

A DIRECTIONAL BORING TOOL

The present invention relates to a boring assembly using a jet of liquid under pressure which enables a deflected hole to be bored.

5 The technique known as "jet grouting" consists in making columns of concrete in the ground by using a fluid which is delivered at high pressure to destructure the soil. This destructuring operation is performed from a mechanically bored hole on the axis of the column that is
10 to be obtained in this way. It is very important for the quality of the final structure that these columns be properly positioned and properly vertical, particularly when the final structure is to perform a sealing function. For example, in order to obtain good
15 continuity of a web that results from juxtaposing columns or masses of concrete, it is necessary for the axes of all of the columns making up the work to be positioned very accurately. In order to correct errors in positioning and in particular in verticality, directed
20 boring techniques are used in order to correct for deviations of the axis of the hole being bored.

 The technique of directed boring relies on two systems: firstly detecting the position of the borehole, and secondly the ability to cause the borehole to be
25 deflected in the desired direction in order to correct an error in verticality, or more generally an error in direction.

 The techniques commonly used in hard soils, i.e. essentially in the field of boring oil wells, are based
30 on three principles:

- inserting a bend in the tool line;
- using controlled deflectors which apply a lateral force on the tool; and
- changing the angle of incidence of the tool, e.g.
35 by bending its axis.

 Those three techniques are associated with the continuous rotation of the boring tool which is driven

either by a downhole motor or directly by the boring head via the bore string. The boring tool is fitted solely with mechanical cutting members. The purpose of establishing circulation of a liquid or a boring mud is solely to lubricate the mechanical cutting members and to enable the debris that is cut from the ground to be raised to the surface.

In covering soils, other deflected boring techniques are used. They are based on driving a sloping blade which is fitted with the tool, the driving sometimes being assisted by a jet of boring fluid. To perform deflection, the bore string having the tool mounted at its end must be stopped from rotating, and after being oriented in a particular direction, the tool is driven into the soil over several centimeters before restarting rotation. This operation is repeated several times until significant deflection is obtained suitable for correcting the error of direction. To bore normally, the tool is set into continuous rotation.

When boring for the purpose of constructing columns by means of jet grouting, the boring must necessarily be taking place in soil that is capable of being destroyed by a jet under high pressure, i.e. in soil that is relatively loose.

A boring technique that is used in alluvial soil with little cohesion consists in destructuring the ground by means of a high pressure jet of fluid that is directed towards the front of the tool. That technique is known as jetting. It is very widely used in sandy ground that is not very compact. The main drawback of that boring technique is that it ceases to operate as soon as it encounters an obstacle that is a little harder.

An object of the invention is to provide an assembly for boring in the ground by injecting fluid under pressure and making it possible, during certain stages of boring, to deflect a borehole so as to correct for an error in the direction of the borehole.

To achieve this object, the assembly for boring in the ground by injecting fluid under pressure comprises:

- a plurality of interconnected boring rods including means forming a pipe for a fluid under pressure, said rods forming a bore string;
- a boring head for controlling the movement of said bore string in rotation and in vertical translation;
- a boring tool fixed to the bottom end of said bore string, said tool having a body presenting a longitudinal axis extending the axis of the bore string, a bottom end provided with a plurality n of cutting members and means for creating a jet of fluid under pressure to break up the ground, means for coupling the pipe-forming means to the jet-creation means, and means for imparting a mean distribution to said jet that is not symmetrical about said longitudinal axis of said tool; and
- means for feeding said pipe-forming means under a pressure that is sufficient for the jet that is produced actually to break up the ground.

In the present specification, the term "means for creating a jet of fluid under pressure" is used to mean means enabling an outlet of fluid under pressure to be created at the bottom end of the boring tool, so as to establish a single jet or a plurality of jets.

In addition, since the motion of the boring tool about its longitudinal axis can be in continuous rotation or else in alternation, the term "asymmetrical mean distribution" about the longitudinal axis refers not only to the distribution of the jet in the static state (i.e. in the absence of rotation) but also in the dynamic state, (i.e. the set of positions occupied by the jet(s) during a complete cycle of the tool in its motion about its axis).

In a first embodiment, the tool is characterized in that the means for creating a jet of fluid under pressure comprise g injection nozzles distributed generally symmetrically about the longitudinal axis of said tool,

and in that it includes means for causing the feed to some of said nozzles to be interrupted temporarily in such a manner that said r nozzles that are being fed produce a distribution that is not symmetrical about the longitudinal axis of said tool.

It will be understood that in this first embodiment, apart from periods during which deflection is being performed, the jet of fluid under pressure presents distribution about the axis of the tool that is symmetrical and the jet is modified temporarily, only during deflection stages in order to impart asymmetry in the desired direction.

In a second embodiment, the directional boring tool is characterized in that said means for creating a jet of fluid under pressure comprise g nozzles for injection under pressure, said g nozzles being distributed in generally asymmetrical manner about the longitudinal axis of said tool, and in that the assembly further comprises means for feeding said nozzles simultaneously.

In this second embodiment, the jet of fluid under pressure is continuously asymmetrical about the axis of the tool body, and thus during deflection stages deflection is obtained. In contrast, outside deflection stages, the tool is caused to rotate continuously in order to ensure that the mean distribution of the jet of fluid under pressure to become symmetrical over each rotation of the tool.

Other characteristics and advantages of the invention will appear better on reading the following description of various embodiments of the invention given as non-limiting examples. The description refers to the accompanying figures, in which:

• Figure 1 is an elevation view of an assembly for boring by means of a jet under pressure;

• Figure 2A is a longitudinal section view of a boring tool constituting a first embodiment of the invention;

- Figure 2B is an end view of the Figure 2A tool;
- Figure 3A is an end view of a boring tool constituting a second embodiment of the invention; and
- Figure 3B is a side view of the Figure 3A tool showing the deflection effect.

Figure 1 shows a boring assembly comprising a platform 10 preferably mounted on crawler tracks 14 or on any other displacement system. A guide mast 16 is hinged to the platform 10 and serves to guide a carriage 18 in translation. The carriage 18 supports a boring head 20 for setting a drill string 22 into rotation and for moving it in translation. The bore string 22 has a boring tool 24 mounted at its bottom end 22a. The boring tool 24 is of the type that is capable of creating jets of fluid under pressure.

Pressure feed is implemented from a source 26 of fluid under pressure, preferably a liquid, which source feeds a pipe (not shown) placed inside the boring string 22, said pipe possibly being constituted by the rods making up the string and connected to the string by a hose 28 and a rotary joint 30. By way of example, vertical displacements of the boring head 20 are controlled by means of a cable or chain system 32 driven by a motor (not shown), while rotation of the bore string is achieved by means of a motor 34, for example.

With reference initially to Figures 2A and 2B, there follows a description of a first embodiment of the boring tool which is referenced 24a. This tool comprises a body 40 having a bottom end 42 with cutting members of conventional type (such as the members 44) mounted thereon. In the bottom face 42, there are also provided nozzles such as 46 that are capable of creating respective jets of liquid under pressure that are directed substantially along the longitudinal axis X-X' of the body 40 of the tool. The body 40 of the tool has a second end 48 provided with a thread 50 for connection to the bore string 22. There can also be seen a pipe 52

inside the bore string 22 for feeding liquid under pressure. The pipe 52 is connected to passages such as 54 made through the tool body so as to feed the nozzles 46. As shown in Figure 2A, the nozzle 46a is fitted with
 5 a controllable interrupter 56. Figure 2B shows four mechanical cutting tools such as 44 and four injection nozzles 46a, 46b, 46c, and 46d. These nozzles are disposed at 90° relative to one another. More generally, the number of nozzles need not necessarily be four, and
 10 the nozzles are disposed in a manner that is generally symmetrical about the axis X-X' of the tool.

It will be understood that when the nozzles are fed with liquid under pressure, the nozzles 46b, 46c, and 46d continuously create respective localized jets of liquid,
 15 whereas the nozzle 46a creates such a jet or creates no such jet depending on the state of its interrupter 56. By way of example, the interrupter 56 can be controlled by a bistable system whose state depends on applying a temporary pressure surge.

20 It will be understood that while the tool 24a is not being rotated and the nozzle 46a is closed, then the overall jet of liquid under pressure created by the nozzles 46b, 46c, and 46d is asymmetrical and will enable the trajectory of the tool in the ground to be deflected.
 25 In contrast, if the nozzle 46a is also fed, then the overall jet is symmetrical and no such deflection occurs.

It is possible during the deflection stage to combine the effect of the jets under pressure with the mechanical action of the cutting members 44 in order to
 30 obtain the borehole. To maintain the deflection effect, it suffices to cause the tool to rotate in alternation through an angle of 90° , for example, thus not interfering with the asymmetry of the jet but enabling the various cutting tools to act over 360° . More
 35 generally, if the tool has n cutting members 40, then alternating rotation should be performed through an angle of not less than $360/n$ degrees but less than 360° in

order to maintain the mean asymmetry of the jets produced by the nozzles. The motor 34 of the boring head can be controlled accordingly.

In the embodiment shown in Figures 3A and 3B, the boring tool which is referenced 24b has three cutting members 60 and three nozzles 62a, 62b, and 62c for injecting liquid under pressure. The injection nozzles 62a and 62c are closed continuously while the nozzle 62b is open continuously. It would be equally possible to provide a tool having only one nozzle. It will be understood that when the boring tool is fed with fluid under pressure, the resulting overall jet in the static state, i.e. when the tool is not rotating, is asymmetrical about the axis X-X' of the boring tool. This makes it possible to cause the tool to be deflected as shown in Figure 3B. To enable the various cutting members 60 to enter into action, the tool can be caused to rotate in alternation F through an angle equal to 120° . This rotation enables the cutting members to act over 360° but does not interfere with the mean asymmetry of the overall jet of liquid under pressure produced by the nozzle 62b. More generally, if the tool has n cutting members 40, the alternating rotation should correspond to an angle of not less than $360/n$ degrees in order to ensure that cutting takes place over 360° . The angle of alternating rotation must comply with the condition that the mean distribution of the jet(s) of liquid under pressure must remain asymmetrical. This angle is therefore necessarily less than 360° .

In contrast, whenever the tool is not being deflected, it can be caused to rotate continuously under the control of the boring head 20. On average, the single jet produced by the nozzle 62b occupies all possible angular positions around the axis X-X' during one complete revolution. It is also possible to cause the tool to rotate in alternation through plus or minus 360° .

Naturally, the number of active nozzles injecting liquid into the borehole can be other than one.

5 It suffices that the number of active nozzles and the angular disposition thereof about the longitudinal axis of the tool ensures that the jets are asymmetrical about said axis.



CLAIMS

1. An assembly for boring in the ground by injecting fluid under pressure, the assembly comprising:
- a plurality of interconnected boring rods (22)
- 5 including means forming a pipe for a fluid under pressure (28, 30), said rods forming a bore string;
- a boring head (20) for controlling the movement of said bore string in rotation and in vertical translation;
 - a boring tool (24) fixed to the bottom end of said
- 10 bore string, said tool having a body (40) presenting a longitudinal axis extending the axis of the bore string, a bottom end (42) provided with a plurality n of cutting members and means for creating a jet of fluid under pressure to break up the ground, means for coupling the
- 15 pipe-forming means to the jet-creation means, and means for imparting a mean distribution to said jet that is not symmetrical about said longitudinal axis of said tool; and
- means for feeding said pipe-forming means under a
- 20 pressure that is sufficient for the jet that is produced actually to break up the ground.
2. A boring assembly according to claim 1, characterized in that the means for creating a jet of fluid under
- 25 pressure comprise q injection nozzles (46) distributed generally symmetrically about the longitudinal axis of said tool, and in that it includes means (56) for causing the feed to some of said nozzles to be interrupted temporarily in such a manner that said r nozzles that are
- 30 being fed produce a distribution that is not symmetrical about the longitudinal axis of said tool.
3. A boring assembly according to claim 1, characterized in that said means for creating a jet of fluid under
- 35 pressure comprise q nozzles (62) for injection under pressure, said q nozzles being distributed in generally asymmetrical manner about the longitudinal axis of said



tool, and in that the assembly further comprises means for feeding said nozzles simultaneously.

4. An assembly according to claim 2 for boring in the
5 ground by injecting a fluid under pressure, the assembly
being characterized in that said boring tool (24a) has n
cutting members (44), and in that during deflection
stages, only r of said nozzles, where $r \leq n$, are fed with
fluid under pressure and the boring head (20) is
10 controlled so as to cause the bore string to rotate in
alternation in one direction and in the other through an
angle of not less than $360/n$ degrees and less than 360° .
5. An assembly according to claim 3 for boring in the
15 ground by injecting fluid under pressure, the assembly
being characterized in that said boring tool comprises n
cutting members (60) where $n \geq q$, and in that the boring
head is controlled to cause the bore string to rotate
continuously in a single direction or to rotate in
20 alternation through plus or minus 360° during stages of
boring without deflection, and in that said boring head
is controlled to cause the bore string to rotate in
alternation in one direction and in the other through an
angle of not less than $360/n$ degrees and less than 360°
25 during deflection stages.