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

(11) Publication number: **0 598 457 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **93203222.0**

(22) Date of filing: **17.11.93**

(51) Int. Cl.5: **E02D 5/56**, E02D 7/22, E02D 5/44

(30) Priority: **18.11.92 NL 9202008**

(43) Date of publication of application: **25.05.94 Bulletin 94/21**

(84) Designated Contracting States: **BE DE FR GB NL**

(71) Applicant: **BETON SON B.V.**
Ekkersrijt 3301
NL-5692 CJ Son(NL)

(72) Inventor: **Poot, Simon Jacob**
Zwaansweg 7
NL-4247 EX Kedichem(NL)

(74) Representative: **Smulders, Theodorus A.H.J., Ir. et al**
Vereenigde Octrooibureaux
Nieuwe Parklaan 97
NL-2587 BN 's-Gravenhage (NL)

(54) Method for providing a foundation pile in the ground without vibration, and apparatus for applying such method.

(57) The invention relates to a method and apparatus for providing in the ground, free from vibration, a foundation pile having a slender section and an enlarged pile base (2). The method comprises the steps of

- driving a drill tube (17) into the ground with rotation under axial pressure, which is closed at the lower end by means of a preformed hollow displacement tip (3) and is provided on the outer surface thereof with helical coils (13), until the displacement element has penetrated into a bearing ground layer (P) for a certain distance;
- subsequently increasing the distance between the lower edge of the drill tube (1) and the displacement tip (3) forming an enlarged pile base (2) after penetration into a bearing ground layer (P) due to the pile base (2) being forced with rotation into the bearing ground layer (P) for a distance of at least twice the outer diameter of the pile base (2); and
- providing in the thus formed borehole a prefabricated slender foundation pile (11) whose section is considerably smaller than that of the drill tube (11), while the lower end of the foundation pile (11) comes to rest on the pile base (2).

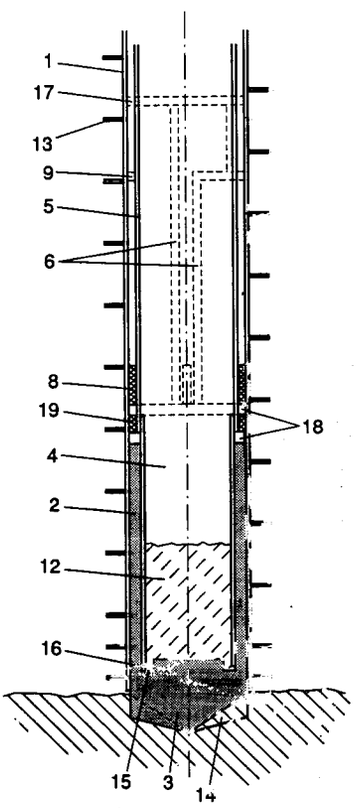

Fig. 1

EP 0 598 457 A1

The invention relates to a method for providing a foundation pile having a slender section and an enlarged pile base in the ground without vibration, which method comprises the steps of

- driving a drill tube which is closed at the lower end by means of a closing element and provided, on the outer surface thereof, with helical coils, into the ground with rotation under axial pressure until the closing element has penetrated into a bearing ground layer for a certain distance;
- subsequently increasing the distance between the lower edge of the drill tube and the tip of the closing element mounted therein; and
- providing in the thus formed borehole a prefabricated slender foundation pile whose section is considerably smaller than that of the drill tube, while the lower end of the foundation pile comes to rest on the closing element.

Such a method is disclosed in Dutch patent application 88.02318. In this known method, after the drill tube has penetrated into a bearing ground layer for a certain distance and the borehole formed has been partially filled with swelling concrete, the drill tube is unscrewed in upward direction, so that a prefabricated, slender foundation pile, provided in the borehole formed, is surrounded by a borehole into which swelling concrete is poured. This swelling concrete forms the enlarged pile base, which on the one hand is to adhere to the foundation pile and on the other comes to abut, by the outer surface thereof, against the wall of the borehole made by the drill tube.

The bearing capacity of the foundation pile is determined to a significant extent by the ability of the enlarged pile base to transmit forces to the surrounding ground layer, which, however, has been disturbed by the drill tube and has consequently obtained a slight coherence. This slight coherence is insufficiently compensated by the pile base of swelling concrete. Consequently, a reduction factor must be applied to the theoretical bearing capacity of the enlarged pile base, which may for instance be approximately 0.7. To ensure an adequate connection between the slender foundation pile and the pile base poured, the length of the pile base poured must be chosen to be greater than would be required for transmitting bearing capacity to the surrounding ground layer. Also in the absence of specific pile-driving reinforcement, a slender foundation pile must produce sufficient bearing capacity for the load to be applied to it. Typically, the transportation of such a slender foundation pile requires a separate transport reinforcement. Slender foundation piles further have the advantage that they can be used successfully in ground layers having negative adhesion.

The object of the invention is to provide a method in which the bearing capacity of the enlarged pile base per unit of area is greater than the bearing capacity according to the method described hereinabove, so that the reduction factor need not be applied. To this end, the method according to the invention is characterized in that

- the closing element is a preformed hollow-cylindrical displacement tip having a length at least twice the outside diameter, accommodated in the end of the drill tube and forming the enlarged pile base,
- the distance between the lower edge of the drill tube and the tip of the pile base being increased after penetration into a bearing ground layer due to the pile base being forced into the bearing ground layer with rotation for a distance of at least twice the outside diameter of the pile base.

As the closing element consists of a preformed, cylindrical displacement tip, forced further into the ground for a particular distance after reaching a bearing ground layer, the preformed displacement tip is surrounded by a ground layer that is not disturbed by the end of the drill tube, enabling transmission of a greater bearing capacity to the surrounding ground by the thus formed closing element.

Dutch patent application 78.15059 describes a method in which the foundation pile, after having penetrated into a bearing ground layer for some distance, is forced further into the ground for a short distance by means of a hydraulic system acting on the top of the foundation pile. In this known method, a force should be exerted on the foundation pile which is approximately three times the intended bearing capacity of the foundation pile, so that in particular the crushing strength of the foundation pile should be considerably greater than a foundation pile can provide. In this known method, forcing the foundation pile into the ground for a short distance is intended to compact the ground surrounding the pile tip and hence to obtain a certain setting. When the drill tube is unscrewed, the ground surrounding the pile tip is released again, so that a reduction factor should as yet be applied to the bearing capacity. In the method according to the invention, only the closing element is driven further into the bearing ground layer with rotation, with the forces being exerted on the closing element rather than the end of the foundation pile. The axial force exerted is considerably less than the intended bearing capacity.

The invention further relates to an apparatus for applying the method described hereinabove, which comprises a drill tube provided with helical windings on the outer surface thereof. According to the

invention, this known apparatus is suitable for applying the method in that within the drill tube an inner tube is provided which is movable in axial direction for a limited distance and can be coupled to the drill tube in two pressure-transmitting positions.

The method according to the invention and embodiments of the apparatus suitable for the application thereof are explained in more detail with reference to the accompanying drawings. In these drawings:

Fig. 1 shows the end of the drill tube at the moment when it has reached a bearing ground layer;

Fig. 2 shows the apparatus according to Fig. 1 with the drill tube unscrewed;

Fig. 3 shows the closing element of the drill tube in the position where it has been forced into the bearing ground layer; and

Figs 4-6 show a variant of the apparatus according to Figs 1-3.

Fig. 1 shows the end of a drill tube 1, known per se, which drill tube 1 is provided with helical coils 13 on the outer surface thereof. The drill tube 1 is closed at the lower end by a prefabricated displacement tip or pile base 2 of concrete or steel, precisely projecting from the end of the drill tube 1 by the tip 3 thereof. The tip 3 is provided with displacement faces 14. Within the pile base 2, a cylindrical recess 4 is present, partially filled with grout 12. The axial length of the pile base 2 is at least twice the outside diameter thereof.

Accommodated in the drill tube 1 is an axially movable inner tube 5, whose lower edge 16 practically bears on the bottom 15 of the recess 4 in the pile base 2. The inner tube 5 is provided, on the outer surface thereof, with a pressure ring 18 bearing on the upper edge of the pile base 2. Provided on the inner tube 5 above the pressure ring 18 is a stop ring 17, with the axial distance between the rings 17, 18 being somewhat greater than the axial length of the pile base 2. Provided between the rings 17, 18 are axial ribs 6, evenly distributed along the circumference, staggered circumferentially over some distance in the vicinity of the ring 17 to form a locking recess 7. Located between the staggered ring portion 7 and the rib 6 is a circumferential ring portion 9. Two adjacent ribs 6 bound an axial slot.

The pressure ring 18 can be formed by two separate rings 18, enclosing a guiding and sealing ring 19. This guide-sealing ring 19 abuts against the inner surface of the drill tube 1 and also prevents underground water from finding its way into the recess 4 of the pile base 2. The drill tube 1 is provided, on the inner surface thereof, with fixed keys 8 slidably accommodated in these axial slots and capable of exerting pressure on the pressure ring 18 so as to be able to force the pile base 2 into the ground in this manner, with drill tube 1 rotating. In a position where the drill tube 1 is staggered relative to the inner tube 5, the keys 8 can take up the position shown in Fig. 2, with the lower edge of the keys 8 bearing on the ring portion 9, in which position the keys 8 can also exert a vertical pressure on the pile base 2.

Located between the lower edge 16 of the inner tube 5 and the bottom 15 of the recess 4 is a unidirectional coupling 10, capable of transmitting a rotary motion to the pile base 2 via the inner tube 5 during rotation of the drill tube 1 in one direction, while during rotation of the drill tube 1 in the opposite direction, the lower edge 16 of the tube 5 can rotate relative to the bottom 15 of the recess 4.

The first method step consists in forcing the drill tube 1 and the pile base 2 accommodated therein into the ground, for instance during clockwise rotation of the drill tube 1, until the tip 3 of the pile base 2 has reached the level of a bearing ground layer P. Subsequently, the drill tube 1 is rotated in opposite direction, i.e. anti-clockwise, until the lower edge of the drill tube 1 has been displaced in upward direction for a distance X (see Fig. 2) and has reached the level of the upper edge of the pile base 2. During this anti-clockwise rotary movement of the drill tube 1, the weight of the inner tube 5 rests on the pile base 2, so that it remains in position in vertical direction. If, due to clamping, the pile base 2 is entrained in upward direction by the drill tube 1, a force may be exerted on the inner tube 5, for instance hydraulically, to hold the pile base in position. When the drill tube 1 is displaced, the keys 8 are displaced in upward direction in the axial slots between the ribs 6, until the keys 8 strike the stop ring 17.

Subsequently, the drill tube 1 is again driven in the original direction of rotation, i.e. clockwise. The keys 8 are displaced in circumferential direction, while the lower edge of the keys 8 comes to bear on the ring portion 9, in which position the keys 8 can exert a downward pressure on the tube 5 and hence on the pile base 2. During further rotation of the drill tube 1 (see Fig. 3), the pile base 2 is forced into the bearing ground layer with rotation until the level P minus X metres has been reached. The force exerted on the pile base 2 is taken from the weight of the tubes 1, 5 and parts of the drilling installation coupled therewith, and from the vertical component of the drive couple provided by the screw windings 13 of the drill tube 1.

After the tip 3 of the pile base 2 has reached the level P-X (see Fig. 3), a vertical load is applied to the upper end of the inner tube 5 by means of hydraulic jacks (not shown), such that the tip 3 of the pile base 2 is forced further into the ground for a short distance Y (Fig. 3). By measuring the force

exerted on the tube 5 and the resultant lowering Y, data with regard to the magnitude and the quality of the bearing capacity of the foundation pile are obtained.

The hydraulic jacks for applying a vertical load to the inner tube 5 are mounted on the one hand on the drill tube 1 and on the other hand on a yoke coupled to the inner tube 5. The reaction forces for the vertical load are provided by the weight of the drill tube 1 with the parts of the drilling installation coupled thereto and the resistance of the helical windings, located in the ground, on the outer surface of this drill tube 1.

The pile base 2, forced into the ground in the manner described hereinabove, is surrounded by a bearing ground layer, the cohesion of which has not been disturbed by the end of the drill tube 1, so that the bearing capacity of the pile base has been increased considerably.

Subsequently, a slender foundation pile 11 is provided in the cylindrical recess 4 of the pile base 2, the annular interspace between the outer surface of the foundation pile 11 and the wall of the cylindrical recess 4 being filled with the grout 12 provided in the cylindrical recess 4 of the pile base 2 (see Fig. 2).

Figs 4-5 show a variant of the apparatus according to Figs 1-3. In this variant the coupling between the drill tube 1 and the inner tube 5, provided directly above the pile base 2, is missing. This coupling has been replaced by a coupling provided on the ends of the drill tube 1 and the inner tube 5 that project from the ground. When the coupling is connected and the inner tube 5 is driven in the direction of rotation, the drill tube 1 is driven along with it. When the coupling is disconnected, a turning moment can be exerted on the inner tube 5 alone, with the inner tube 5 being forced into the ground while the drill tube 1 is stationary. The parts of the apparatus according to Figs 4-5 which correspond to parts of the apparatus according to Figs 1-3 have been provided with identical reference numerals.

The apparatus according to Figs 4-5 is preferably used when foundation piles are to be provided in a soil structure in which very slack ground layers are present above the bearing layer. If, in such a soil structure, the pile base is driven into the ground for such a length that a bearing ground layer P is reached, it is undesired to subsequently move the drill tube 1 upwards in axial direction for a distance X and subsequently drive it in the direction of rotation in order to force the pile base 2 further into the ground, as shown in Figs 2 and 3. The slack ground layer above the bearing ground layer P will then provide too little grip for the helical coils 13 of the drill tube 1. Therefore, in ground layers of the above-described type, it is desired first to force the drill tube 1 and the inner tube 5 coupled thereto into the ground until a bearing ground layer P has been reached and subsequently to disconnect the coupling of the drill tube 1 and the inner tube 5, whereupon a turning moment is applied to the inner tube 5, and to force the pile base 2 further into the ground with rotation, by means of the inner tube 5, until the level P-X has been reached. The drill tube 1 remains in the position shown in Fig. 4, so that the helical coils 13 hold more grip on the slack layers above the level P.

After the pile base 2 has been brought to the desired depth in this manner, in this case, too, a vertical load is applied to the inner tube 5 in order to force the tip 3 of the pile base further into the ground for a short distance Y, while the force exerted and the resultant lowering Y are measured, as described hereinabove with reference to Fig. 3.

Fig. 6 shows the pile base 2 with the pile shaft 11 provided therein, after the tube assembly 1, 5 has been withdrawn from the ground with rotation. Because the drill tube 1 is retained, i.e., subjected per revolution to an axial displacement smaller than the pitch of the helical coils 13, these coils 13 function as a screw conveyor, so that the space between the pile shaft 11 and the wall of the borehole is filled.

Claims

1. A method for providing a foundation pile having a slender section and an enlarged pile base in the ground without vibration, said method comprising the steps of

- driving a drill tube into the ground with rotation under axial pressure, which is closed at the lower end by means of a closing element and is provided on the outer surface thereof with helical coils, until the closing element has penetrated into a bearing ground layer for a certain distance;
- subsequently increasing the distance between the lower edge of the drill tube and the tip of the closing element mounted therein; and
- providing in the thus formed borehole a prefabricated slender foundation pile whose section is considerably smaller than that of the drill tube, while the lower end of the foundation pile comes to rest on the closing element,

characterized in that

- the closing element is a preformed cylindrical hollow displacement tip having a length of at least twice the outside diameter, accommodated in the end of the

drill tube and forming the enlarged pile base,

- the distance between the lower edge of the drill tube and the closing element being increased after penetration into a bearing ground layer due to the pile base being forced into the bearing ground layer with rotation for a distance of at least twice the outside diameter of the pile base.

2. A method according to claim 1, characterized in that

- the distance between the lower edge of the drill tube and the tip of the pile base is increased by driving the drill tube in opposite direction of rotation, the pile base remaining in position, and
- the drill tube is subsequently driven in the direction of rotation again, while the pile base, projecting freely from the drill tube, is forced into the bearing ground layer with rotation for the same distance as the distance for which the drill tube was previously displaced in upward direction.

3. A method according to claim 1 or 2, characterized in that the pile base, after being rotatingly forced into the ground, is loaded by an axial force such that the pile base is forced further into the ground for a short distance (Y), while both the force exerted and the resultant lowering (Y) are measured.

4. An apparatus for applying the method according to any one of claims 1-3, substantially consisting of a drill tube provided with helical windings on the outer surface thereof, characterized in that within the drill tube (1), an inner tube (5) is provided which is movable in axial direction for a limited distance (X) and can be coupled to the drill tube (1) in two pressure-transmitting positions.

5. An apparatus according to claim 4, characterized in that two axially spaced rings (17, 18) are mounted on the outer surface of the inner tube (5), in the vicinity of the lower end thereof, while provided between said rings (17, 18) are axial ribs (6, 7), evenly distributed over the circumference, with the drill tube (1) comprising inwardly projecting keys (8) extending into axial slots, each slot being bounded by two adjacent ribs (6, 7).

6. An apparatus according to claims 4-5, characterized in that the axial slots of the inner tube (5), at the upper end thereof, are provided with a circumferentially enlarged locking recess (7), wherein the keys (8) of the drill tube (1) are receivable for exerting pressure on the bottom (9) of the locking recess (7).

7. An apparatus according to claims 4-6, characterized in that the inner tube (5) has a free end projecting beyond the pressure ring (18), receivable in a hollow recess (4) of the pile base (2), the lower edge (16) of said end and the bottom (15) of the recess (4) together forming a coupling acting in one direction of rotation.

8. An apparatus for applying the method according to claims 1 and 3, substantially consisting of a drill tube provided with helical windings on the outer surface thereof, characterized in that an inner tube (5) is provided within the drill tube (1), the two tubes (1, 5) being interconnected in the vicinity of the upper end by means of a disconnectable coupling and the inner tube (5), when the coupling is disconnected, being drivable in the direction of rotation and axially movable relative to the drill tube (1), while the inner tube (5) bears on the upper end of a pile base (2) via a pressure ring (18).

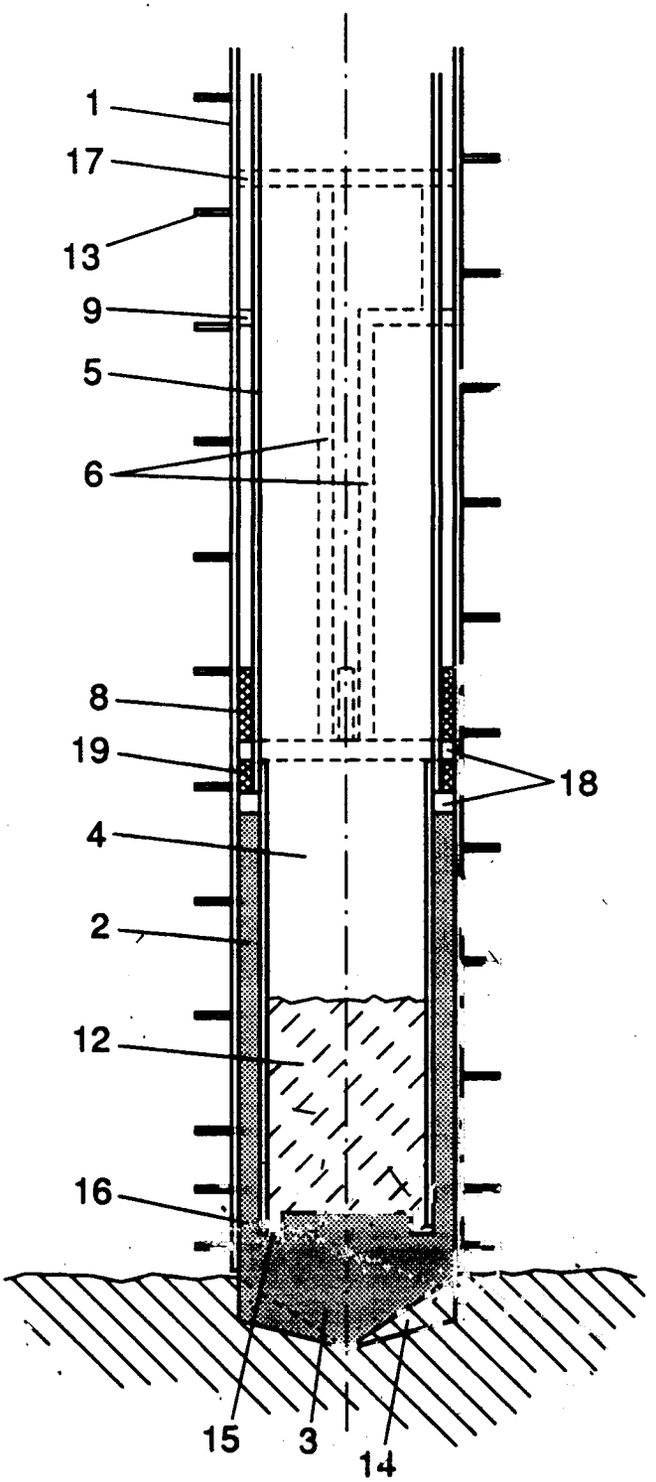

Fig. 1

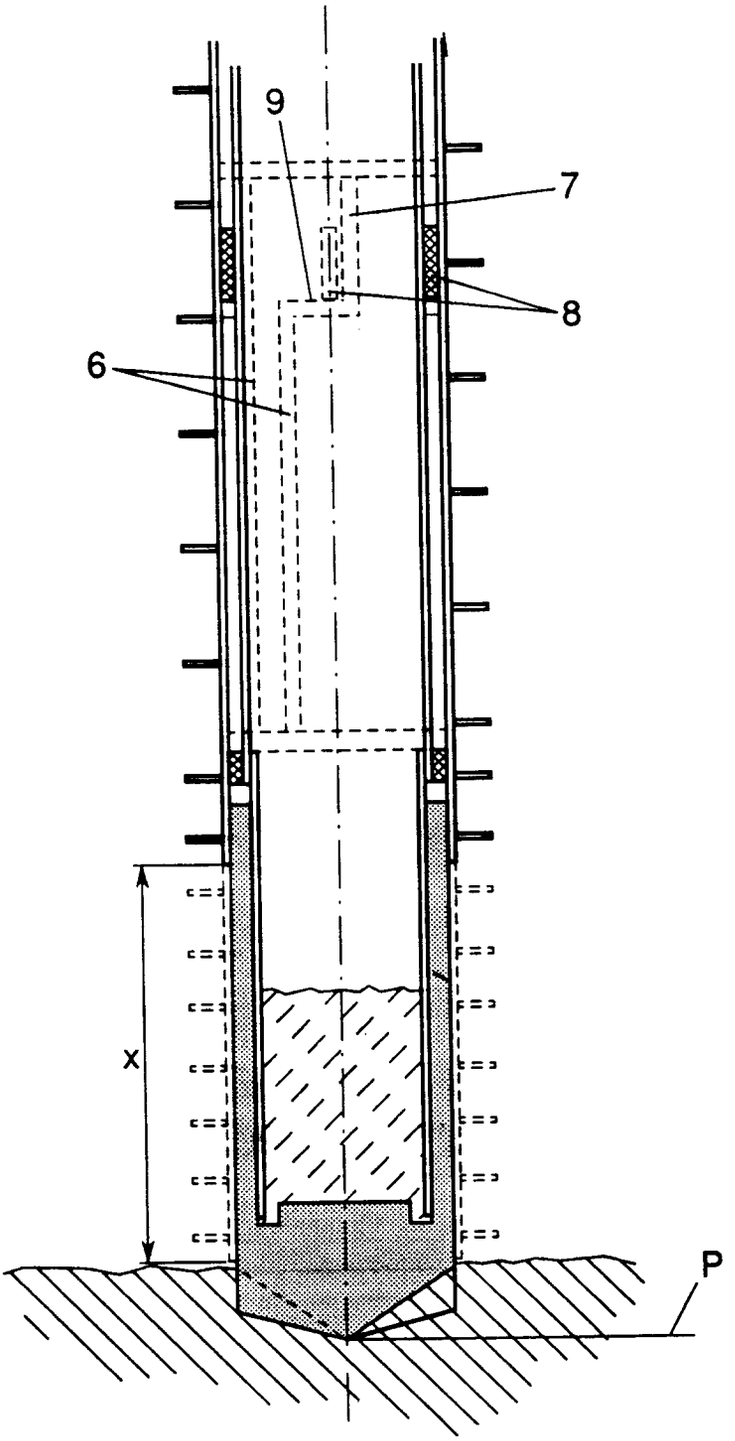

FIG. 2

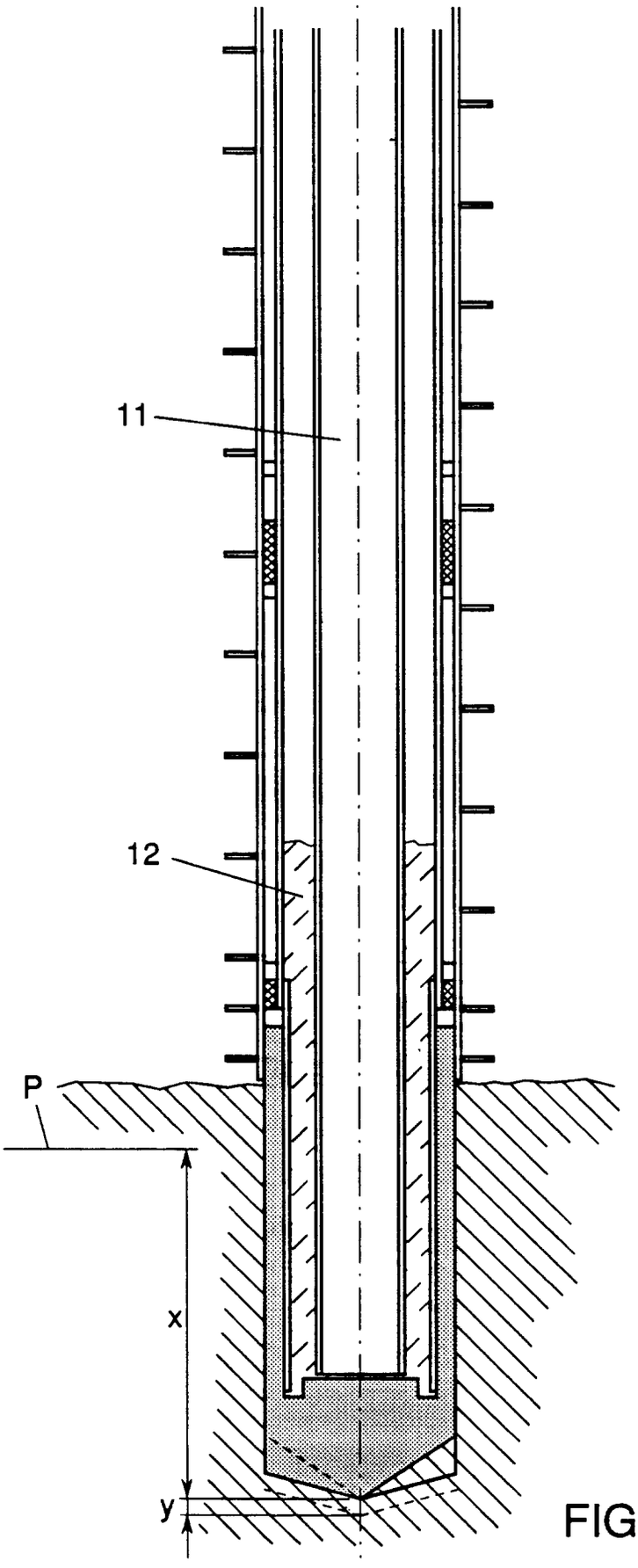

FIG. 3

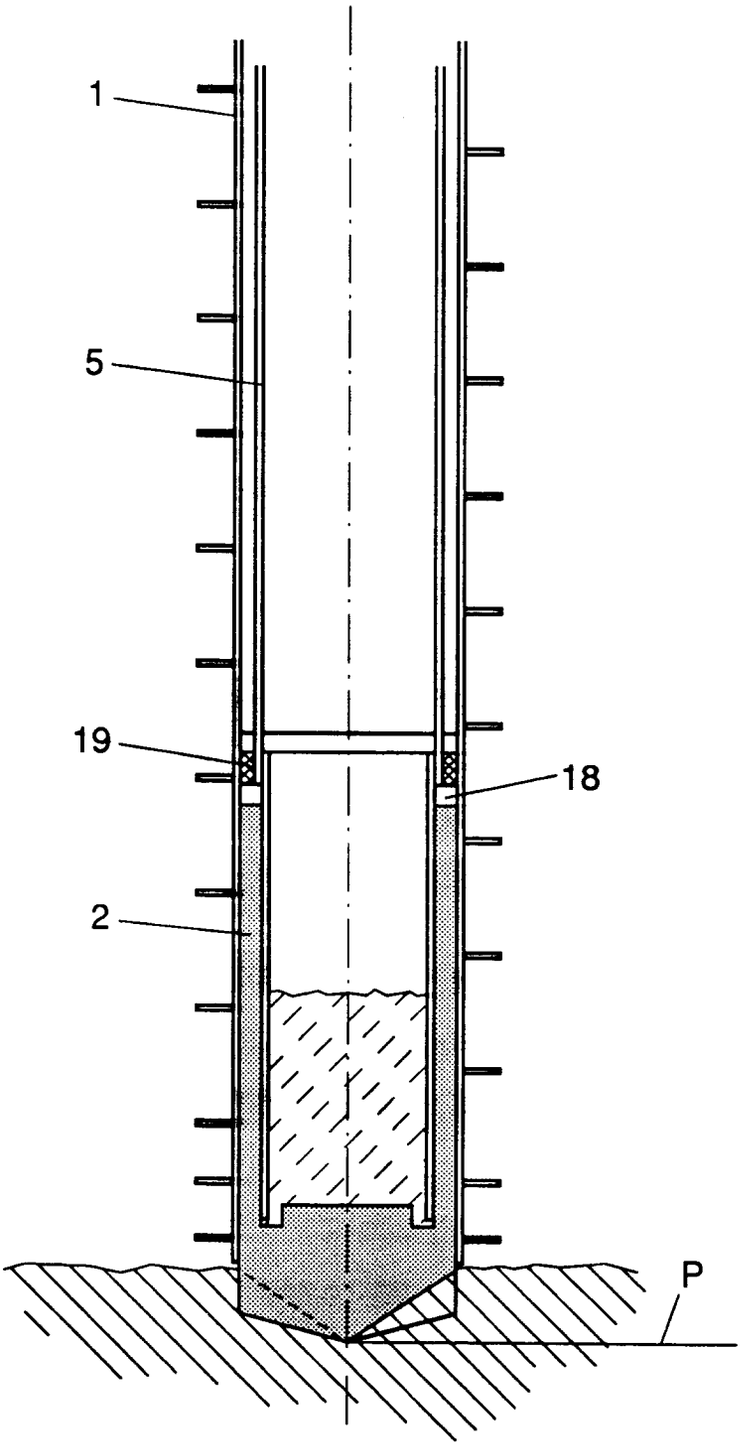

FIG. 4

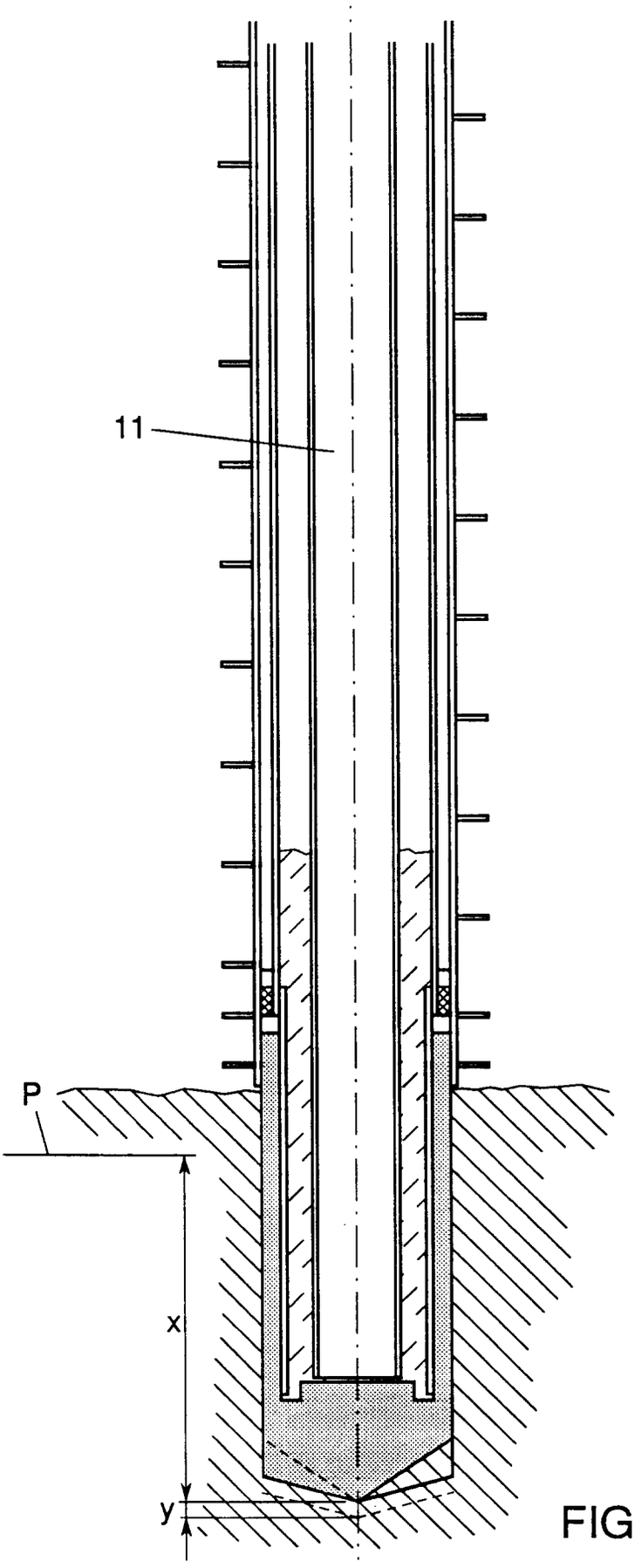

FIG. 5

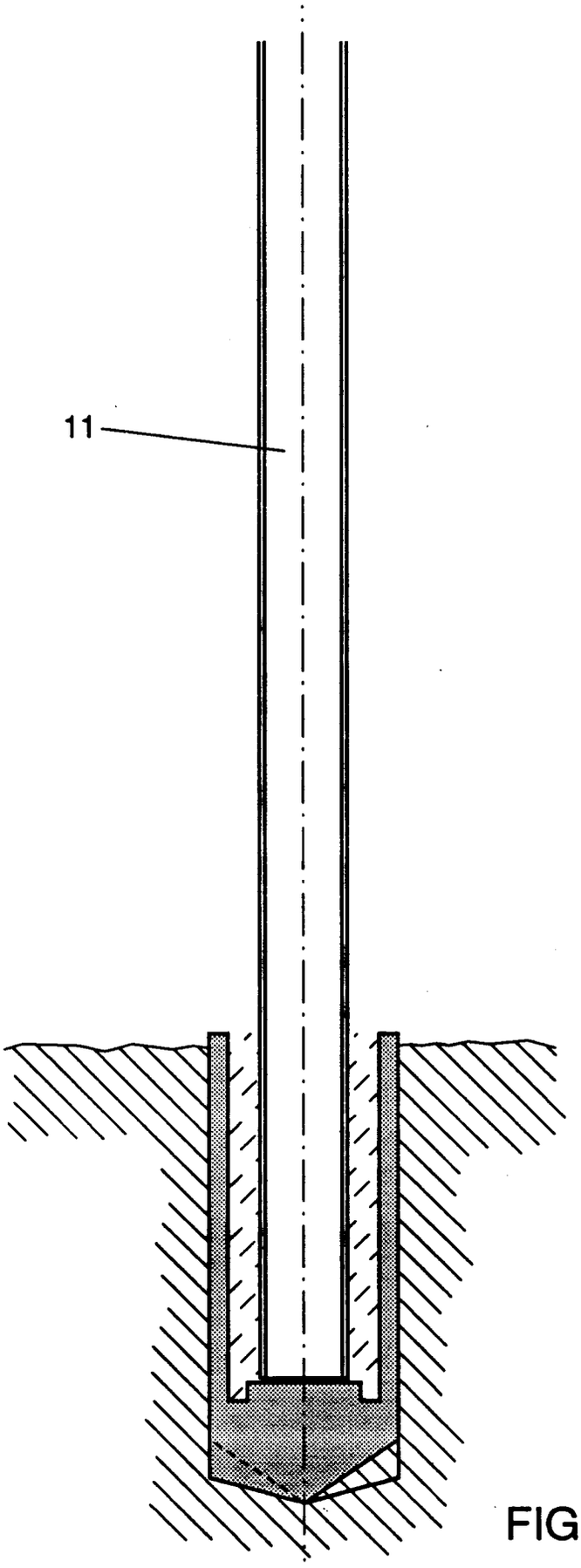

FIG. 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 20 3222

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A,D	NL-A-8 802 318 (BALLAST-NEDAM) * page 2, line 26 - page 6, line 4; figures 1-12 *	1,4	E02D5/56 E02D7/22 E02D5/44
A	GB-A-552 928 (BRAITHWAITE) * page 1, line 9 - page 3, line 75; figures 1-3 *	1,2,4,8	
A	NL-A-80 192 (MARIGJE VISSER GEB. VEENENBOS)		
A	EP-A-0 185 402 (ROMBALDI)		

TECHNICAL FIELDS SEARCHED (Int.Cl.5)
E02D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	8 February 1994	Tellefsen, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)