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

(11) EP 0 989 241 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
29.03.2000 Bulletin 2000/13

(51) Int. Cl.[7]: **E02D 5/36**

(21) Application number: **98203265.8**

(22) Date of filing: **24.09.1998**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(71) Applicant: **HARENINVEST**
B-2110 Wijnegem (BE)

(72) Inventor:
Cortvrindt, Guy Adolf August
1790 Affligem (BE)

(74) Representative:
Van Reet, Joseph et al
Gevers & Vander Haeghen,
Patent Attorneys,
Rue de Livourne 7
1060 Brussels (BE)

(54) **Method for forming concrete piles in the ground**

(57) A method for installing concrete piles in the soil, wherein a hole is made in the soil by forcing a soil displacement head (11), fixed to a tubular rod (12), either by ramming or screwing into the soil thereby laterally displacing the soil over a distance larger than the diameter of the tubular rod (12) to form a cavity (13) around the tubular rod (12), at least the tubular rod (12) is withdrawn from the hole, and, when withdrawing the tubular rod, concrete is injected through this rod into the hole to form the concrete pile therein. In order to prevent contaminants, which may be present is a higher soil layer, from penetrating to deeper soil layers, a liquid material (18) is injected at the bottom in said cavity (13) to keep it filled therewith when screwing or ramming the soil displacement head into the soil.

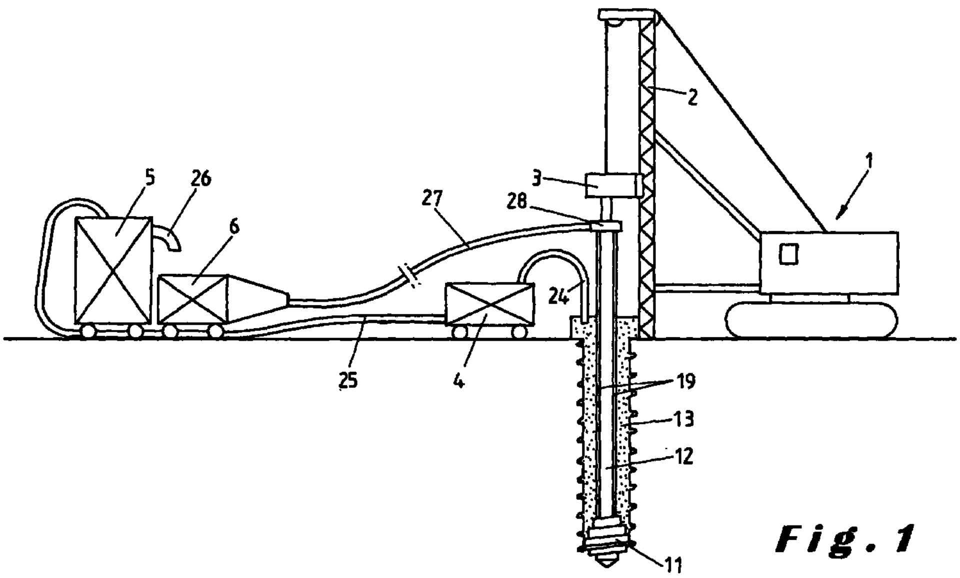

Fig. 1

EP 0 989 241 A1

Description

[0001] The present invention relates to a method for installing concrete piles in the soil, wherein a hole is made in the soil by forcing a soil displacement head, fixed to a tubular rod, into the soil thereby laterally displacing the soil over a distance larger than the diameter of the tubular rod to form a cavity around the tubular rod, at least the tubular rod is withdrawn from the hole, and, when withdrawing the tubular rod, concrete is injected through this rod into the hole to form the concrete pile therein.

[0002] In practice there exist different methods of the above type for making in situ concrete piles in the soil. First of all, the soil displacement head and the tubular rod can be rammed in the soil to make the required hole therein. When withdrawing the tubular rod, the soil displacement head, which is in fact a relatively simple base plate closing off the lowermost end of the tubular rod, is left in the ground and concrete is injected in the hole through the tubular rod. In this way a so-called ramming pile is formed. In order to avoid the vibrations caused by ramming the tubular rod in the soil, use is usually made in practice of soil displacement auger heads which are screwed in the soil. Examples thereof are the so-called Atlas pile described in FR-B-2 215 075 and the Omega pile described in WO95/12050 in the name of the present applicant. Other soil displacement auger heads are for example disclosed in WO94/02687, US-A-4 458 765, EP-B-0 228 138 and in various other patent publications.

[0003] A problem of these methods for installing concrete piles according to the aforementioned method is that they may cause pollution of the underground, in particular of ground water layers. This problem arises especially in case the hole is to be made through different soil layers comprising a relatively water impermeable layer, for example a clay containing layer, covered by a permeable layer containing just above the water impermeable layer, a layer of polluted water. Since the water impermeable layer does not provide a sufficient bearing capacity, the pile has to extend through this layer into the bearing layer situated thereunder. This bearing layer is, however, permeable for water. Due to the fact that when making the hole, a hollow cavity is formed around the tubular rod, the polluted water can easily penetrate into the bearing layer which is normally not yet polluted. It is clear that a pollution of such deeper ground layers is to be avoided especially since they are often exploited for drinking-water winning.

[0004] An object of the present invention is therefore to propose a new method of the above type which allows installing concrete piles in the soil whilst avoiding possible penetration of pollutants into deeper soil layers.

[0005] To this end, the method according to the invention is characterized in that when forcing the soil displacement head into the soil and forming said cavity around the tubular rod, a liquid material is injected at the bottom in this cavity to keep it filled therewith.

[0006] Due to the fact that the cavity around the tubular rod is constantly filled with the liquid material, any possible polluted water is prevented from flowing into this cavity when the tubular rod is either screwed or rammed in the soil. It should be noted that WO95/02687 and US-A-4 458 765 also discloses a method wherein a liquid material, in particular concrete, is injected at the bottom in said cavity but the injected concrete is subsequently immediately laterally displaced to reinforce the wall of the hole while this hole is still being made. At the level of a polluted water layer, the reinforced wall will quickly be penetrated by the polluted water, due to the hydrostatic pressure thereof, which water will then meet no further obstacle for flowing to the deeper soil layers. US-A-4 458 765 further also discloses a method wherein the cavity around the tubular rod is filled from the soil surface with concrete when the auger head is screwed in the soil. This concrete is not laterally displaced when screwing the auger head in the soil but instead when it is screwed out of the soil to form a hole with a reinforced wall therein. This method, however, also does not solve the problem of polluted water penetrating to deeper soil layers since it has been found that, by feeding the concrete from the soil surface, the cavity cannot be filled sufficiently completely with concrete to prevent penetration of water to the deeper soil layers. Moreover, when the auger head has been withdrawn from the soil, water can penetrate through the wall of the formed hole and can subsequently easily flow therethrough to the deeper soil layers since the bottom end of this hole is even not covered with concrete.

[0007] In an advantageous embodiment of the method according to the invention, said liquid material has a specific weight and a viscosity higher than that of water.

[0008] In this way, the liquid material will keep the cavity around the tubular rod filled down to the bottom thereof and cannot be urged upwards by penetration of water into this cavity. Due to the higher viscosity, local mixing of the liquid material with possibly polluted water is also prevented.

[0009] In a preferred embodiment of the method according to the invention, said liquid material comprises an aqueous slurry of a clay, in particular of bentonite.

[0010] Other particularities and advantages of the invention will become apparent from the following description of some particular embodiments of the method for installing concrete piles in the soil according to the present invention. This description is only given by way of illustrative example and is not intended to limit the scope of protection. The reference numerals relate to the annexed drawings wherein:

[0011] Figure 1 shows schematically a side elevational view of a drill rig for installing concrete piles in the soil in accordance with the present invention.

[0012] Figure 2 shows schematically the different steps for installing a pile in the soil by means of the drill rig shown in Figure 1 and in accordance with the method according to the invention.

[0013] The drill rig or installation for installing concrete piles in the soil as illustrated in Figure 1 comprises a crane 1 with a vertical mast 2 provided with an auger motor 3 or drill table which is slidably mounted onto the mast 2. In a variant embodiment, the motor 3 could also be fixed at the bottom of the mast 2. The installation further comprises a bentonite reclaiming unit 4, a bentonite mixing installation 5 and a bentonite pump 6.

[0014] The different steps for installing a concrete pile in the soil are schematically shown in Figure 2. The illustrated soil shows three different soil layers, namely an incoherent top layer 7, a non-bearing, water impermeable intermediate layer 8, and a bearing layer 9. Such a soil profile is for example typical in polders raised by means of dredged materials, the original polder clay forming the intermediate layer 8. Due to contaminants present in the dredged materials or originating from the industry which has developed in these area's, a polluted water layer 10 is often situated on top of the water impermeable layer 8. A problem with such soils is that the polluted water may not be allowed to penetrate to deeper soil layers when installing concrete piles in the soil.

[0015] In the method according to the invention, a hole is made in the soil by forcing a soil displacement head 11, fixed to a tubular rod 12 in the soil so that the soil is displaced laterally over a distance larger than the diameter of the tubular rod 12. In this way, a cavity 13 is thus formed around the tubular rod 12. In the illustrated embodiment, the soil displacement head is a soil displacement auger head 11 which comprises a screw blade 14 so that it can be screwed in and out of the soil. However, if necessary, an additional push down force can further be exerted onto the drill table 3 to enhance the penetration of the auger head 11 into the soil.

[0016] The illustrated auger head corresponds to the auger head disclosed in FR-A-2,215,075 and comprises a lower displacement body part 15 for displacing the soil when screwing in and an upper displacement body part 16 for displacing the soil again when screwing out. An other possible type of auger head is for example disclosed in WO95/12050, the description of which is incorporated herein by way of reference.

[0017] In Figure 2a, the auger head 11 has been screwed according to arrows 17 over a certain distance into the top soil layer 7. An essential feature of the present invention is that a liquid material 18, preferably water-bentonite, is injected at the bottom in the cavity 13 formed along the tubular rod or drill stem 12. In the illustrated embodiment, this is done through two ducts 19 welded or otherwise fixed along the outer side of the tubular rod 12. Alternatively, the ducts 19 could also be provided within the tubular rod 12, preferably integrated into the wall thereof in order not to hamper the possible later insertion of a reinforcement.

[0018] The bentonite slurry is preferably injected so that the cavity is kept filled therewith up to the soil level. On top of the soil, an enclosure 20 is placed around the tubular rod 12 on the soil surface and pushed somewhat in the soil to collect the possible excess of water-bentonite which could flow out of the hole.

[0019] Figure 2b shows the situation wherein the hole has been drilled through the polluted water layer 10. As can be seen, no substantial amount of polluted water has entered the cavity 13 around the tubular rod 12. This can be explained by the fact that the injected water-bentonite has a somewhat higher specific weight than water so that it cannot be urged upwards by the water pressure and by the fact that it is relatively viscous so that the polluted water does not easily mix with the bentonite. In fact, in area's where the bentonite is not stirred, it will quickly form a kind of a rather solid cake.

[0020] In Figure 2c, the hole has been made sufficiently deep into the bearing soil layer 9, a reinforcement 21 has been inserted through the interior of the tubular rod 12 and a concrete mixture is injected also through this tubular rod 12 into the hole, the tip 22, which closed off the concrete channel when screwing in, remaining on the bottom of the hole. Instead of inserting the reinforcement 21 into the tubular rod 12 before injecting the concrete, the reinforcement 21 could also be inserted in the hole after having filled it with concrete. In this way, the ducts 19 could be mounted within the tubular rod 12 without hampering the insertion of the reinforcement 21.

[0021] When injecting the concrete, the auger head 11 is screwed out of the soil according to arrows 23, i.e. in opposite direction of arrows 17. However, in case use is made of an auger head 11 as disclosed in WO95/12050, the auger head could be rotated in the same direction as when screwing in.

[0022] As can be seen in Figures 2c and 2d, the bentonite slurry which has been injected into the cavity 13 is urged out of the hole when screwing the auger head 11 out and is gradually replaced by concrete. At the level of the polluted water layer 10, penetration of water in the hole is thus continuously avoided namely successively by the presence of the bentonite slurry around the tubular rod and subsequently by the concrete which entirely fills the hole.

[0023] During screwing out, the bentonite slurry is mainly urged out of the hole to the soil surface and is collected there in the enclosure 20. As shown in Figure 1, the collected bentonite is pumped through a tubing 24 to the bentonite reclaiming unit 4 wherein sand and other coarse materials are filtered out. The reclaimed bentonite is then pumped through a tubing 25 to the bentonite mixing installation 5 wherein further dry bentonite and water may be added to compensate for the amount of bentonite which may be left in the soil. Wen making a new hole, the bentonite mixture can be fed trough an outlet 26 to the bentonite pump 6, which pumps the bentonite through a tubing 27 into the ducts

19. Since this has to be done when the tubular rod 12 is rotating, an injection ring 28 is provided on top of the tubular rod 12. This injection ring 28 has not been shown in detail but can easily be designed by a skilled person. It comprises for example a stationary annular space extending around the tubular rod 12 and comprising a fitting for connecting the tubing 27. The bottom of the annular space may consist of a disk, provided with a central opening for the tubular rod, which is rotatably mounted to the stationary part of the injection ring and which comprises two fittings for connecting the ducts 19.

[0024] In the above described embodiment, an aqueous slurry of bentonite was injected in the cavity 13 around the tubular rod 12. This slurry usually contains about 20 to 40 kg dry matter (bentonite) per cubic meter. Instead of bentonite, which forms a relatively solid cake but which does not harden, it is also possible to inject a hardening mixture in the cavity around the tubular rod 12, in particular a mixture comprising water, cement, sand and optionally gravel. As hardening mixture, preference is given to a grout containing water, cement and sand, since such a grout can be injected through relatively narrow ducts 19 and substantially does not increase the frictional resistance against the tubular rod 12. When using a mixture of water, cement, sand and gravel, i.e. a concrete, as hardening mixture, one could consider omitting the ducts 19 and providing instead one or more holes in the tubular rod above the soil displacement head 11 so that, when making the hole, concrete can be injected through the interior of the tubular rod itself.

[0025] When using a hardening mixture and a soil displacement auger head, this auger head has preferably a top portion provided for displacing this hardening mixture at least partially laterally into the soil during screwing out so that a pile with an increased bearing power is obtained. On the other hand, when use is made of a bentonite slurry, this bentonite is preferably removed as much as possible from the hole.

[0026] As mentioned already here before, the present invention is not only applicable to so-called screw piles but also to ramming piles. These piles are in particular made by ramming a steel tube, which is closed off at its lowermost extremity, into the soil. The base plate or head used for closing the tube, also displaces the soil laterally over a distance larger than the diameter of the tube so that, in this case also, a cavity is formed around the tube or tubular rod. When the hole is made, the tube is withdrawn from the hole and concrete is simultaneously poured through the tube into the hole, the head which closed off the tube, remaining in the bottom of the hole.

[0027] Just like described hereinabove for the screw piles, one or more ducts 19 can also be provided along or within the tube or tubular rod 12 of a ramming pile for filling the cavity around this tube with a liquid material. This liquid material may also be bentonite slurry. When withdrawing the tubular rod, this bentonite slurry will indeed be urged to the rod surface by the concrete poured through the tubular rod in the hole. In case of ramming piles, preference is however given to the use of a hardening mixture, in particular of concrete, for filling the cavity. Indeed, due to the fact that the soil displacement head remains in the soil, this hardening mixture has not to be displaced laterally in the soil when withdrawing the tubular rod and will form the outer portion of the pile. Further, no separate injection ducts 19 have to be provided but it is sufficient to provide one or more openings underneath in the tubular rod so that the hardening mixture can be injected through the interior of the tubular rod itself.

[0028] From the above description of some particular embodiments of the method according to the invention, it will be clear that many modifications can still be applied thereto without leaving the scope of the invention as defined by the appended claims.

[0029] In particular, it should be noted that the liquid material which is injected in the cavity around the tubular rod, should not necessarily be injected above the soil displacement head but could also be injected at the level of the soil displacement head itself, but then above the portion of this head showing the maximum diameter. Indeed, when injecting the liquid material below this maximum diameter, it has to be injected in the soil at a relatively high pressure so that this soil is disintegrated and mixed with the liquid material. Since this mixture is further laterally displaced, it will be difficult to obtain in this way an effective seal against penetration of the polluted water along the tubular rod into deeper layers.

Claims

1. A method for installing concrete piles in the soil, wherein a hole is made in the soil by forcing a soil displacement head (11), fixed to a tubular rod (12), into the soil thereby laterally displacing the soil over a distance larger than the diameter of the tubular rod (12) to form a cavity (13) around the tubular rod (12), at least the tubular rod (12) is withdrawn from the hole, and, when withdrawing the tubular rod (12), concrete is injected through this rod (12) into the hole to form the concrete pile therein, characterized in that when forcing the soil displacement head (11) into the soil and forming said cavity (13) around the tubular rod (12), a liquid material (18) is injected at the bottom in this cavity (13) to keep it filled therewith.

2. A method according to claim 1, characterized in that said soil displacement head (11) is a soil displacement auger head and is screwed in the soil to make said hole therein.

3. A method according to claim 1, characterized in that said soil displacement head (11) and the tubu-

lar rod (12) to which it is fixed are rammed in the soil.

4. A method according to any one of the claims 1 to 3, characterized in that when withdrawing the tubular rod (12) the liquid material (18) injected into said cavity (13) is urged at least partially out of the hole.

5. A method according to claim 4, characterized in that the liquid material (18) urged out of the hole is collected at the soil surface and is reclaimed for use when installing a further concrete pile in the soil.

6. A method according to any one of the claims 1 to 5, characterized in that said liquid material (18) has a specific weight and a viscosity higher than that of water.

7. A method according to any one of the claims 1 to 6, characterized in that said liquid material (18) comprises an aqueous slurry of a clay, in particular of bentonite.

8. A method according to any one of the claims 1 to 6, characterized in that said liquid material (18) comprises a hardening mixture, in particular a mixture comprising water, cement, sand and optionally gravel.

9. A method according to claim 2 and 8, characterized in that when withdrawing the tubular rod (12), the auger head (11) is screwed out of the hole and at least a portion of said mixture (18) is displaced laterally in the soil.

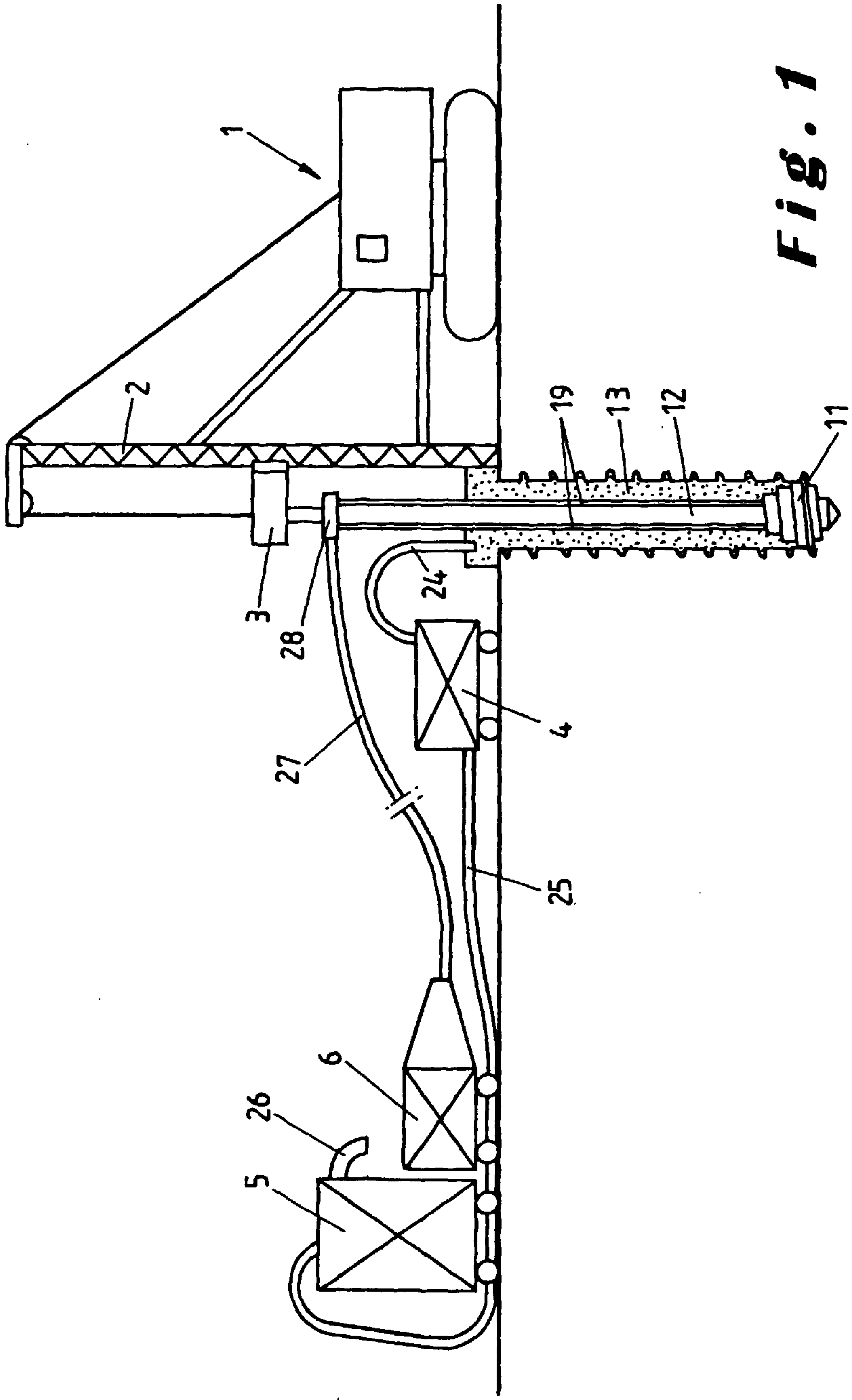

Fig. 1

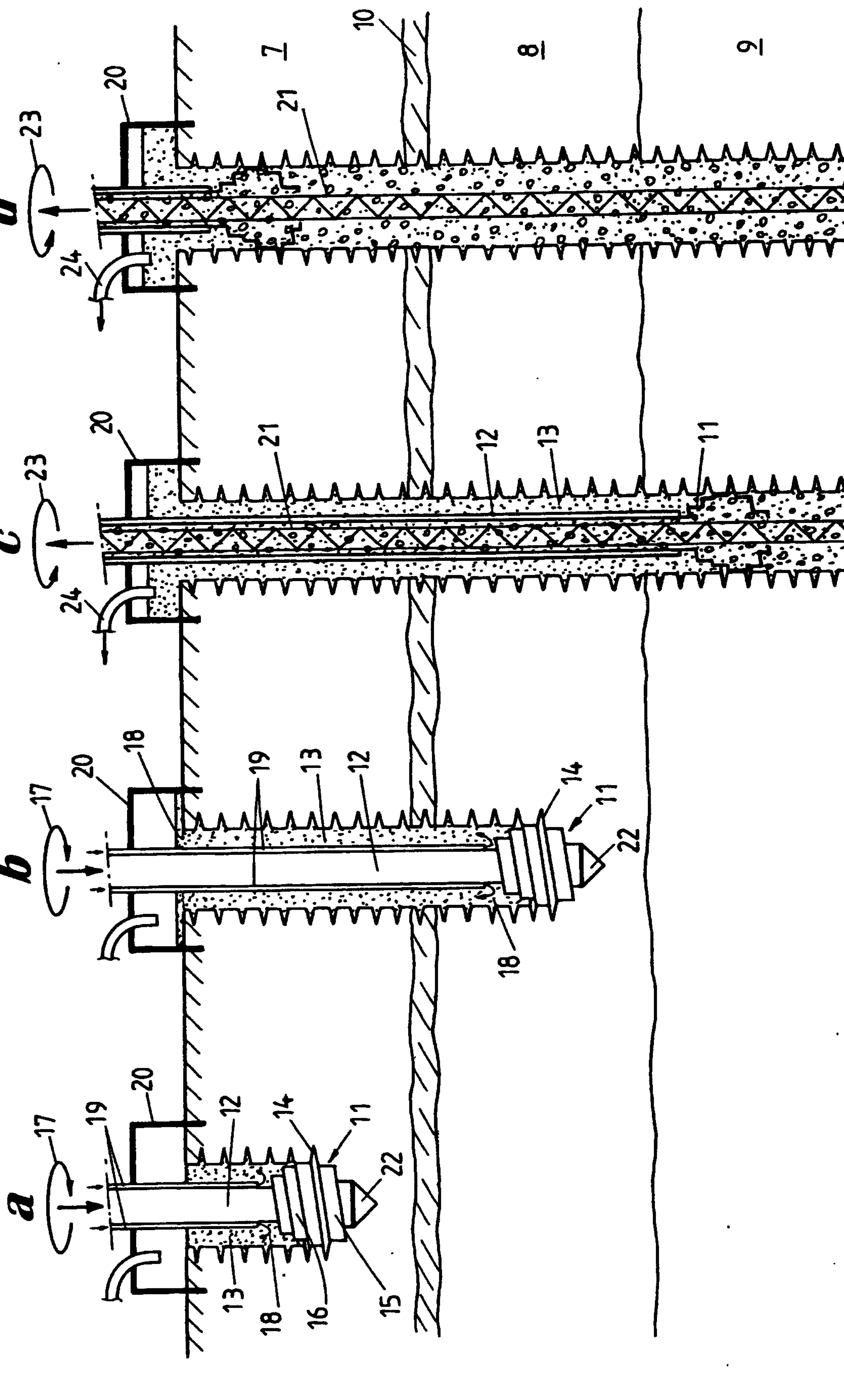

Fig. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 20 3265

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.6)
X	NL 9 000 865 A (BEHEERMAATSCHAPPIJ VERSTRAETEN) 1 November 1991	1,2,6-9	E02D5/36
Y	* the whole document *	4,5	
A		3	
X	NL 6 405 193 A (PREPAKT IBÉRICA S.A.) 12 November 1964	1,2,6-9	
A	* claims; figures *	3,4	
X	CH 336 337 A (MÜLLER) 31 March 1959	1,3,6,8	
A	* the whole document *	2,7,9	
Y	US 4 180 350 A (WATTS JAMES P) 25 December 1979	4,5	
A	* column 3, line 7 - line 52; figures *	1,2	
A	GB 2 064 627 A (PILING TECH LTD;HARRISON & CO SOILS & FOUNDATI) 17 June 1981 * the whole document *	1,3,6,8	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
E02D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 February 1999	Blommaert, S

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

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 20 3265

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

24-02-1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
NL 9000865 A	01-11-1991	NONE	
NL 6405193 A	12-11-1964	BE 646386 A	31-07-1964
CH 336337 A		NONE	
US 4180350 A	25-12-1979	NONE	
GB 2064627 A	17-06-1981	GB 2064625 A	17-06-1981

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82