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(54) A PROCESS FOR BUILDING A CONCRETE STRUCTURE IN LOOSE MATTER, FROM GROUND LEVEL, AND EQUIPMENT FOR CARRYING OUT SAID PROCESS.

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Description

The present invention relates to a process for building a concrete structure in loose matter, from ground level, by use of a rotatable erosion head and a grouting head providing with a drill bit, of the kind disclosed in SE-B-433 639, and as stated in more detail in the preamble of the independent process claim 1 below. The invention also relates to equipment for carrying out said process and of a kind as stated above.

The present invention relates to building permanent structural elements in loose matter without necessitating any preliminary conventional digging operations and temporary safety measures.

Slightly generalizing, we can say that most processes used to day for building permanent structural elements in loose matter constitute relatively small improvements of processes which where introduced 40 - 50 years ago. Present technology is also based on a large percentage of manual labour, resulting in high total cost, e.g. due to digging, boarding, and casting one section at a time. Expensive temporary structures, e.g. for injection, and earth reinforcements, braced sheet pile walls, must be erected before the permanent structure can be established.

The advantages of the process according to the present invention are due to the fact that it permits drilling down into loose matter from ground level, either indoors or outdoors, irrespective of the kind of soil, to the necessary level for erecting water-proof and permanent structures. Upon completing the structure in the ground the only wounds in the terrain visible on the surface will be moderate "pinpricks", i. e. holes with diameters in the range of 15 cm.

The process and equipment according to the present invention will render a series of other conventional operations redundant, e.g. soil stabilizing operations, like freezing, injection, digging, boarding, casting, also pumping wells, ground compensation and compensations for inconvenience. Also, a reduced construction period is achieved.

According to the invention the above mentioned is achieved by the aid of the features stated in the characterizing part of the independent process claim 1 below as well as subsequent claims, and by the aid of the equipment with features as stated in the characterizing part of equipment claim 4 below and following claims.

When a tunnel structure is built in the ground by the aid of processes known to day, loose matter remaining inside the tunnel is dug out. This means that a concrete shell is provided, from which loose matter must be removed after hardening. With present technology it is practically impossible to build a tunnel in loose matter without extensive digging operations and operations to stabilize loose matter.

The process and equipment according to the present invention is also well suited for building tunnels (culverts) below existing railway tracks and roads without interfering with traffic on the crossing railway or road line. With present methods these are problems which could only be solved by temporary by-pass roads or by-pass tracks, which are expensive arrangements per se.

The present invention is disclosed in more detail below with reference to the drawings, in which

Figure 1	is a diagrammatical front view of the equipment for carrying out the process according to the present invention, shown in a position upon completed drilling and before erosion and grouting operations are started;
Figure 2	is a diagrammatical elevation of the equipment provided on a caterpillar rig;
Figures 3-5	show the principle of the process in three steps comprising a beginning erosion of the drill hole, expansion of the bore hole by erosion, and continued expansion of the bore hole in the direction of its height with simultaneous grouting of the bore hole with concrete, respectively.

Figure 1 shows the equipment in the position reached upon drilling down into the ground, before erosion of the drilled hole and grouting of the bore hole which is expanded by erosion.

The equipment comprises two units, i. e. an erosion unit 2, and a grouting unit 3 for grouting with concrete.

The erosion unit comprises an erosion head 2a with a drill bit 2b provided lowermost. Above the latter an erosion nozzle 2c is provided and comprises a water nozzle which is surrounded by an air nozzle for ejecting a radial jet stream of water and air. The erosion unit, furthermore, comprises a guiding tube 8 on which the above mentioned components are mounted and through which water and air conduits extend to feed said erosion nozzles 2c. Guiding tube 8 is mounted in a bearing 8a to be raisable and lowerable as well as rotatable, and rotating motor 8b is provided in a frame 6a. Guiding tube 8 is at its uppermost end connected to supply conduits 10 and 11 for water and air, respectively, via a swivel means 10a.

Grouting unit 3 with grouting head 3a and drill bit 3b is rotatably and raisably as well as lowerably mounted in a bearing 9a, and rotating motor 9b is provided in a frame 6b, and unit 3 is at its uppermost end connected with a supply conduit for concrete, via swivel means 11a.

Together, frames 6a and 6b constitute a rack 6 with adjusting means 7 of mutual spacing between frames 6a, 6b. Rack 6 is intended for adjustable attachment to a rig F, e.g. a caterpillar rig, as shown in Figure 2, by the aid of means F_1 known per se, permitting the equipment to be raised and lowered as well as inclined by the aid of pressure cylinders in a manner known per se, as shown in Figure 2. Erosion head 2a and grouting head 3a may, thus, be independently actuated for lowering, raising, and rotation, respectively. Frames 6a, 6b are movable to and from each other for adjustment of the centre-line spacing C between erosion head 2a and grouting head 3a. As shown in the drawings, Figure 1, adjusting means 7 consists of adjustable telescopic rods 7a which connect frames 6a and 6b.

A collar 12 is provided about guiding tube 8 in order to collect and guide eroded loose matter from bore holes in a controlled manner through a mass and density gauge to permit calculation of the volume of the eroded void, i.e. the expanded void. By the aid of adjustable spacer means 7a the center-line spacing between erosion head 2a and grouting head 3a can be adjusted according to the projected diameter of the expanded bore hole 4a.

Grouting unit 3 comprises extendable grouting pipes 9.

In carrying out said process by the aid of the above mentioned equipment, erosion unit 2 and grouting unit 3 are drilled down to rock or portative ground with a predetermined center-line spacing C between units 2 and 3. In order to establish good rock contact only the downwards directed erosion nozzle 2d on erosion head 2a is used. Upon erosion of the rock surface erosion head 2a and guiding tube 8 are pulled up by a raising means, not shown. Pulling up occurs slowly during constant rotation, and simultaneous ejection of highly compressed water and air at a high pressure of 100-1000 bar, from water and air nozzle 2c. Said water jet enveloped by air will break down the particulate structure and dissolve soil in bore hole 4 which is drilled by drill bit 2b of erosion head 2a. An expanded bore hole 4a with a desired diameter is thus formed, its diameter being measurable by the aid of equipment known per se, which is not described in detail here. In this manner a cylindrical eroded void is formed which constitutes said expanded bore hole 4a. Due to the overpressure created by high-pressure jet 5a from nozzle 2c flushed down material E will be urged towards the surface through bore hole 4 and said collar 12. Simultaneously , or upon establishment of void 4a high-grade concrete D is pumped through grouting pipe 9 with grouting head 3a to fill void 4a, which will also cause expulsion up through bore hole 4 of material E which was broken down by flushing. Concrete D may be provided with additives rendering it water-repellent, so that flows in void 4a due to erosion jet 5a will cause a minimum of binder to be washed out from concrete D.

When guiding tube 8 with erosion head 2a and grouting pipe 9 with grouting head 3a are pulled up, grouting head 3a should preferably be positioned at least 0.5 m below erosion jet nozzle 2c if the latter is active, so as to reduce harmful flows in the eroded space which may wash out binder from concrete D.

Bore hole 4 is eroded by the aid of air and water jet 5c to a desired level H while erosion head 2a is pulled up, then erosion is stopped. Grouting of void 4a with concrete D is continued during simultaneous pulling up of grouting pipe 9, until void 4a is filled, which is checked by the aid of eroded matter forced up through bore hole 4. When void 4a is completely filled such matter is replaced by squeezed up cement binder from concrete D.

Figure 3, thus, shows erosion head 2a and grouting head 3a drilled down to a desired depth in ground A and with a finishing downwards directed erosion jet 5b from erosion head 2a to clean the rock ground. When said erosion jet 5b terminates, erosion beam 5a from nozzle 2c is started to expand bore hole 4 and provide the expanded bore hole 4a and, thus, the desired void as shown in Figure 4, with a desired diameter B and a desired height H, as shown in Figure 5.

Figure 4 shows incipient expansion of bore hole 4 during rotation and pulling up of erosion head 2a, whereas supply pipe 9 with grouting head 3a is at rest in a peripheral position in the lower portion of the expanded bore hole 4a.

Figure 5 shows the next step, in which erosion head 2a is pulled up approximately to a desired level H of the expanded bore hole 4, and in which concrete D is supplied through supply pipe 9 to fill up the expanded bore hole 4a. This operation is continued until the expanded bore hole 4a is filled.

In Figures 4 and 5 expanded bore holes 4a with a substantially circular cross section and desired diameter B are shown, which will result in a cylindrical structure of concrete D.

By causing erosion jet, i.e. air and water jet 5a to swing forwards and back across a sector by corresponding rotation of erosion head 2a, a concrete structure with a corresponding cross section may be provided.

By full rotation of erosion head 2a with simultaneous control of the erosion pressure of air-water jet 5 it is possible, e.g. to provide concrete structures having oval cross sections, e.g. oval piles, dependent on the rotational angle of rotating head 2a.

The process according to the present invention may be carried out in all kinds of ground. This process is, thus, applicable in clay, silt, sand and gravel, as well as in most kinds of fillers, moraine, and boggy soil/peat.

In cohesion soils the erosion and grouting process may, if desired, be carried out in two phases, since transitory tensions in cohesion soils will generally prevent the eroded void from collapsing if it is filled with water. There are several advantages of carrying out the erosion and grouting process in two operations:

1. Local loose matter is prevented from mixing with concrete, since grouting is carried out like normal casting of a void (boarding) under water.

2. Concrete in the return matter up through bore hole 4, consisting of eroded material and water added from the erosion jet 5a, is avoided. If the volume and density of return matter is continuously measured in mass and density gauge 12 which is connected with collar 12 in bore hole 4, it is consequently, possible to calculate the volume of the eroded void 4a. The height H - possibly length if bore hole 4 is inclined or horizontal - of void 4a always being known, its mean diameter B can also be calculated.

3. It is possible to carry out accurate mapping of the extent of void 4a by the aid of an acoustic probe, which may be lowered into the void. By systematically rotating the probe as it is pulled up, the entire width, usually diameter B can be mapped.

In friction soils both operations, i.e. erosion and grouting, must be carried out in one operation, since the provided void 4a will generally collapse before grouting with concrete D is completed. The void, i.e. the expanded bore hole 4a, may however be stabilized if a heavy stabilizing liquid, e.g. bentonite, is introduced into the void. Said liquid will, however, tend to mix with the return matter, i.e. the eroded soils and flushing water, so that the extent, i.e. width B of the structure/pile can only be measured by the aid of an acoustic probe or by measuring the volume of concrete D which is cast inside void 4a.

It was mentioned before that the distance between erosion head 2a and grouting head 3a is adjustable by the aid of telescopic rods 7a in rack 6. It is, thus, possible to ensure that grouting head 3a and erosion head 2a receive a desired mutual center distance when drilled down into ground A, causing grouting head 3a to be located in the periphery of the eroded/expanded bore hole 4a, as shown in Figures 4 and 5. Consequently, concrete D which is injected through the relatively thick supply pipe 9 will fill the expanded bore hole 4a from a location at the hole wall and will, thus, expel any eroded matter and water up through bore hole 4.

Claims

1. A process for building a concrete structure in loose matter, below ground level, by use of a rotatable erosion head and a grouting head provided with a drill bit to be lowered by drilling into the ground to a desired level, if desired to firm ground, the drilled hole subsequently to be expanded to a desired width and height by erosion with the aid of air/water jets at the same time as the erosion head is pulled up with eroded loose matter flowing upwards and out through the bore hole, and with simultaneous or subsequent grouting of the expanded bore hole by supplying grouting material with the aid of the grouting head, **characterized in** that the erosion head (2a) with drill bit (2b), and the separate grouting head (3a) with drill bit (3b), forming components of an erosion unit (2), and a grouting unit (3), respectively, are simultaneously drilled parallel down into ground (A) with a centre-line spacing (C), after which the erosion head (2a) is rotated and raised during simultaneous erosion of the bore hole (4) walls, and that said spaced grouting head (3a) is raised at the same time, but slightly displaced in a downward direction relative to the erosion head (2a), during supply of grouting material, e.g. concrete (D), under pressure for grouting the expanded bore hole (4a) and during simultaneous expulsion of the eroded loose matter (E).

2. A process as stated in claim 1, **characterized in** that the centre-line spacing (C) between erosion head (2a) and grouting head (3a) is adjusted before lowering into ground (A) to the desired mean radius of the expanded bore hole (4a) which is then provided by erosion.

3. A process as stated in claim 1 and/or claim 2, **characterized in** that a grouting head (3a) having a sufficient opening for concrete to pass trough it is used.

4. Equipment for carrying out the process as stated in claims 1, 2 and/or 3 which comprises an erosion unit (2), and spaced therefrom, a separate grouting unit (3) with a grouting head, both units being supported in a rack (6) with means (7) for adjusting their centre-line spacing, which rack is intended for being adjustably attached to a rig (F) by the aid of means (F_1) known per se, the erosion head (2a) of said erosion unit (2) and the grouting head (3a) of said grouting unit (3) being mounted so as to be able to be independently lowered, raised and, if desired, rotated, respectively.

5. Equipment as stated in claim 4, **characterized in** that the rack (6) comprises two frames (6a, 6b) with bearings (8a, 9a) and a rotating motor (8b, 9b) to guide tube (8) of erosion head (2a) and guiding and grouting pipe (9) of grouting head (3a), said pipes (8, 9) being, as known per se, provided with rotatable connections (10a, 11a) at their upper portions for connection of supply conduits (10, 11) for water/air, and con-

crete, respectively, said two frames (6a, 6b) being mutually movable towards and away from each other for adjustment of the centre-line spacing (C) between erosion head (2a) and grouting head (3a).

6. Equipment as stated in claim 5, **characterized in** that frames (6a, 6b) are connected by the aid of adjustable telescopic rods (7a).

Patentansprüche

1. Verfahren zum Errichten eines Betonaufbaus in lockerem Material unter der Bodenhöhe, durch Verwendung eines drehbaren Abtragekopfs, und eines Ausgießkopfs, welche mit einer Bohrspitze versehen sind, die durch Bohren in den Boden bis zu einem gewünschten Niveau abzusenken ist, wenn es gewünscht wird bis zu festem Boden, wobei das gebohrte Loch nachfolgend durch das Abtragen mit Hilfe von Luft/Wasserstrahlen auf eine gewünschte Breite und Tiefe zu erweitern ist zur gleichen Zeit, zu der der Abtragekopf nach oben gezogen wird, wobei abgetragenes lockeres Material nach oben und durch das Bohrloch herausfließt, und mit gleichzeitigem oder nachfolgendem Ausgießen des erweiterten Bohrlochs durch Zuführen von Ausgießmaterial mit Hilfe des Ausgießkopfs,
dadurch gekennzeichnet,
daß der Abtragekopf (2a) mit der Bohrspitze (2b) und der separate Ausgießkopf (3a) mit der Bohrspitze (3b), welche Komponenten einer Abtrageeinheit (2) bzw. einer Ausgießeinheit (3) bilden, gleichzeitig mit einem Mittellinienabstand (C) parallel nach unten in den Boden (A) gebohrt werden, worauf der Abtragekopf (2a) während eines gleichzeitigen Abtragens der Wände des Bohrlochs (4) gedreht und angehoben wird, und daß der beabstandete Ausgießkopf (3a) zur gleichen Zeit aber geringfügig in einer Richtung nach unten bezüglich des Abtragekopfs (2a) versetzt, während des Zuführens von Ausgießmaterial, z.b. Beton (D), unter Druck zum Ausgießen des erweiterten Bohrlochs (4a) und während gleichzeitigem Ausstoßen des abgetragenen lockeren Materials (E), angehoben wird.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet**, daß der Mittellinienabstand (C) zwischen dem Abtragekopf 2a und dem Ausgießkopf (3a) vor dem Absenken in den Boden (A) auf den gewünschten mittleren Radius des erweiterten Bohrlochs (4a), welches dann durch Abtragen gebildet wird, eingestellt wird.

3. Verfahren nach Anspruch 1 oder 2, **dadurch gekennzeichnet**, daß ein Ausgießkopf (3a) verwendet wird, welcher eine ausreichende Öffnung zum Strömen von Beton durch diese aufweist.

4. Vorrichtung zum Durchführen des in den Ansprüchen 1, 2 und/oder 3 angegebenen Verfahrens, wobei diese eine Abtrageeinheit (2) und eine von dieser beabstandete separate Ausgießeinheit (3) mit einem Ausgießkopf umfaßt, wobei beide Einheiten durch Mittel (7) zum Einstellen ihres Mittellinienabstands in einem Gerüst (6) getragen sind, welches Gerüst dazu vorgesehen ist, einstellbar mit Hilfe von an sich bekannten Mitteln (F1) an einem Aufbau (F) angebracht zu werden, wobei der Abtragekopf (2a) der Abtrageeinheit (2) und der Ausgießkopf (3a) der Ausgießeinheit (3) so angebracht sind, daß sie jeweils unabhängig voneinander abgesenkt, angehoben und, wenn gewünscht, gedreht werden können.

5. Vorrichtung nach Anspruch 4, **dadurch gekennzeichnet**, daß das Gerüst (6) zwei Rahmen (6a, 6b) mit Lagern (8a, 9a) und einem Drehmotor (8b, 9b) zum Führen eines Rohrs (8) des Abtragekopfs (2a) und zum Führen eines Ausgießrohrs (9) des Ausgießkopfs (3a) umfaßt, wobei die Rohre (8, 9), wie an sich bekannt ist, jeweils an ihren oberen Abschnitten mit Drehverbindungen (10a, 11a) zur Verbindung mit Zuführleitungen (10, 11) für Wasser/Luft und Beton versehen sind, wobei die beiden Rahmen (6a, 6b) gegenseitig aufeinander zu und voneinander weg bewegbar sind zum einstellen des Mittellinienabstands (C) zwischen dem Abtragekopf (2a) und dem Ausgießkopf (3a).

6. Vorrichtung nach Anspruch 5, **dadurch gekennzeichnet**, daß die Rahmen (6a, 6b) mit Hilfe von einstellbaren Teleskopstangen (7a) miteinander verbunden sind.

Revendications

1. Procédé de construction d'une structure en béton dans un terrain meuble, au-dessous du niveau du sol, au moyen d'une tête d'érosion rotative et d'une tête d'injection de béton pourvues d'un trépan à enfoncer par forage dans le sol jusqu'à un niveau désiré, si on le désire jusqu'au sol dur, le puits foré étant ensuite

agrandi à une largeur et une hauteur désirées par érosion à l'aide de jets d'air/eau en même temps qu'on remonte la tête d'érosion, les matériaux détachés érodés circulant vers le haut et étant évacués hors du puits, et avec remplissage simultané ou subséquent en béton du puits agrandi,par introduction d'une matière de bétonnage à l'aide de la tête d'injection, caractérisé en ce que la tête d'érosion (2a) comportant un trépan (2b) et la tête d'injection séparée (3a) comportant un trépan (3b), qui sont des composants d'une unité d'érosion (2) et d'une unité d'injection de béton (3) respectivement, sont simultanément enfoncées en parallèle par forage dans le sol (A) avec un espacement mutuel entre axes (C), après quoi on fait tourner et monter la tête d'érosion (2a) pendant l'érosion simultanée des parois du puits (4), et en ce que ladite tête d'injection (3a) espacée est remontée en même temps, mais avec un léger décalage vers le bas par rapport à la tête d'érosion (2a) pendant l'introduction d'un matériau de remplissage, par exemple du béton (D), sous pression pour cimenter le puits agrandi (4a) et pendant l'expulsion simultanée des matériaux détachés érodés (E).

2. Procédé suivant la revendication 1, caractérisé en ce que l'espacement entre axes (C), entre la tête d'érosion (2a) et la tête d'injection (3a), est réglé, avant l'enfoncement dans le sol (A), au rayon moyen désiré du puits agrandi (4a) qui est ensuite engendré par érosion.

3. Procédé suivant la revendication 1 et/ou la revendication 2, caractérisé en ce qu'on utilise une tête d'injection (3a) ayant une ouverture suffisante pour permettre le passage de béton.

4. Equipement pour la mise en oeuvre du procédé suivant les revendications 1,2 et/ou 3, qui comprend une unité d'érosion (2) et une unité d'injection séparée (3), espacée de la précédente et comportant une tête d'injection, les deux unités étant supportées dans un portique (6) ayant des moyens (7) de réglage de leur espacement entre axes, ce portique étant conçu pour une fixation réglable à un engin (F) par des moyens (F_1) connus en eux-mêmes,la tête d'érosion (2a) de ladite unité d'érosion (2) et la tête d'injection (3a) de ladite unité d'injection (3) étant montées de façon à pouvoir être descendues, remontées et si on le désire mises en rotation, respectivement, de façon indépendante.

5. Equipement suivant la revendication 4, caractérisé en ce que le portique (6) comprend deux châssis (6a,6b) avec des paliers (8a,9a) et un moteur rotatif (8b,9b), pour guider un tube (8) de la tête d'érosion (2a) et guider un tube d'alimentation (9) de la tête d'injection (3a), lesdits tubes (8,9) étant munis de façon connue de raccords tournants (10a,11a) à leurs parties supérieures pour le raccordement de conduits d'amenée (10,11) d'eau/air et de béton, respectivement, lesdits deux châssis (6a,6b) pouvant être rapprochés et éloignés l'un de l'autre pour le réglage de l'espacement (C) entre les axes de la tête d'érosion (2a) et de la tête d'injection (3a).

6. Equipement suivant la revendication 5, caractérisé en ce que les châssis (6a,6b) sont reliés l'un à l'autre par des tiges télescopiques réglables (7a).

Fig.1

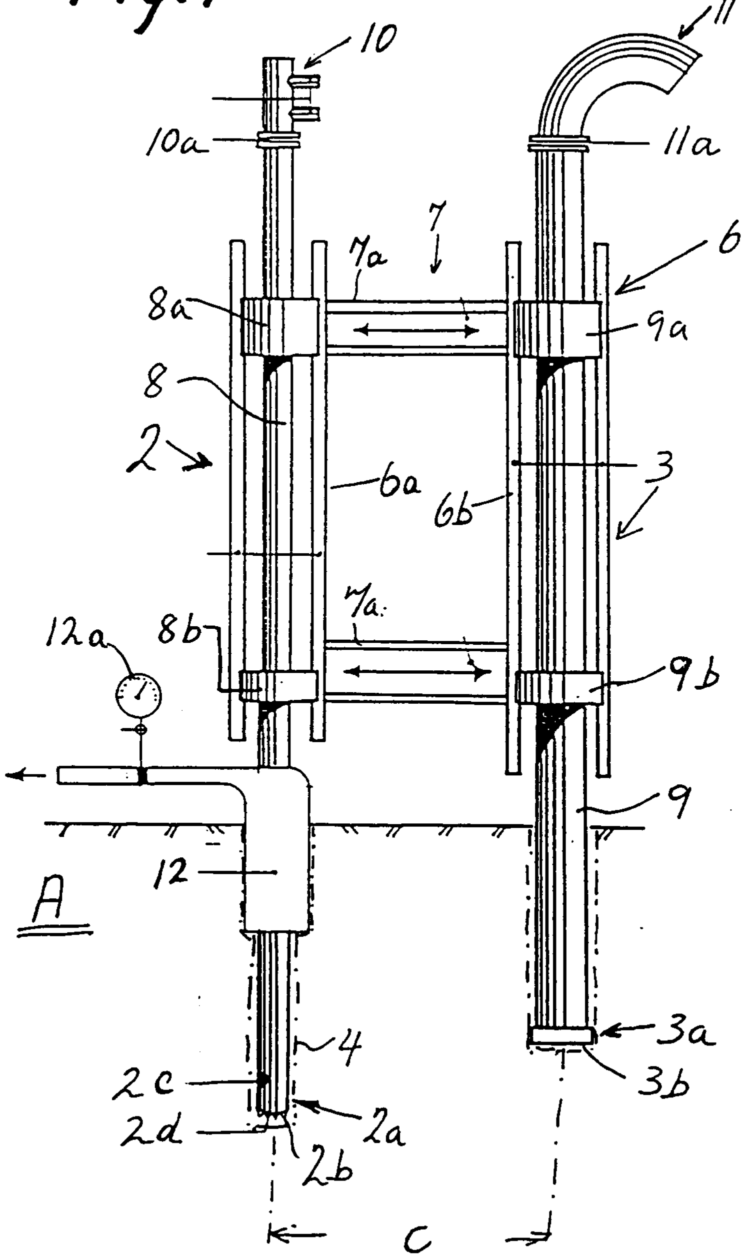
11
10
10a
11a
7
7a
6
8a
9a
8
2
3
6a
6b
3
7a
12a
8b
9b
9
12
A
4
3a
3b
2c
2a
2d
2b
c

Fig.2

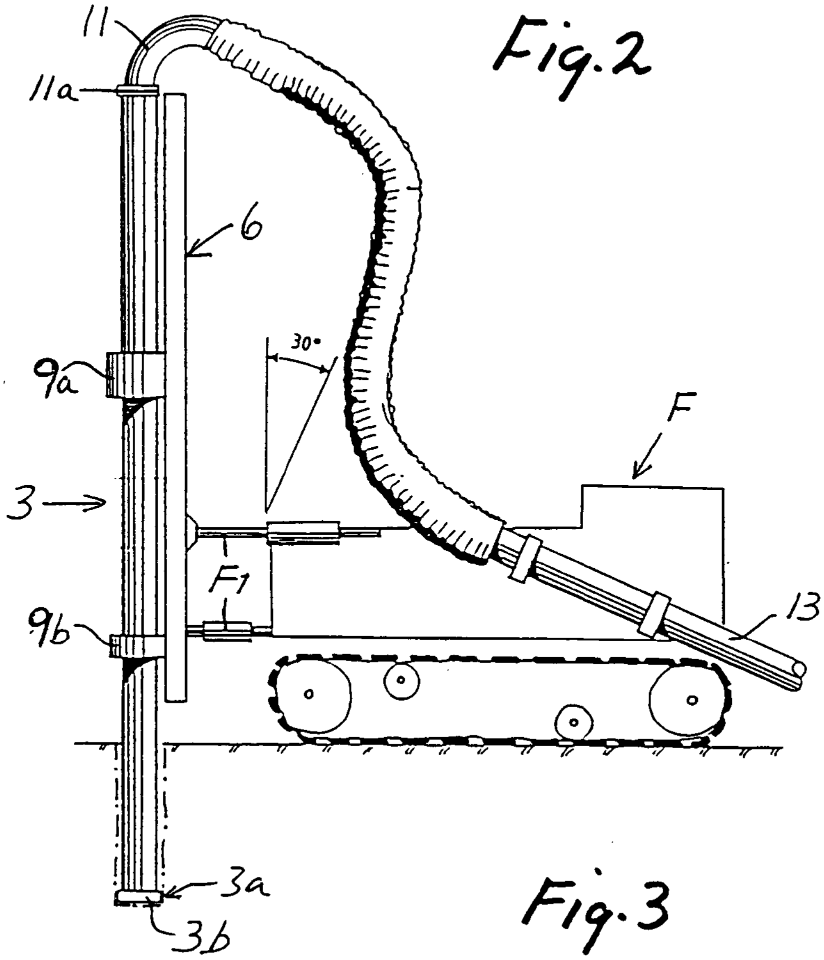

Fig.3

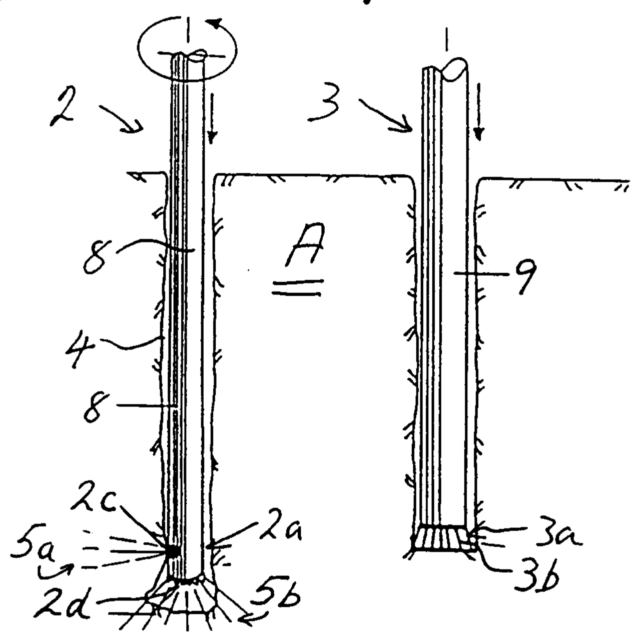

Fig.4

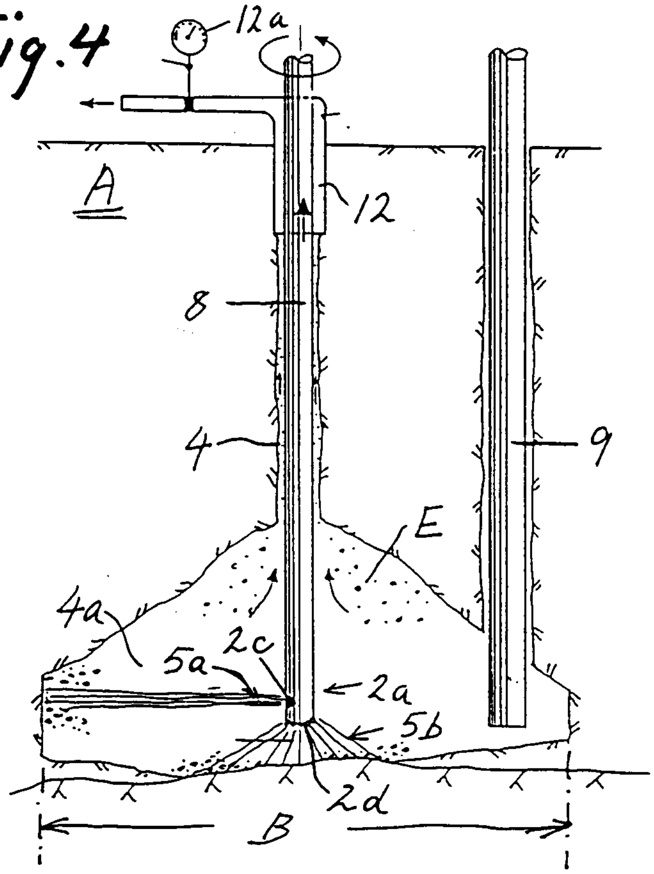

Fig.5