Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2214552 C 2006/08/01

(11)(21) 2 214 552

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(22) Date de dépôt/Filing Date: 1997/09/19
(41) Mise à la disp. pub./Open to Public Insp.: 1998/03/20
(45) Date de délivrance/Issue Date: 2006/08/01
(30) Priorité/Priority: 1996/09/20 (BE9600794)

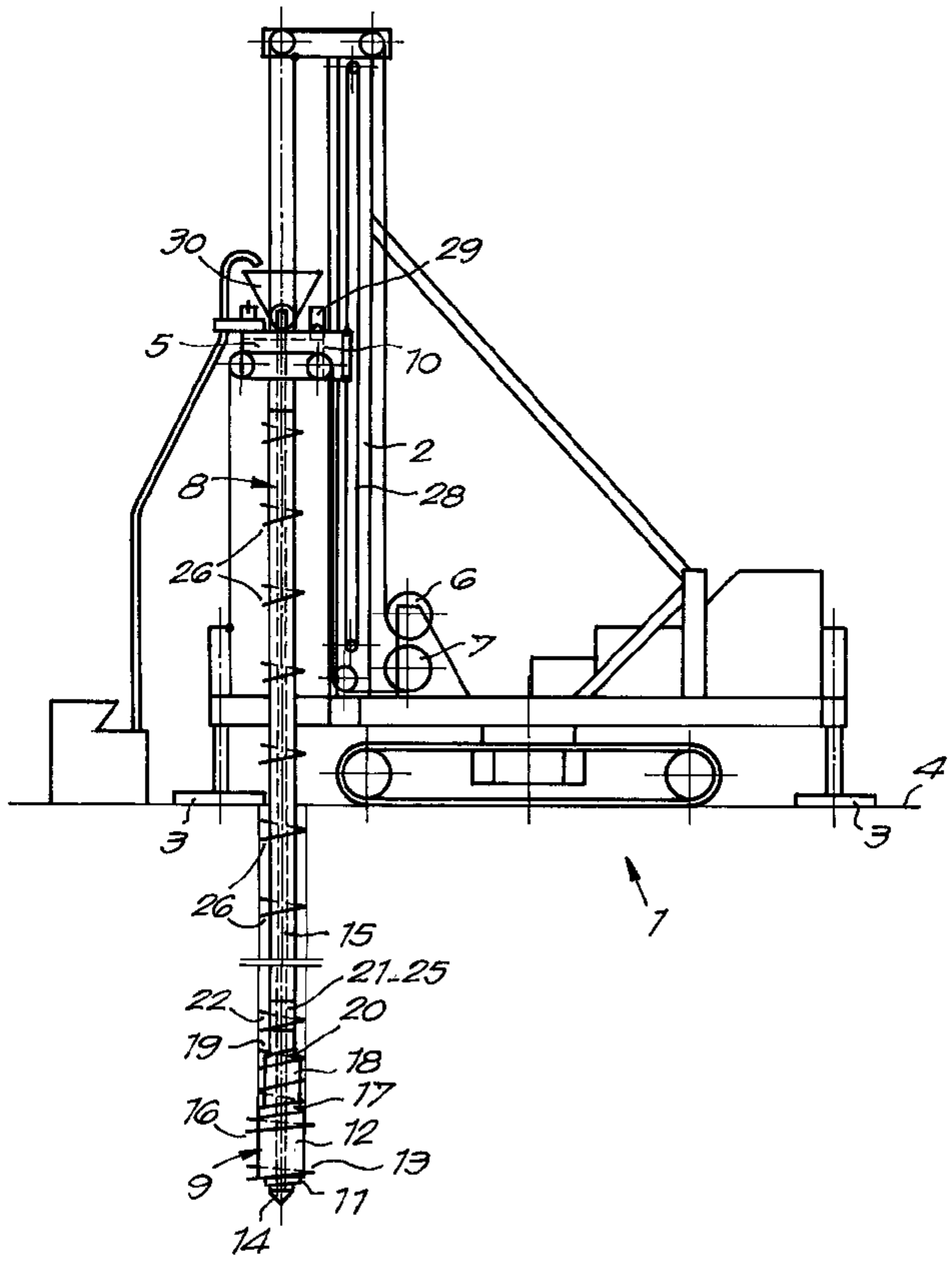
(51) Cl.Int./Int.Cl. *E21B 7/02* (2006.01), *E02D 5/56* (2006.01), *E02D 5/36* (2006.01), *E02D 7/22* (2006.01), *E21B 10/44* (2006.01)

(72) Inventeur/Inventor:
COELUS, GASPAR, BE

(73) Propriétaire/Owner:
WILLEMEN, JOHAN, BE

(74) Agent: ROBIC

(54) Titre : FOREUSE POUR LOGER UN POTEAU DANS LE SOL ET METHODE S'Y APPLIQUANT
(54) Title: DRILL FOR MAKING A POLE IN THE GROUND AND METHOD APPLYING THIS DRILL



(57) Abrégé/Abstract:
Drill for making a pole in the ground, whereby this drill (9) is provided with a passage (15) and whereby this drill has at the bottom a screw-shaped displacement part (11) of which the outside increases in radius upwardly, up to a diameter larger than that of the drill tube (8), characterised in that the displacement part (11) passes with its upper extremity into a cylindrical part (12) which is provided on its mantle with at least a screw blade (13) which runs in the shape of a screw in the same direction as the displacement part (11), but of which the pitch (S2) is larger than the pitch (S1) of the displacement part (11).

Drill for making a pole in the ground and method applying this drill.

Drill for making a pole in the ground, whereby this drill (9) is provided with a passage (15) and whereby this drill has at the bottom a screw-shaped displacement part (11) of which the outside increases in radius upwardly, up to a diameter larger than that of the drill tube (8), characterised in that the displacement part (11) passes with its upper extremity into a cylindrical part (12) which is provided on its mantle with at least a screw blade (13) which runs in the shape of a screw in the same direction as the displacement part (11), but of which the pitch (S2) is larger than the pitch (S1) of the displacement part (11).

Figure 2.

Drill for making a pole in the ground and method applying this drill.

This invention relates to a drill and to a method for making a pole in the ground.

Building constructions which are built on the ground of which the upper layers are compressible, are mostly erected on foundation poles which penetrate through the compressible upper ground layers, until deep enough into a sufficiently thick hard ground layer.

The resistance of the ground against the sinking of a pole with a certain diameter rapidly increases with the depth to which the pole has penetrated the good ground. The maximal resistance is reached at a depth of approximately four times the diameter of the pole in good ground.

On the basis of results of ground research and the load which must be taken by a pole, the most economic pole length and pole diameter can be determined.

However, this calculation is only reliable if the resistance of the fixed bearing-power in the ground layer is not reduced during the making of the pole.

This requirement is met in case of ram piles because the ground is displaced there where the pole comes. However, the ramming causes vibrations in the ground and knocking sounds, which are both a hinder for the surroundings.

This hinder is larger as the poles have a larger diameter and have to be driven deeper into the hard ground. As a result thereof, the maximal diameter of a pile is limited.

As a consequence, especially for making poles with a relatively large diameter, first a hole is made in the ground by means of a drill, and during the removal of this drill a hardening material such as concrete is poured in the liberated space in the drill hole.

Thereby especially two kinds of drills are used: screw drills and displacement drills.

A screw drill or auger consists of a thin drill tube which is provided along its entire length with a screw blade with constant pitch and diameter, and which is closed at the bottom by a lost tip.

This screw drill is screwed in the ground under a downward pressure. When the desired depth is reached, concrete is pumped in the drill tube, while the screw drill is retracted from the ground, mostly without rotation. The lost tip remains in the ground. The concrete fills the hole under the screw drill.

During the drilling in of the screw drill, the surface of the screw blade which is in the ground increases. Since also the ground pressure increases, the friction resistance against the drilling in by a penetration per revolution equal to the pitch, increases by the square of the depth. The continuous screw blade can rapidly no longer penetrate the ground by the pitch per revolution. As a result, a crevice develops between the top of the ground above a winding of the screw blade and the bottom of the winding above it.

This crevice which extends in the shape of a screw along the entire drilling depth, is filled with air under atmospheric pressure and causes that the surrounding ground is eased during the drilling in, thus decreasing the resistance against the penetration of the screw drill in the ground, but which is very detrimental for the bearing-power of the pole.

After the removal from the ground, the ground material which remained between the windings of the screw blade is removed. This material needs to be carried off, which is mostly also a problem.

Displacement drills allow to make the drill hole without removing ground material. Such drills contain a hollow tube which is closed at the bottom by a lost tip, and which is surrounded by a drill head which thickens in the shape of a spiral upwardly and subsequently narrows in the shape of a spiral and which is moreover provided on the broadest part with a screw blade.

During the drilling into the ground, the drilling machine exerts a downward pressure on the drill tube and the drill blade also exerts a downward pressure on the drill if the penetration per revolution is smaller than the pitch of the drill blade.

The bottom of the drill head then assures a sideways displacement of the ground and, at least in compressible ground, the drill sinks per revolution by little less or even more than the pitch of the screw blade. The compressed ground then forms a casing which temporarily protects the drill hole from collapse.

In solid, difficult to compress, ground, however, an empty space can develop at the bottom of the screw blade, since the sinking per revolution is considerably smaller than the pitch of the screw blade. At the place of this empty space the ground is eased and the bearing-power of the pole is much less.

During the screwing out, the lost tip remains in the ground, and concrete is poured, through the drill tube and the drill, into the space coming free under the drill. The ground which has fallen around the drill tube and the ground which has been brought by the screw blade from under the drill to this place around the drill head, is again displaced by the upper part of the drill head.

Thereby it is possible that in solid ground the drill only moves up with a lot less than the pitch of the screw blade per revolution so that a volume of ground is transported down.

This ground is then pushed in the poured concrete so that the effective diameter of the pole decreases and hence its bearing-power.

This last disadvantage is even more dangerous since it occurs imperceptibly and there is no inspection possible in this respect.

The present invention is directed to a drill for making a pole in the ground which does not present the above-mentioned disadvantages and which can have a large bearing-power for a given diameter and which makes easing of the ground impossible even with large diameters and/or in very heavy ground, both during the drilling in and the drilling out.

More specifically, the invention is directed to a drill for making a pole in the ground, comprising:

a top and a bottom lead end;

a screw-shaped displacement part at said bottom lead end, said displacement part having a pitch and having an outside radius which increases upwardly up to a diameter larger than an outer diameter of a drill tube with which said drill is to be used;

a main cylindrical part integrally disposed above said displacement part, said main cylindrical part having a mantle;

at least one screw blade disposed on said mantle, said at least one screw blade having a larger pitch than the pitch of said displacement part and running in the shape of a screw in the same direction as said displacement part; and

an axial passage through said displacement part and said main cylindrical part.

Preferably, the above drill also comprises a lost tip attached to said displacement part such that said bottom lead end is closed.

Preferably, the screw-shaped displacement part extends over approximately one turn.

Preferably also, the screw blade of the cylindrical part extends over approximately one turn.

On the cylindrical part, several screw blades can be applied one above the other. The pitch thereof amounts to between approximately two times and approximately two and a half times the pitch of the displacement part.

The invention also relates to a method for making a pole in the ground whereby a drill according to the invention is drilled into the ground and drilled out again in the opposite sense of rotation, while a hardening material is applied in the liberated space in the drill hole, possibly leaving the lost tip in the ground, whereby the drilling in takes place at a speed whereby the downward movement of the drill per revolution is at least equal to the pitch of the displacement part and the drilling out takes place at a speed whereby the upward movement of the drill per revolution is approximately equal to the pitch of the screw blade on the cylindrical part.

In order to better show the characteristics of the invention, a preferred embodiment of a drill and a method for making a pole in the ground according to the invention are described hereafter, as an example without any limitative character whatsoever, reference being made to the accompanying drawings, in which:

figure 1 schematically represents a side view of a complete drilling installation provided with a drill according to the invention;

figure 2 represents at an enlarged scale a side view of the drill of the installation according to the invention of figure 2;

figure 3 represents a bottom view of the drill of figure 2;

figures 4, 5, 6 and 7 represent cross-sections according to lines IV-IV, V-V, VI-VI and VII-VII respectively in figure 2;

figure 8 represents a side view of a part of the drill tube from the installation of figure 1;

figures 9 to 12 schematically represent the drill with the drill tube represented in consecutive phases during the application of the method according to the invention;

figure 13 represents a side view analogous to that of figure 2, but only of the bottom part of the drill and with respect to a different embodiment of the invention.

The drilling installation according to figure 1 comprises a movable chassis 1 with a mast 2 mounted thereon, which can be toppled down and which is erected vertically during the drilling. During the drilling, the chassis can be stabilised on the ground surface 4 by means of supports 3, or can be anchored in the ground by means of anchors.

A drilling table 5 can slide over the mast 2. On the chassis 1 two winch mechanisms 6 and 7 are mounted, namely a winch mechanism 6 to pull the drilling table 5 up and a winch mechanism 7 to push this drilling table 5 down.

The drilling installation further comprises a drill tube 8 which connects at the bottom to a drill 9. The drill tube 8 passes through a turning mechanism 10 which is mounted in or on the drilling table 5 and can be grasped by this turning mechanism 10 to be rotated and/or moved up or down with the drilling table 5.

According to the invention the drill 9 comprises a displacement part 11 of which the outside broadens in the shape of a spiral away from the bottom extremity of the drill, and thus increases in diameter and, joined to the upper extremity of this displacement part 11, a cylindrical part 12 which is provided on the bottom extremity of its mantle with one screw blade 13 of which the pitch is larger than the pitch of the displacement part 11.

The displacement part 11 extends over approximately one turn and connects at the bottom to a lost tip 14 which temporarily closes an axial passage 15.

The screw blade 13 also extends over approximately one turn and starts there where the upper extremity of the spiral-shaped outer wall of displacement part 11 joins the mantle of the cylindrical part 12, which is bevelled in the shape of a spiral at the bottom.

The sense of rotation of the screw blade 13 is the same as that of the displacement part 11 but the pitch of this screw blade 13 is much larger and preferably two to two and a half times the pitch of this displacement part 11. This screw blade 13 has a constant outer diameter.

In the represented example, a second screw blade 16 is applied on the cylindrical part 12 near the upper extremity. This second screw blade 16 is directed in the same sense and has the same pitch and outer diameter as the screw blade 13. It also extends over approximately one turn.

The diameter DS1 of the screw blades 13 and 16 fulfils the following equation:

$$DS1^2 = DC1^2 \times S2/(S1-S2)$$

in which DC1 is the diameter of the cylindrical part 12;

S1 is the pitch of the displacement part;

S2 is the pitch of the screw blade 13.

The length of the cylindrical part 12 is approximately equal to five times the diameter DC1.

The upper extremity of the cylindrical part 12 connects, by means of a spirally upward narrowing passage part 17, which thus has an outer wall of which the radius gradually decreases towards the top, to a second cylindrical part 18 with a smaller diameter DC2 which fulfils the following equation:

$$DC2^2 = DC1^2 \times (S2-S1)/S2$$

The pitch of the passage part 17 is approximately equal to the pitch S2 of the screw blade 13.

The length of this second cylindrical part 18 is approximately equal to three times the diameter DC1 of the cylindrical part 12.

Also on this second cylindrical part 18 are mounted one or more screw blades 19, in the represented example two screw blades 19, which extend over one turn in the same sense of rotation and with the same pitch as the screw blades 13 and 16.

These screw blades 19 have a constant outer diameter DS2 which is approximately equal to the outer diameter DC1 of the first cylindrical part 12.

By means of a second passage part 20 of which the outer wall gradually decreases in radius towards the top and which has the same pitch S2 as the screw blades 13, 16 and 19, the upper extremity of the second cylindrical part 18 connects to a cylindrical end part 21 of which the outer diameter is approximately equal to the diameter D of the drill tube 8.

This end part 21 is provided on the outside with a screw blade 22 which extends over approximately one turn in the same sense and with the same pitch as said screw blades 13, 16 and 19, and which has a constant outer diameter DSE which fulfils the equation

$$DSE^2 = D^2 \times S2/(S2-S1)$$

The end part 21 is provided at its extremity with and internal relief which is formed for instance by ribs 23 and which is complementary to a corresponding relief which is formed for instance by grooves 24 in the outside of an end part 25 with a smaller diameter of the drill tube 8.

The end parts 21 and 25 form two mutually fitting parts of a coupling with which the drill tube 8 can thus be coupled to the drill 9.

This drill tube 8 can itself consist of several parts which can be coupled to each other with such coupling parts. In figure 8 a bottom part of this drill tube 8 is represented.

As represented in this figure 8 each part of the drill tube 8 is provided with several screw blades 26 which extend over one turn in the same sense and with the same pitch as said screw blades 13 and 16, and which have a constant diameter which is approximately equal to the outer diameter of said screw blade 22.

It is clear that between the end part 21 and the second cylindrical part 18 one or more additional cylindrical parts and passage parts may be applied, especially in case of very large diameters of the pole to be formed. For that matter, figures 9, 10 and 11 schematically represent a drill 9 with three cylindrical parts.

A third or subsequent cylindrical part has a diameter which fulfils the following equation:

$DCX^2 = (DCX-1)^2 \times (S1-S2)/S2$, whereby DX-1 is the diameter of the cylindrical part below it.

The diameter of the screw blade on a subsequent cylindrical part is each time approximately equal to the diameter DCX-1 of the cylindrical part below it.

The displacement part 11 and the passage parts 17 and 20 are massive around the passage 15. The cylindrical parts 12 and 18 are hollow and have internally a tube part 27 of which the inside forms the passage 15 at the place of these parts.

This passage 15 has everywhere approximately the same diameter, which is so large that concrete of an other hardening material can be poured fast enough.

In the following table some examples are given of the different values of diameter and pitch in cm with two and three (X=3) cylindrical parts, respectively:

S1	S2	D	DC1	DS1	DC2	DSE
10	20	27.3	41	58.0	29.0	38.6
10	20	29.9	46	65.0	32.5	42.3
10	20	29.9	51	72.0	36.0	42.3
9	21	32.4	56	74.0	42.3	42.9
9	21	32.4	61	80.7	46.1	42.9
9	21	32.4	66	87.3	49.9	42.9

S1	S2	D	DC1	DS1	DC2	DCX	DSE
8	22	36	71	89.0	56.6	45.2	45.1
8	22	36	76	95.3	60.6	48.4	45.1
8	22	36	81	101.5	64.6	51.5	45.1

In order to form a pole in the ground with the installation described above, the following method is used.

By means of a winch 7, the drill table 5 is pushed down and the drill tube 8 and thus also the drill 9 coupled therewith are rotated by the drill table 5 in such a way that the drill 9 is drilled into the ground.

This takes place with a downward movement which is for each rotation or turn of the drill 9 at least equal to the pitch S1 of the displacement part 11.

By the displacement part 11 a volume of ground V1 is displaced per turn, equal to pi x $DC1^2$ x S1/4.

By the screw blade 13 a volume of ground V2 is displaced, equal to $(DS1^2 - DC1^2) \times A \times pi/4$, whereby A is the thickness of the screw blade 13. V2 amounts to only 5 to 6% with respect to V1.

By the screw blade 13 a volume of ground V3 is transported up per turn, equal to $(DS1^2 - DC1^2) \times (S1 - S2) \times pi/4$.

The dimensions of said diameters and pitches are adjusted in such a way that V3 approximately equals V1. As a result, no empty space will develop under the screw blade 13, since the space under this screw blade 13 is immediately filled with ground which was displaced by the displacement part 11. Therefore, no easing of the ground can develop. The volume V2 must be purely compressed.

Only a small volume needs to be compressed, only enough to prevent an easing of the ground, thus requiring a minimal energy for the drilling in.

At first, one drills through the loose ground with a descent per turn of more than S1 and in practice almost equal to the pitch S2 of the screw blade 13, for instance over approximately 9 m, as represented in figure 9 which relates to the drilling with a drill with three cylindrical parts.

Due to the downward speed which is more than S1 per turn, the screw blades 13 and 16 will transport less ground up, and more ground will be compressed, thus forming a compressed cohesive ground mantle around the drill 9.

Subsequently, one drills through a transitory area and finally over a distance of at least 8 times the diameter of the pole to be formed under the loose ground, in solid ground up to for instance approximately 14 m, as represented in figure 10. This still takes place at a descent speed higher than S1 per turn.

Hereby it may be necessary to anchor the chassis 1 in the ground or to apply a counterweight on this chassis 1.

In order to be certain that the drill descends also in the solid ground with a distance of at least the value of S1 per turn, the downward movement of the drill table 5 is measured with a device 28 which is mounted on the mast 2, and the number of revolutions of the drill tube 8 is measured by a device 29 mounted on the drill table 5. From these data, a micro processor can control the winch 7 and the turning mechanism for the drill head 5 in such a way that the above-mentioned requirement is met.

Due to the relatively large length of the cylindrical part 12, the ground which is transported up by the transport blades 13 and 16 is brought to a place where the ground is relatively compressible so that the displacement is relatively easy later on.

After reaching the desired depth, the sense of rotation of the drill table 5 is reversed and this table 5 is pulled up by the winch 6.

During this drilling out concrete is poured in the drill tube 8 through a funnel 30.

Due to the weight of the concrete, the lost tip 14 remains in the ground, as represented in figure 11.

This drilling out takes place at a rise per turn of a distance which is almost equal to the pitch S2 of the screw blades 13 and 16. This can also be adjusted by said micro processor which controls among other things the winch 6.

As a result, it is assured that also during the drilling out no easing of the ground takes place and also that no ground is pushed in the poured concrete.

As represented in figure 12, a concrete pole is obtained with a diameter equal to the diameter DC1 of the first cylindrical part 12, but with a concrete screw blade on it which corresponds with the screw-shaped groove made by the screw blades 13 and 16.

In this way poles with a large diameter and/or into very hard ground can be made in a ground which is guaranteed not to ease, so that the poles have a large bearing-power.

In figure 13 an embodiment of the drill 9 is represented which is especially destined for the rarely occurring case that immediately below a loose ground layer a very hard ground layer is present.

In such a case the screw blades 13 and 16 can deliver practically no pulling power since they are located in loose ground.

For this reason, in this embodiment of the drill 9 the displacement part 11 is extended towards the bottom by an extension piece 31-32. The lost tip 14 connects to the bottom extremity of this extension piece 31-32.

This extension piece 31-32 consists of a cylindrical body 31 through which the passage 15 extends, and of which the outer diameter is approximately equal to the outer diameter of the tube part 27, and of a screw blade 32 mounted thereon, with the same sense of rotation and pitch as the screw blades 13 and 16 but with a smaller outer diameter which is slightly larger than twice the largest radius of the displacement part 11.

This screw blade 32 helps to pull the displacement part 11 in the hard ground layer.

The present invention is in no way limited to the embodiments described above and represented in the drawings, but such a drill and method applying this drill can be realised in many variants without leaving the scope of the invention.

More specifically, the number of screw blades on the cylindrical parts 12 and 18 need not necessarily be exactly two. One or more than two screw blades are possible. Also on the end part 21 no or more than one screw blade can be applied.

These screw blades need not necessarily extend over exactly one turn.

WHAT IS CLAIMED IS:

1. A drill for making a pole in the ground, comprising:

a top and a bottom lead end;

a screw-shaped displacement part at said bottom lead end, said displacement part having a pitch and having an outside radius which increases upwardly up to a diameter larger than an outer diameter of a drill tube with which said drill is to be used;

a main cylindrical part integrally disposed above said displacement part, said main cylindrical part having a mantle;

at least one screw blade disposed on said mantle, said at least one screw blade having a larger pitch than the pitch of said displacement part and running in the shape of a screw in the same direction as said displacement part; and

an axial passage through said displacement part and said main cylindrical part.

2. A drill according to claim 1, further comprising:

a lost tip attached to said displacement part such that said bottom lead end is closed.

3. A drill according to claim 1 or 2, wherein said screw-shaped displacement part extends over approximately one turn.

4. A drill according to any one of claims 1 to 3, wherein said at least one screw blade disposed on said mantle of said main cylindrical part extends over approximately one turn.

5. A drill according to any one of claims 1 to 4, wherein said at least one screw blade is located on a bottom extremity of said mantle of said main cylindrical part.

6. A drill according to any one of claims 1 to 5, wherein said at least one screw blade has a constant outer diameter.

7. A drill according to any one of claims 1 to 6, comprising several of said at least one screw blade that are approximately equal and disposed one above another on said mantle of said main cylindrical part.

8. A drill according to any one of claims 1 to 7, further comprising:

at least one subsequent cylindrical part disposed above said main cylindrical part, said subsequent cylindrical part having a smaller radius than the cylindrical part located below it; and

at least one upward spirally narrowing transition part which connects said subsequent cylindrical part to the cylindrical part located below it.

9. A drill according to claim 8, further comprising:

at least one subsequent screw blade disposed on said subsequent cylindrical part, said at least one subsequent screw blade having an outer diameter approximately equal to the diameter of the cylindrical part located below it, said at least one subsequent screw blade extending in the same direction and with the same pitch as said at least one screw blade on said main cylindrical part.

10. A drill according to claim 8 or 9, further comprising:

an end piece located at said top and above the uppermost subsequent cylindrical part, said end piece having an outer diameter such that said end piece may be coupled to a drill tube with which said drill is to be used; and

a subsequent upward spirally narrowing transition part which connects said end piece to the uppermost subsequent cylindrical part.

11. A drill according to claim 10, further comprising:

a drill tube coupled to said drill by said end piece; and additional screw blades disposed on said drill tube and said end piece, said additional screw blades extending in the same direction and having the same pitch as said at least one screw blade on said main cylindrical part.

12. A drill according to any one of claims 1 to 11, further comprising:

an extension piece having a cylindrical body, said extension piece extending downward from said displacement part; and

an extension piece screw blade mounted on said cylindrical body of said extension piece.

13. A method for making a pole in the ground using a drill comprising a top and a bottom lead end; a screw-shaped displacement part at said bottom lead end, said displacement part having a pitch and having an outside radius which increases upwardly up to a diameter larger than an outer diameter of a drill tube with which said drill is to be used; a main cylindrical part integrally disposed above said displacement part, said main cylindrical part having a mantle; at lest one screw blade disposed on said mantle, said at least one screw blade having a larger pitch than the pitch of said displacement part and running in the shape of a screw in the same direction as said displacement part; and an axial passage through said displacement part and said main cylindrical part, comprising the steps of:

drilling said drill into the ground in a direction of ration at a speed whereby downward movement of said drill per rotation of said drill is at least equal; to said pitch of said displacement part;

drilling said drill out of the ground in an opposite direction of rotation at a speed whereby upward movement of said drill per rotation of said drill approximately equals said pitch of said screw blade on said main cylindrical part; and

applying a hardening material through said axial passage in said drill into the liberated space of the drill hole.

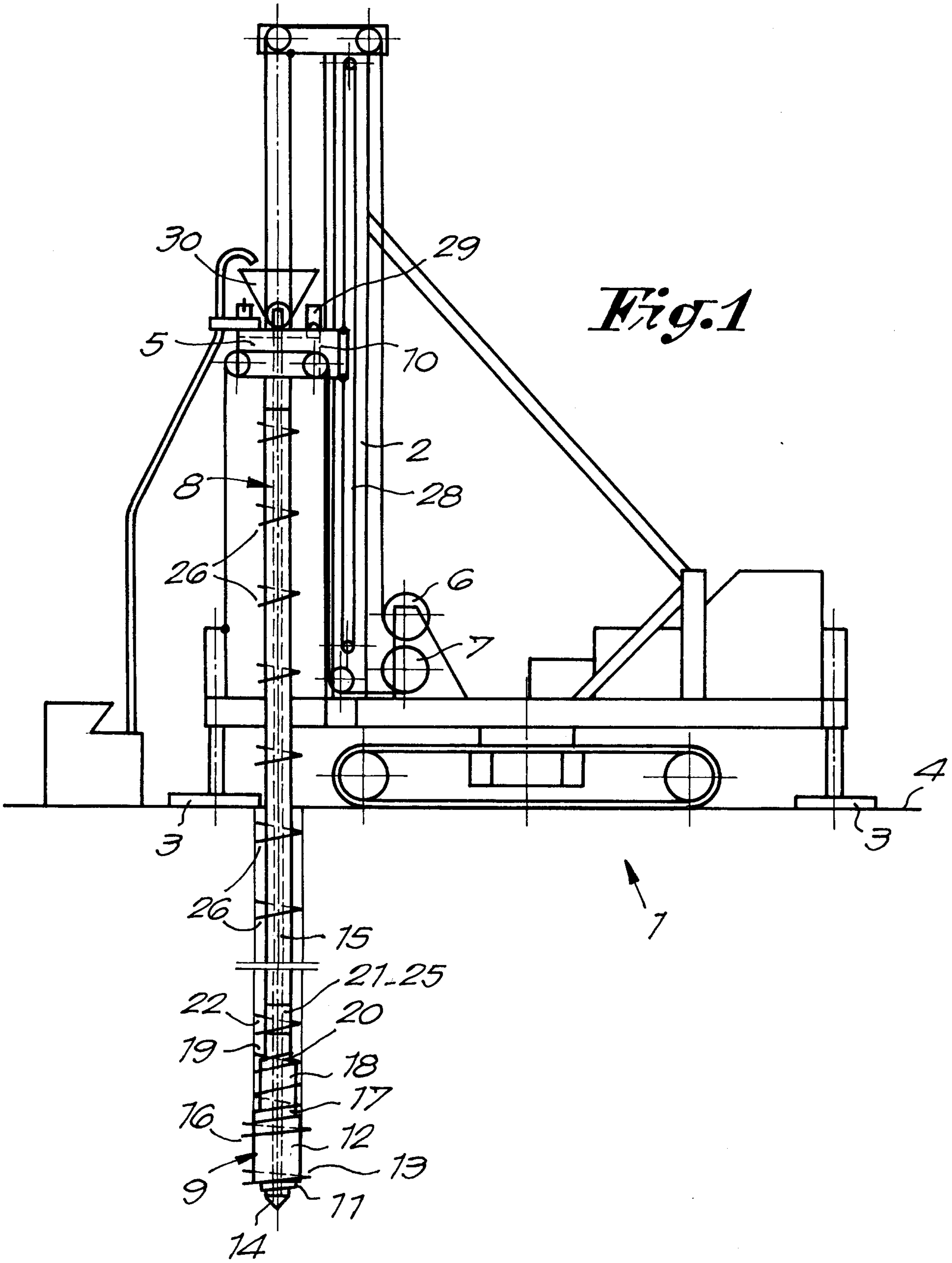


Fig.1

Fig.3

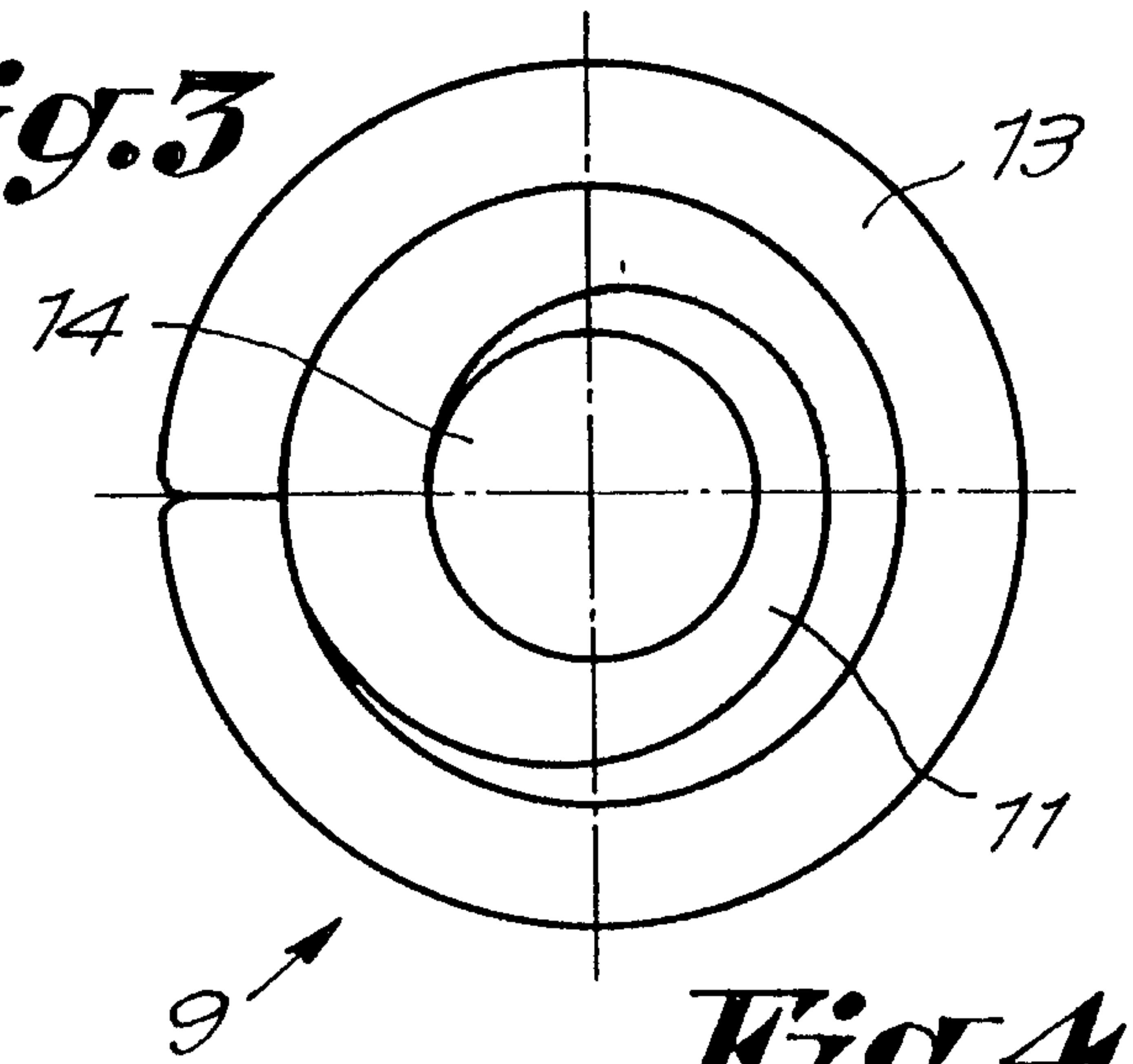


Fig.2

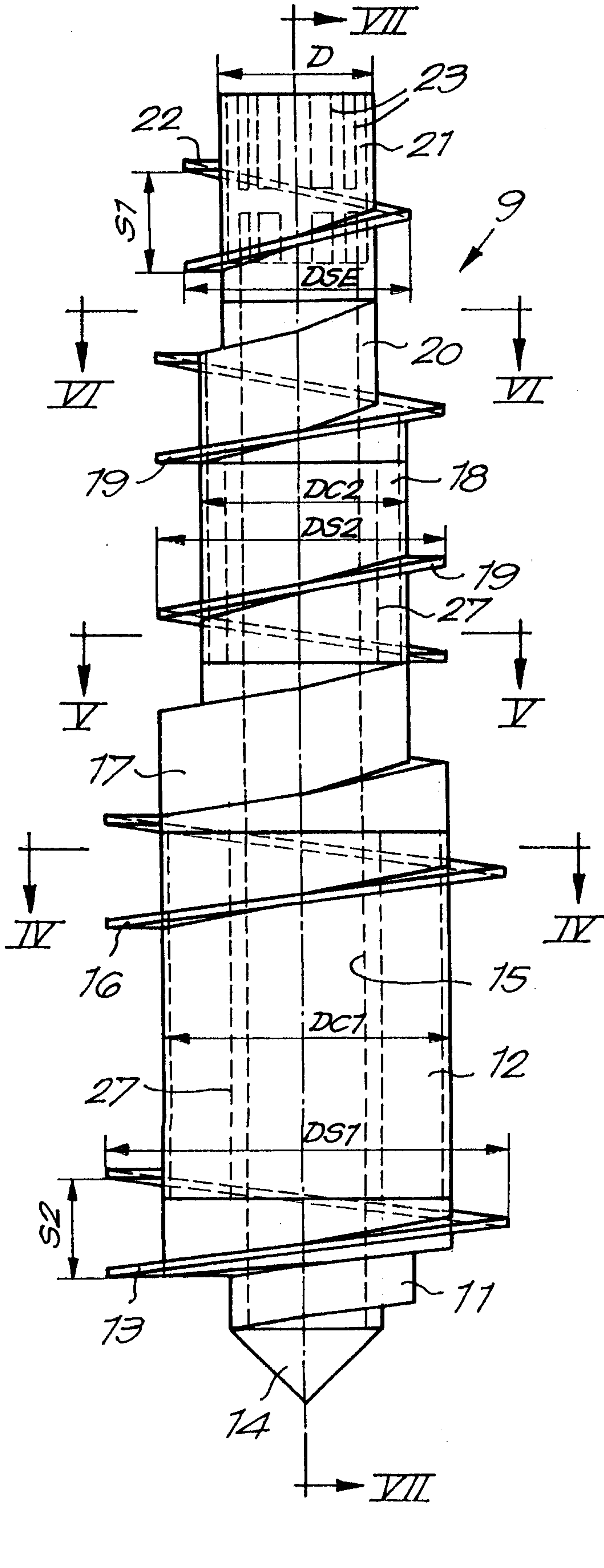


Fig.4

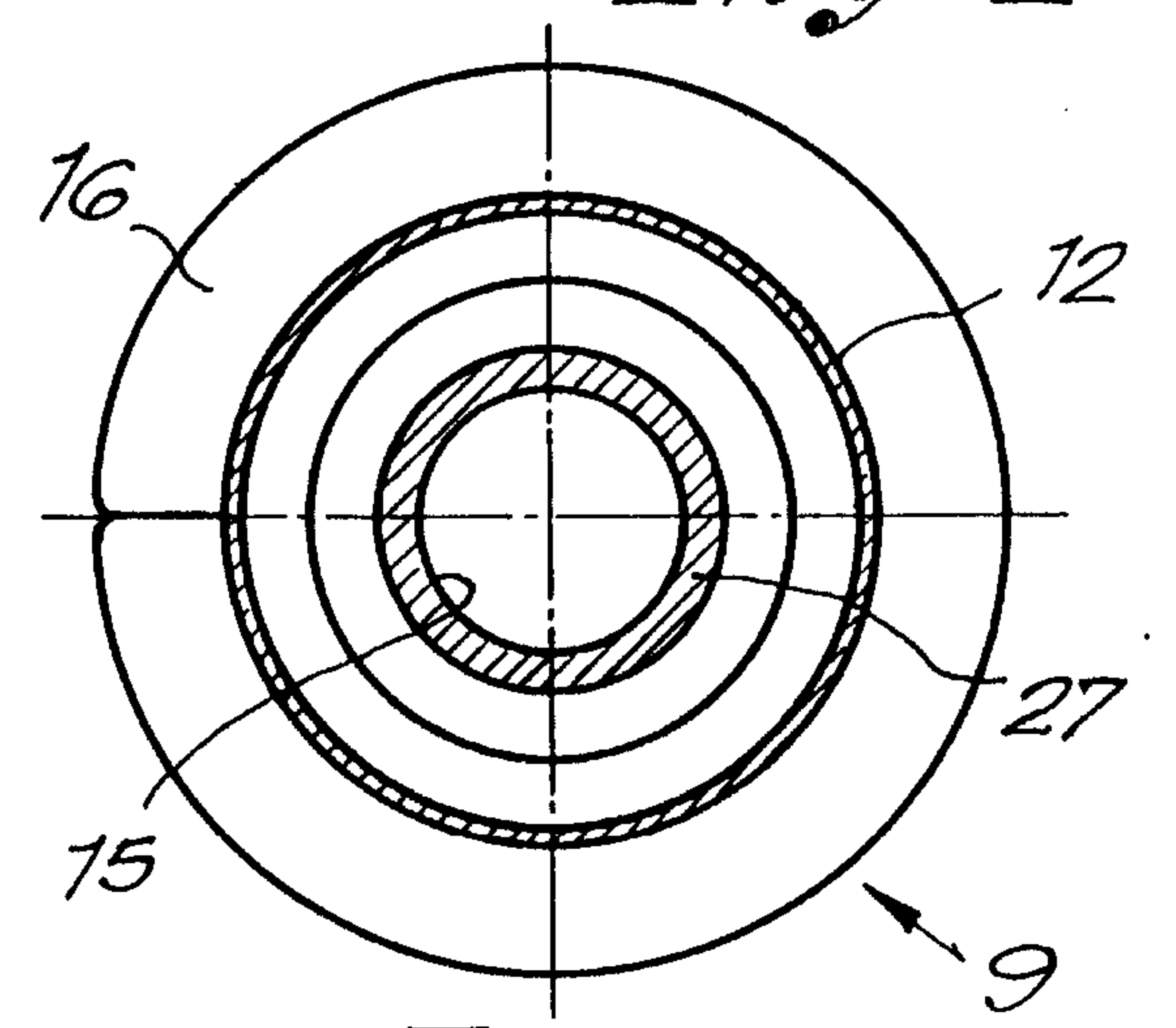


Fig.5

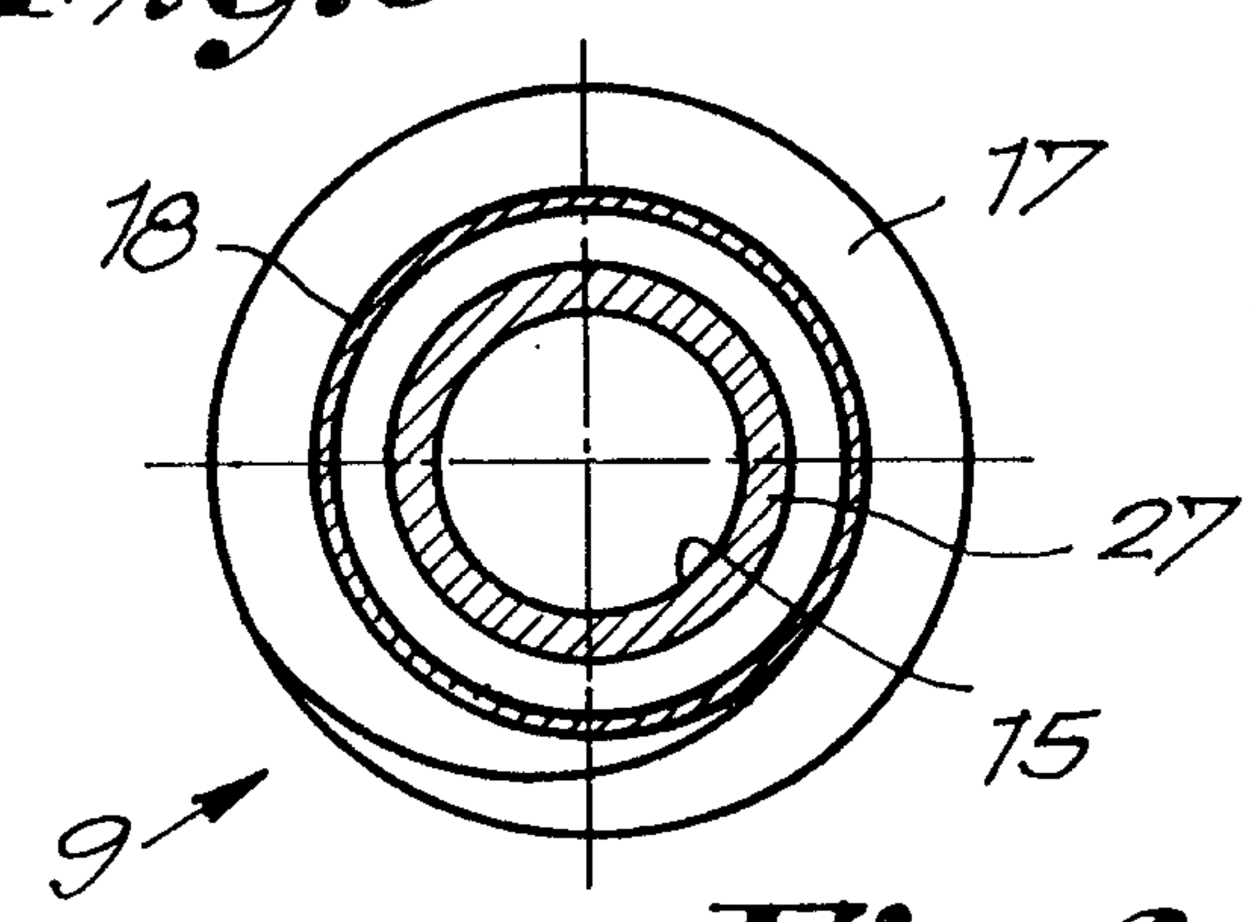


Fig.6

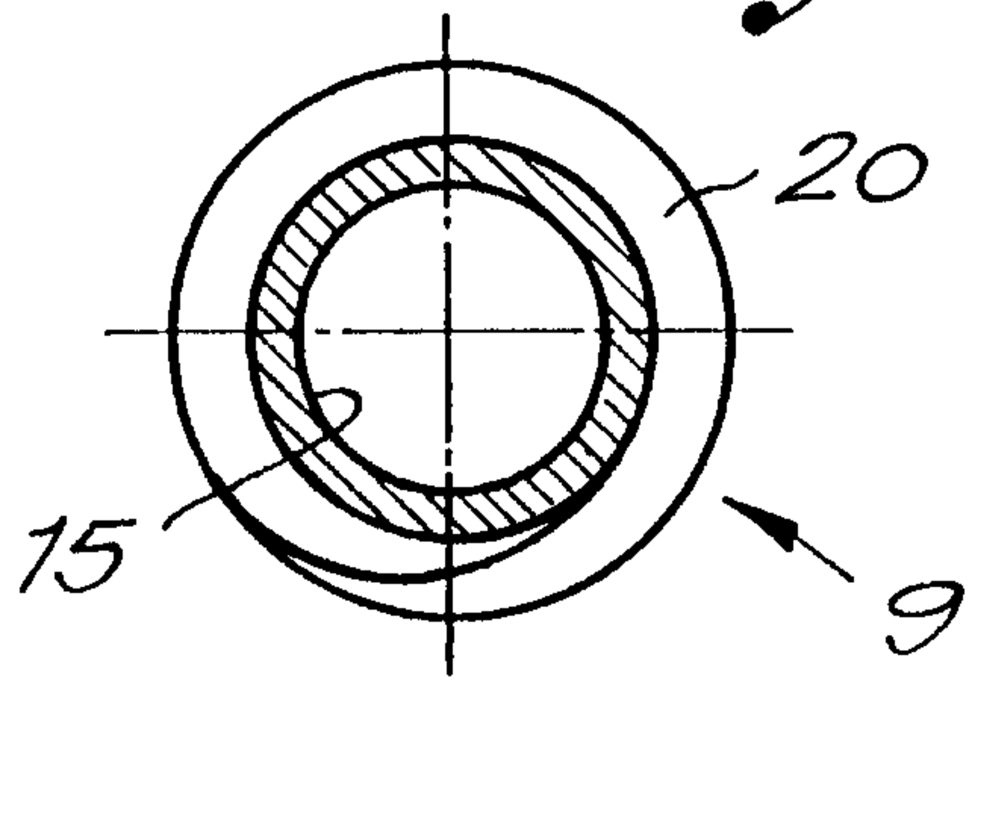


Fig.7

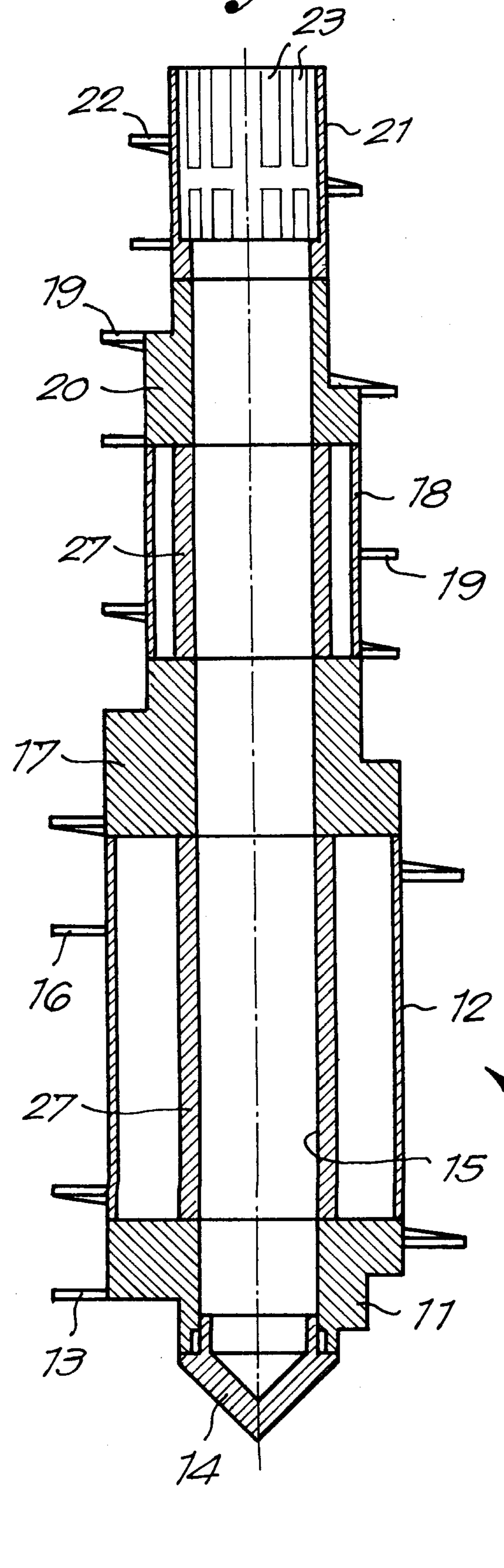

23
22
21
19
20
18
27
19
17
16
12
27
9
15
11
13
14

Fig.8

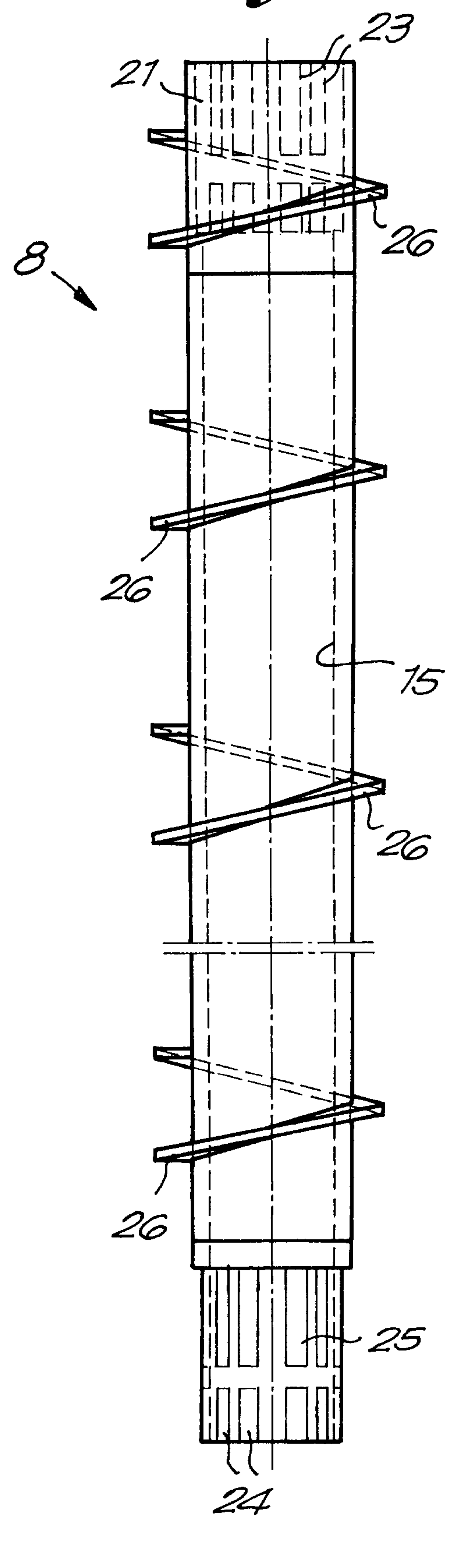

23
21
26
8
26
15
26
26
25
24

Fig.9

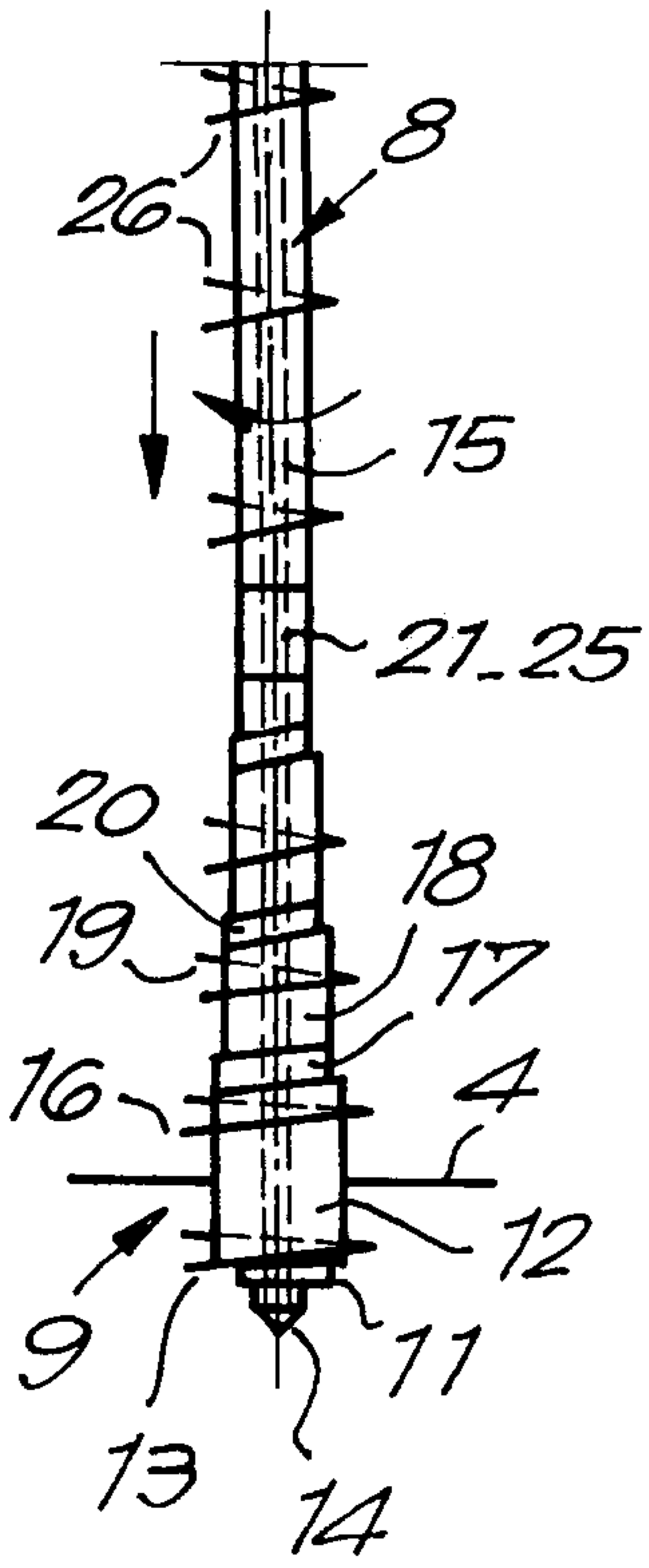


Fig.10

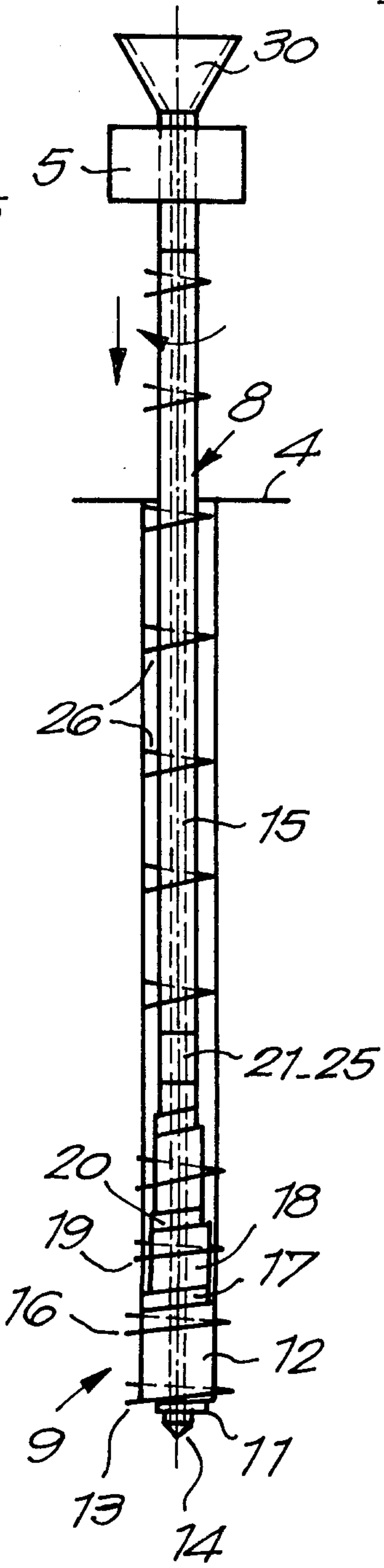


Fig.11

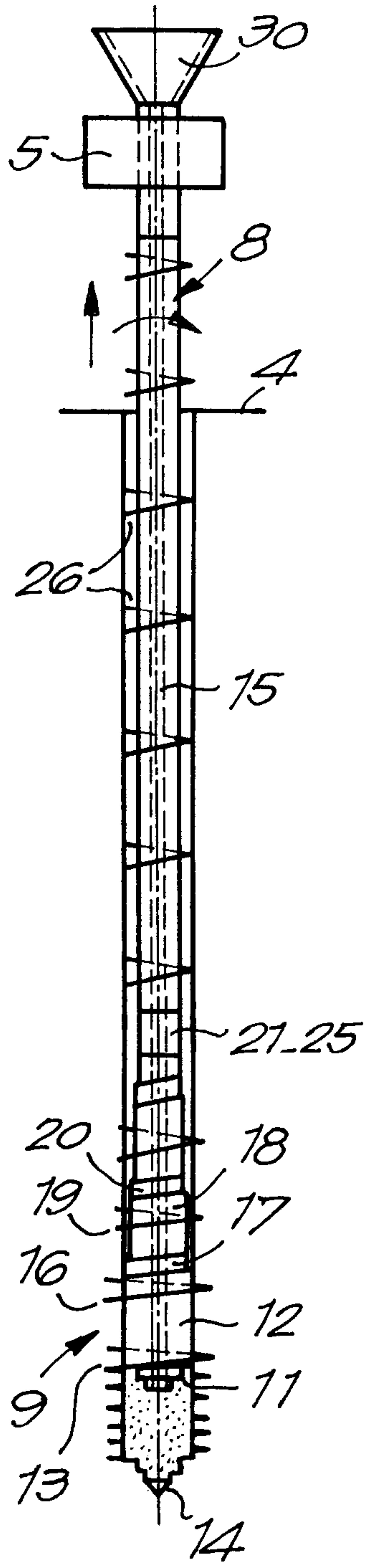


Fig.12

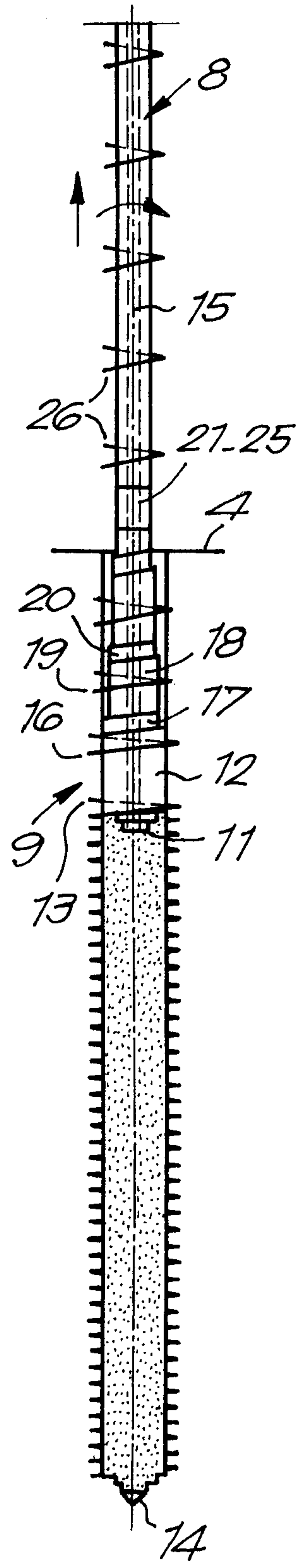
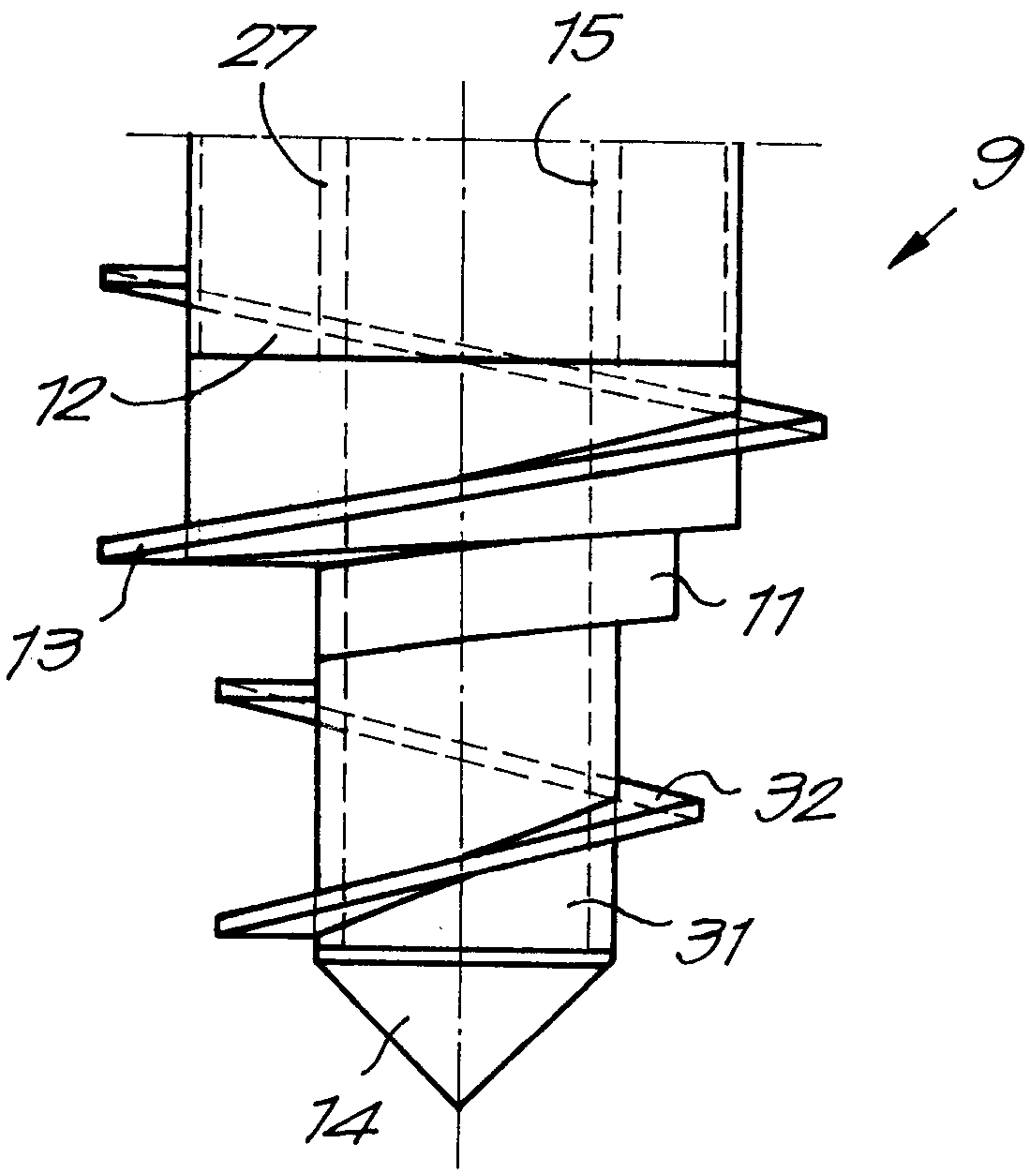
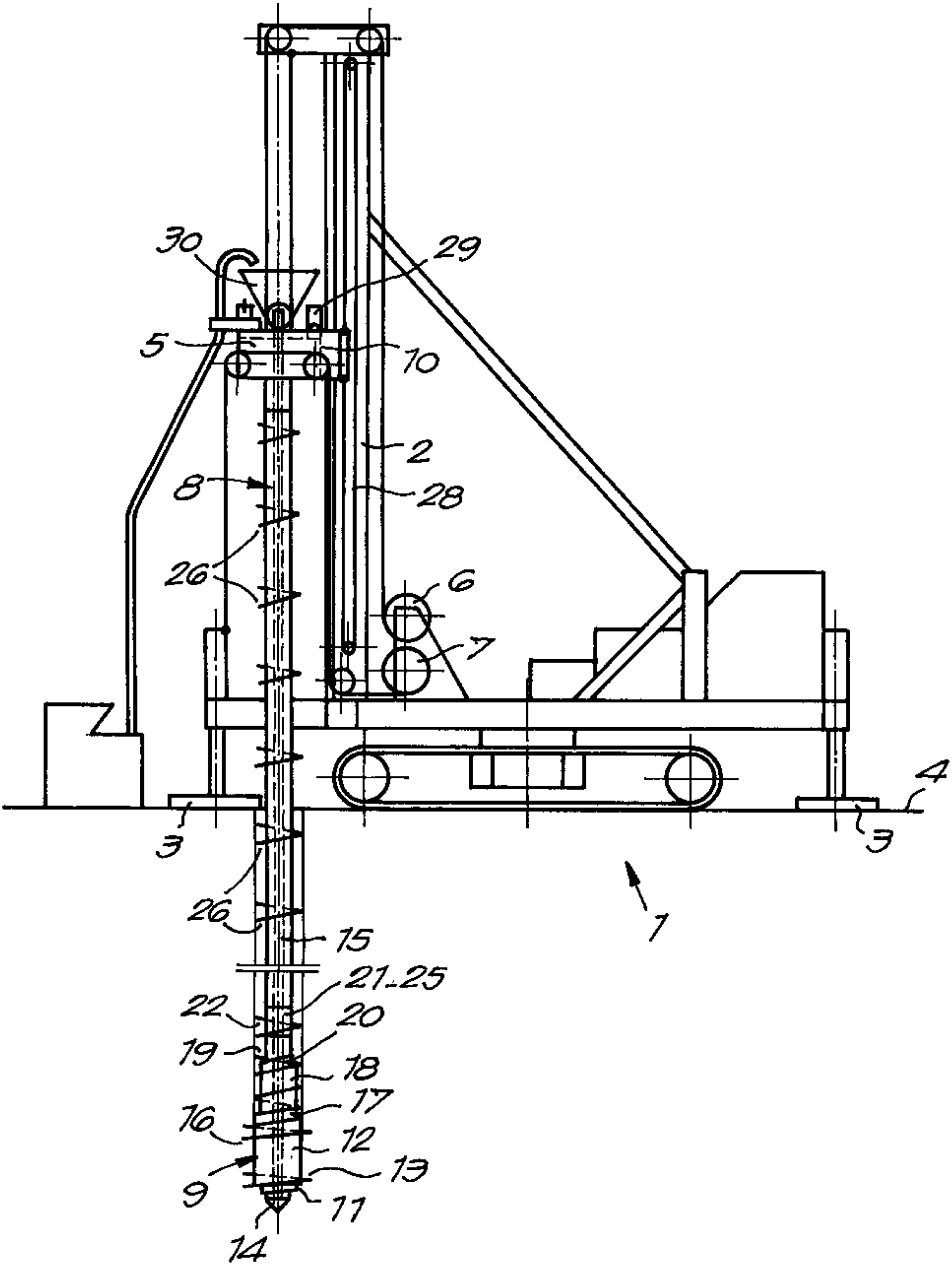


Fig.13




30
29
5
10
2
8
28
26
6
7
4
3
3
26
26
1
15
21-25
22
20
19
18
17
16
12
9
13
11
14