, where the open channels/grooves extend from the hollow channel toward the sides of the pile foundation 10 at the lower end. The pile foundation 10 may be arranged with one or more open channels/grooves extending towards one or more of the sides, preferably all of the sides.

[0062] Fig. 3 is an enlarged view of an upper end of the pile foundation 10. The hollow channel 18 (see fig. 1B and 2B) extends from the upper end towards the lower end but comprises at the upper end coupling means for the interconnection with injection means 38 (see fig. 5B) of an injection system.

[0063] Fig. 4A-5B shows the process of installing the pile foundation 10 into the ground 24. The embodiment of the pile foundation 10 shown corresponds to the embodiment shown in fig. 1A and 1B.

[0064] A hole 40 having a diameter larger than the smallest width of the pile foundation 10, but smaller than the largest width of the pile foundation 10, is drilled by a drill 34, which is in itself commonly known within the tech-

nical field. The pile foundation 10 is lifted, preferably via the hoisting elements 30, into the hole 40, where the pile foundation 10 moves down the hole 40 until the width of the hole 40 prevents the pile foundation 10 from further movement without using driving/hammering means 36. It should however be understood that, due to the heavy weight of the pile foundation 10, the weight of the pile foundation 10 itself will force the pile foundation 10 down the hole 40 by a distance which compresses the soil around the hole 40 until the downward force from the weight of the pile foundation 10 cannot compress the soil any further.

[0065] Thereafter, as shown in fig. 5A, the driving/hammering means 36, which is preferably also used for lifting the pile foundation 10 into the hole 40, drives/hammers the pile foundation 10 into the ground 24 to the desired depth (as shown by the vertical arrows). As described earlier in the application, when the driving/hammering means 36 drives the pile foundation 10 into the ground 24, and as the diameter of the hole 40 is smaller than the largest width/diameter of the pile foundation 10, the soil which surrounds the pile foundation 10 is compressed in a lateral direction compared to the pile foundation 10 (as shown by the horizontal arrows), which compression increases the stability of the pile foundation 10 for better accommodating the bending moment and a shear force from the above construction (not shown). The lowest end of the pile foundation 10 has a width/diameter which is smaller than the diameter of the hole 40, and therefore there is a gap between the pile foundation 10 and the wall of the hole 40.

[0066] After the pile foundation 10 has been driven/hammered to the desired depth, as shown in fig. 5B, a cement grout/mortar injection system (not shown), via injection means 38, injects a cement grout/mortar 26 into the upper end of the pile foundation where the injection means are connected to the pile foundation 10 via coupling means 32, and down through the hollow channel 18 and out via the injection openings 22 and into the cavity between the pile foundation 10 and the wall of the hole 40.

[0067] In the following is given a list of reference signs which are used in the detailed description of the invention and the drawings referred to in the detailed description of the invention.

10 Pile foundation
12 First end part
14 Second end part
16 Connectors
18 Hollow channel
20 Reinforcement elements
22 Injection opening
24 Ground
26 Grout/mortar
28 Channels/grooves
30 Hoisting element
32 Coupling means
34 Drill
36 Driving/hammering means
38 Injection means
40 Hole

Claims

1. A pile foundation for a mast, such as power line mast, overhead mast, etc.,

said pile foundation comprising an elongated body structure, having a first end part with a first end, and a second end part with a second end, reinforcement elements, such as steel reinforcement elements, extending between said first end part and said second end part, and connectors arranged at said second end, such as threaded bolt connectors for interconnection with said mast,
said pile foundation comprising a tapered shape, such that when driving said pile foundation into the ground in a vertical direction, the surrounding soil is compacted in a lateral direction compared to said pile foundation, for stabilizing said pile foundation,
said pile foundation further comprising a hollow channel extending between said first and second end for injecting cement grouts or mortars through said pile foundation and into a cavity between said first end part and said soil.

2. A pile foundation according to claim 1, wherein said first end part has a tapered cross section and said second end part has a primary substantial constant cross section, said first part extending the main part of the elongated body structure.

3. A pile foundation according to any of the previous claims, further comprising an injection opening in said first end part, said opening being in communication with said hollow channel for injecting said cement grouts or mortars through said opening.

4. A pile foundation according to claim 3, wherein said openings are arranged at sides of said pile foundation.

5. A pile foundation according to claim 3 or 4, wherein said first end part at said first end comprises a series of open channels/grooves in connection with said hollow channel, for distributing said cement grouts or mortar towards said sides.

6. A pile foundation according to any of the previous claims, wherein said connectors are connected to said reinforcement elements.

7. A pile foundation according to any of the previous claims, wherein said pile foundation at said second end comprises coupling means, such as a screw thread, for connecting a cement grout or mortar injection system to said second end.

8. A pile foundation according to any of the previous claims, wherein said pile foundation at said first end comprises pile connection elements for interconnection with corresponding pile connection elements arranged on a second pile foundation.

9. A pile foundation system for a mast, such as power line mast, overhead mast, etc., said pile foundation system comprising a pile foundation according to claim 1, and a second pile comprising corresponding pile connection elements for the interconnection of the two piles.

10. A method for installing a pile foundation according to any of claim 1-8 or a pile system according to claim 9 into the ground, said method comprising the following steps:

    • providing a pile foundation according to any of claims 1-8 or providing a pile foundation system according to claim 9, and
    • driving said pile foundation a predetermined distance into said ground.

11. A method according to claim 9, wherein said method comprises the step of drilling a hole into said ground, and said step of driving said pile a predetermined distance into said ground comprises the step of driving said pile foundation into said hole, said hole comprising a diameter less than the largest width of said second end part.

12. A method according to claim 10 or 11, wherein said method further comprises the following step:

    • after said pile foundation has been driven into said ground, a cement grout or mortar being injected into said hollow channel from said second end, and out through said first end part.

13. A method according to claim 12, wherein said method comprises the step of retracting said pile foundation a predetermined distance before injecting said cement grout or mortar.

14. A method according to any of claim 10-13, wherein said hole comprises a diameter less than 2/3 of the average width of said first end part, such as preferably less than ½ of the average width of said first end part.

15. A method for installing a pile foundation for a mast, such as a power line mast, overhead mast, etc., said method comprising the following steps:

    • providing a pile foundation comprising an elongated body structure, having a first end part with a first end, and a second end part with a second end, reinforcement elements, such as steel reinforcement elements, extending between said first end part and said second end part, and connectors arranged at said second end, such as threaded bolt connectors for interconnection with said mast, said pile foundation comprising a tapered shape, such that when driving said pile foundation into the ground in a vertical direction, the surrounding soil is compacted in a lateral direction compared to said pile foundation, for stabilizing said pile foundation,
    • drilling a hole into said ground, said hole having a diameter being smaller than the largest width of said pile and/or smaller than the smallest width of said pile, and
    • driving said pile foundation a predetermined distance into said ground.

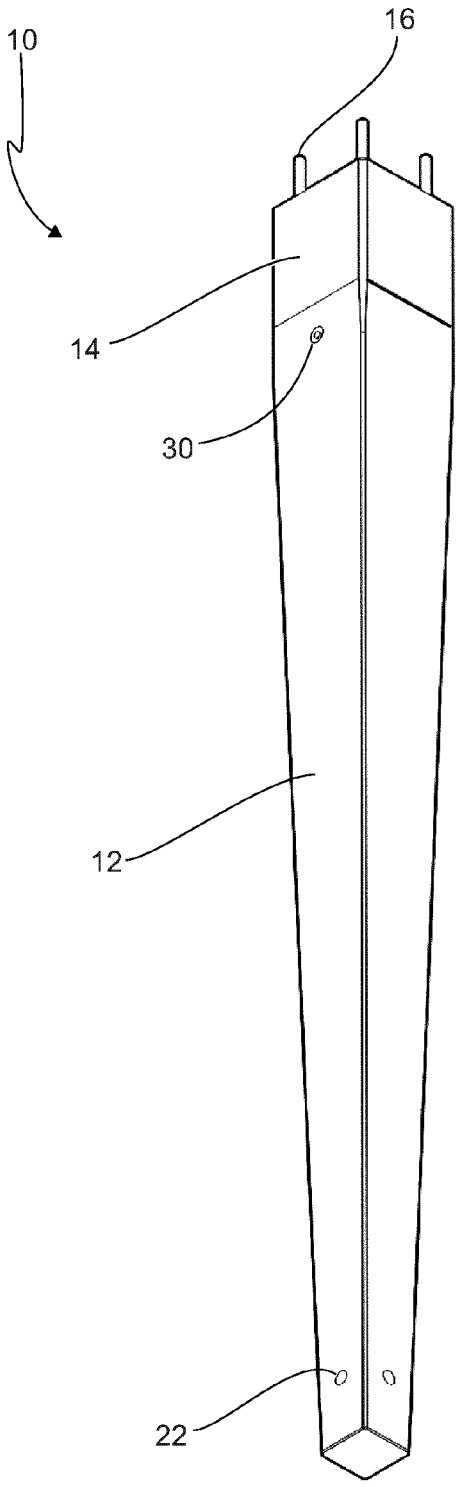

FIG. 1A

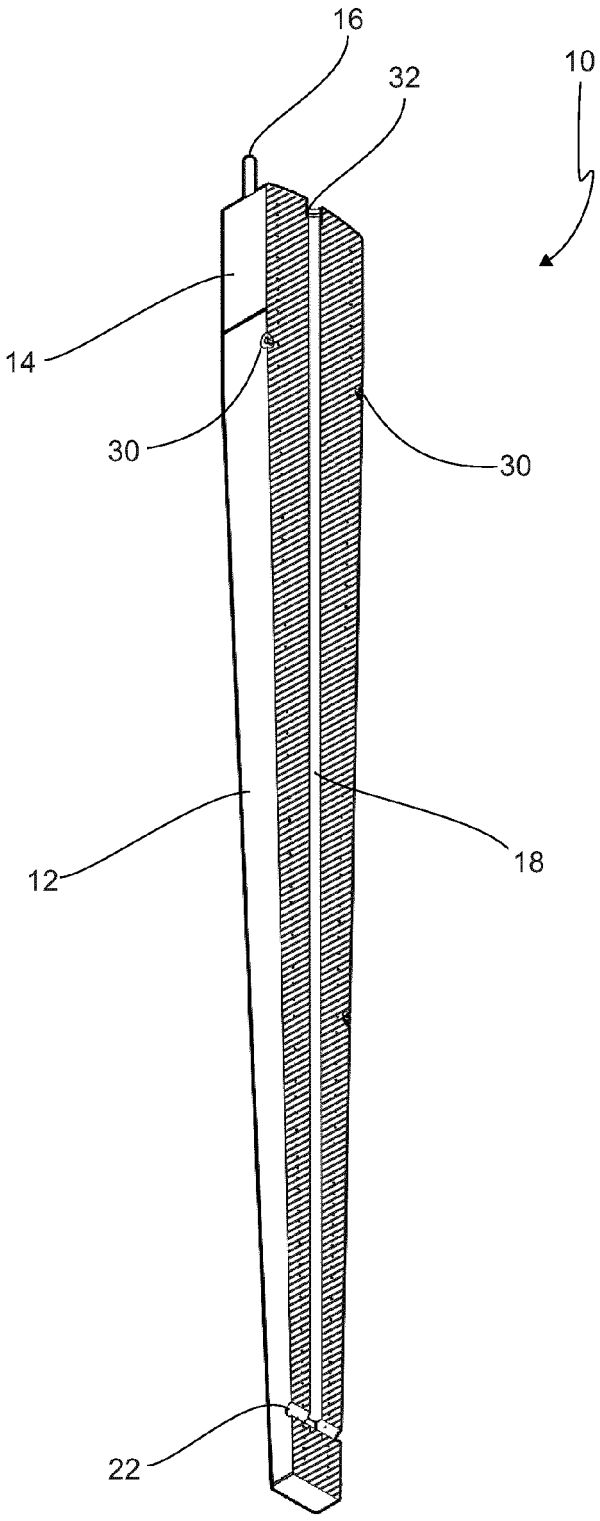

FIG. 1B

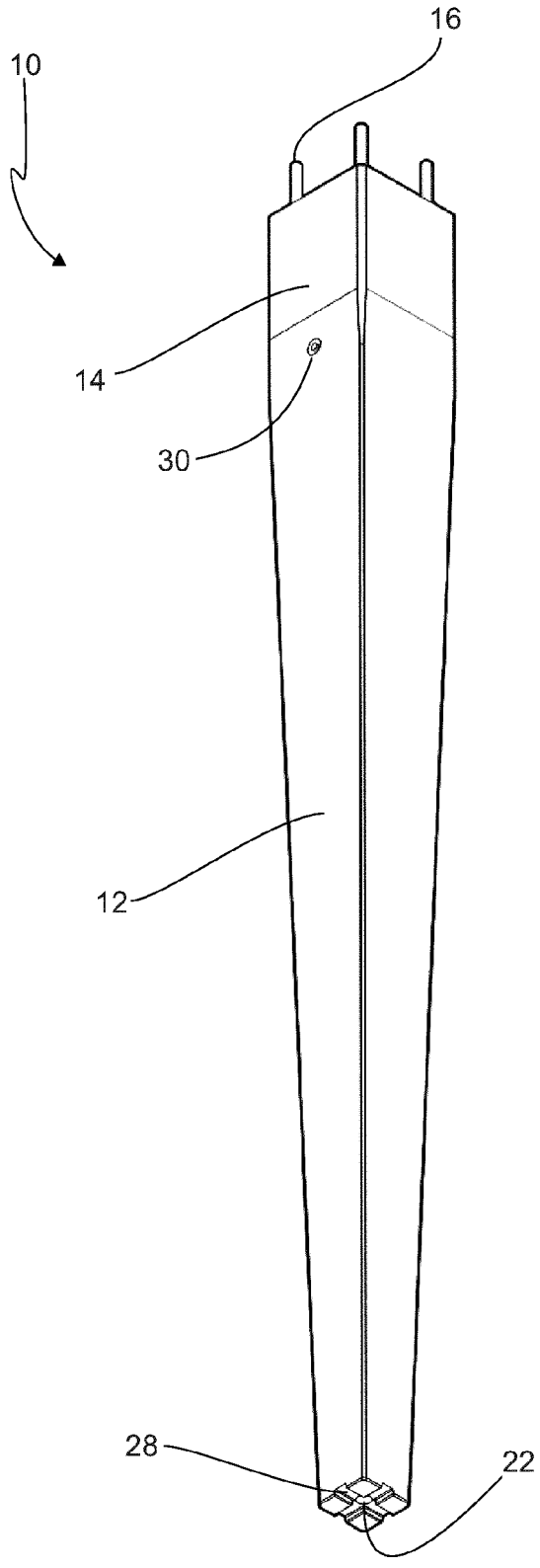

FIG. 2A

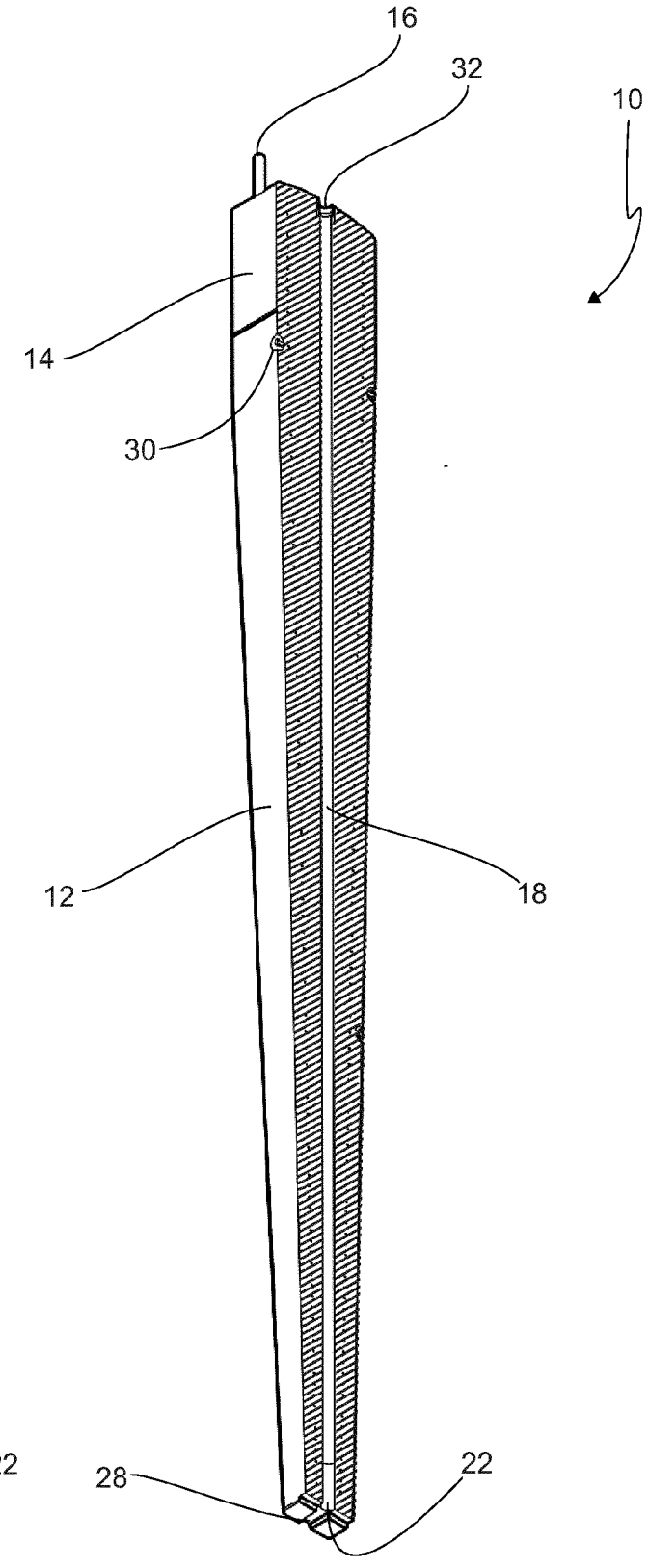

FIG. 2B

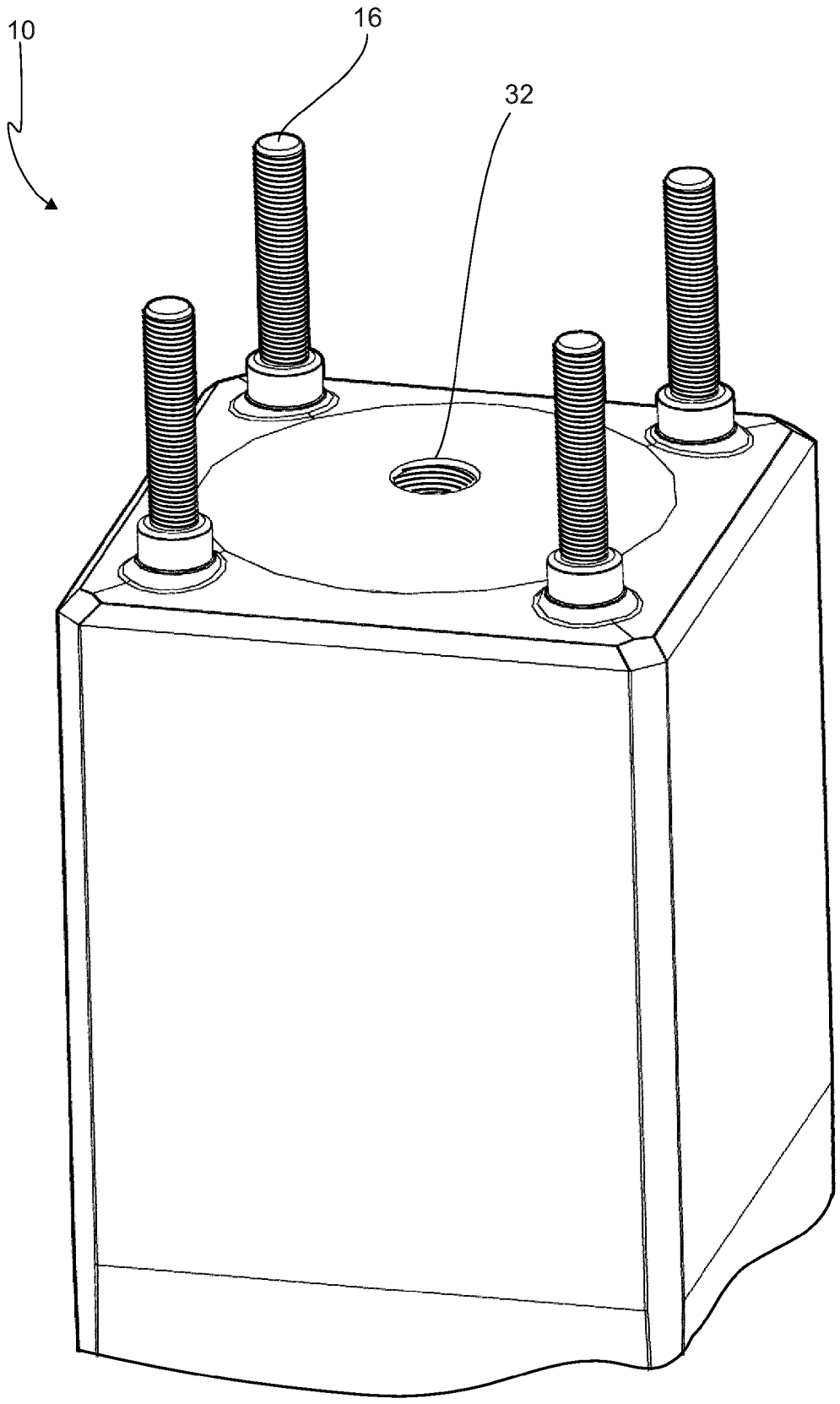

FIG. 3

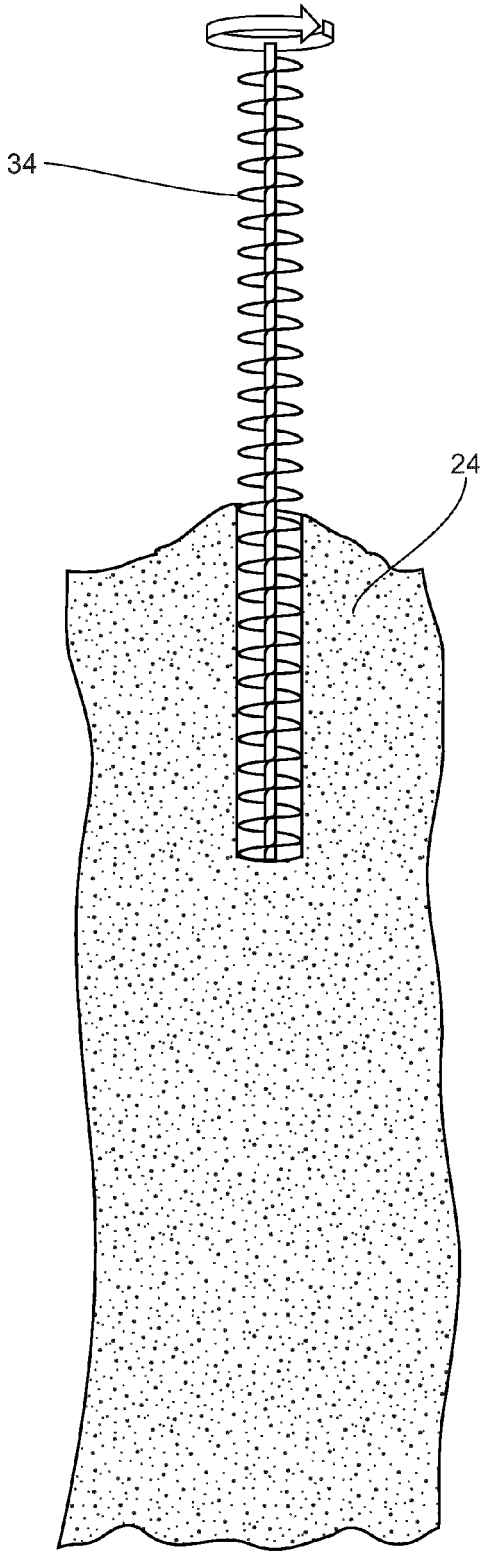

FIG. 4A

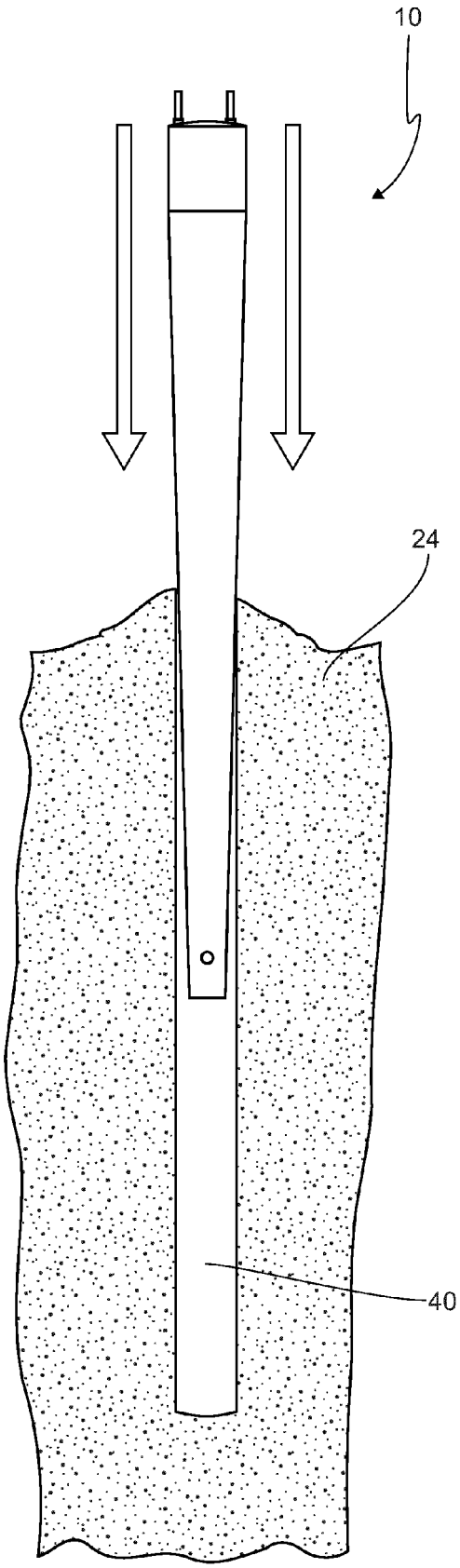

FIG. 4B

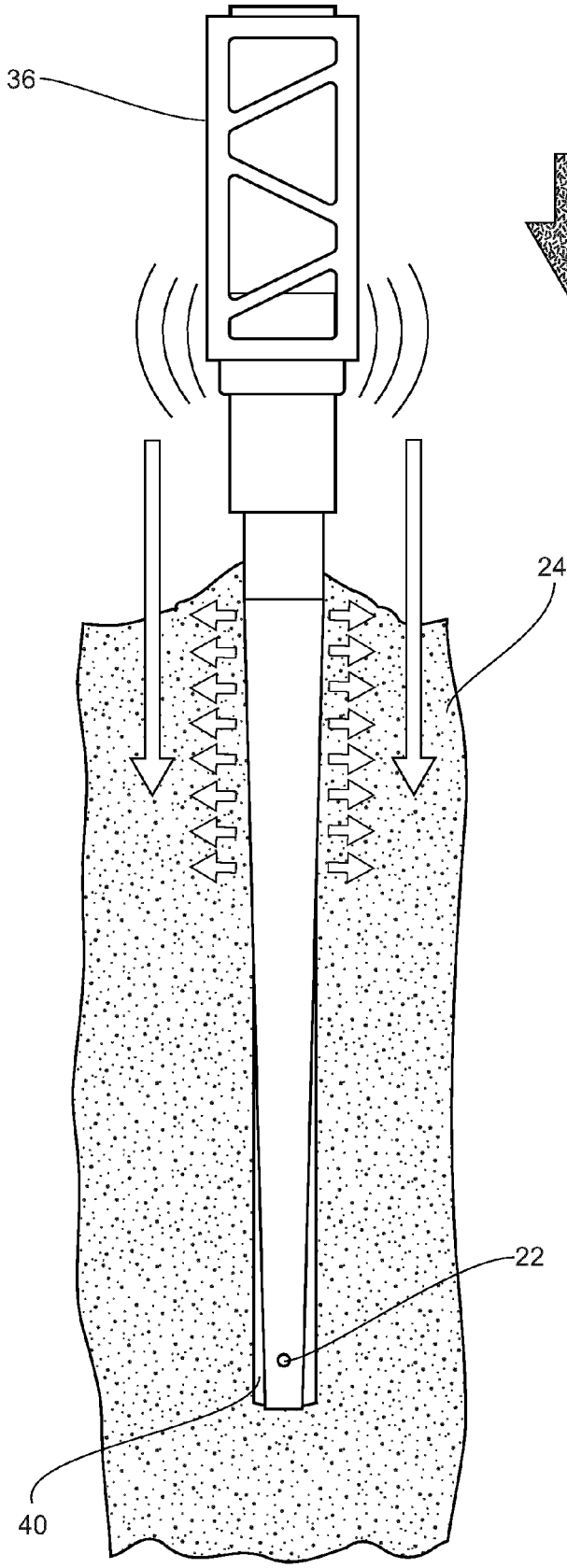

FIG. 5A

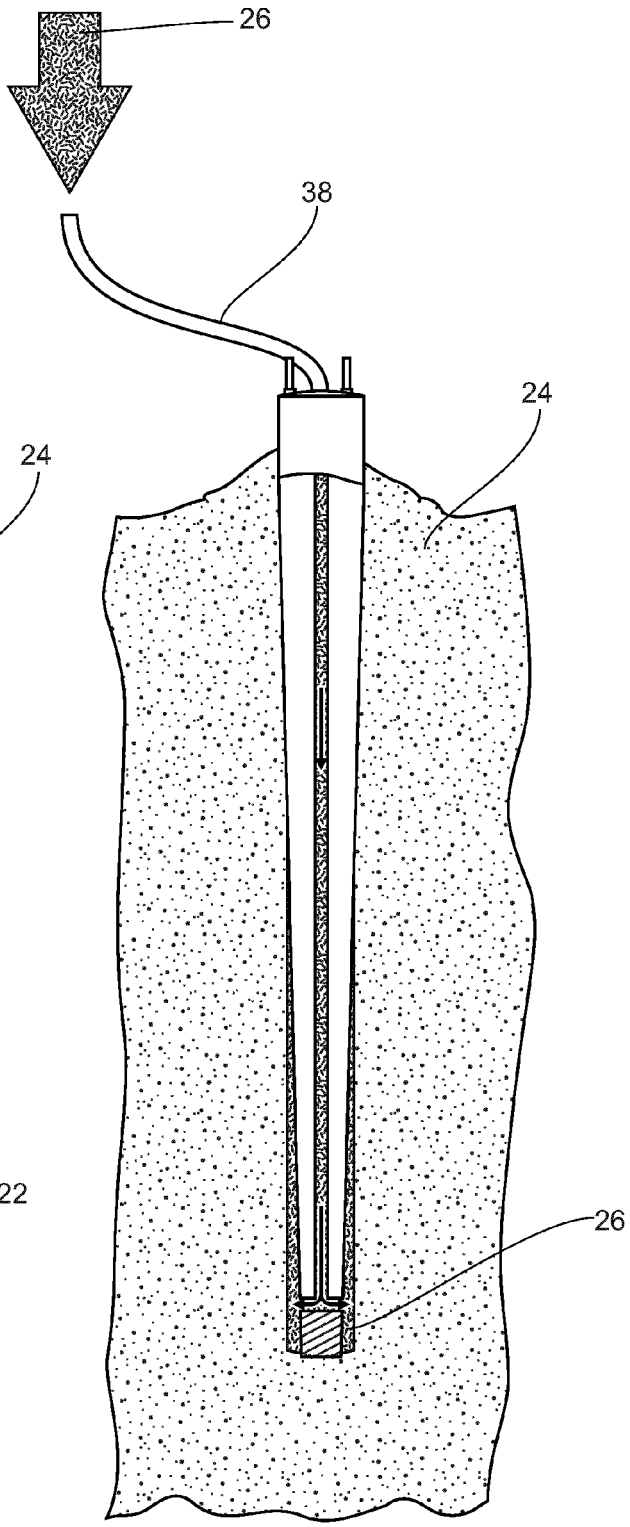

FIG. 5B

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EUROPEAN SEARCH REPORT

Application Number
EP 21 21 1303

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Y	* the whole document *	2-9	E02D5/30
A		15	E02D5/62
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Y	EP 3 447 195 B1 (CENTRUM P LE AS [DK]) 29 September 2021 (2021-09-29)	2-7, 11-14	
A	* paragraph [0030] - paragraph [0038]; figures 2,3 *	8-10,15	

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A	* paragraph [0020] - paragraph [0043]; figures 1-3 *	1-7, 10-15	

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A	figure 4 *	1-10	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 April 2022	Martinez Cebollada

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