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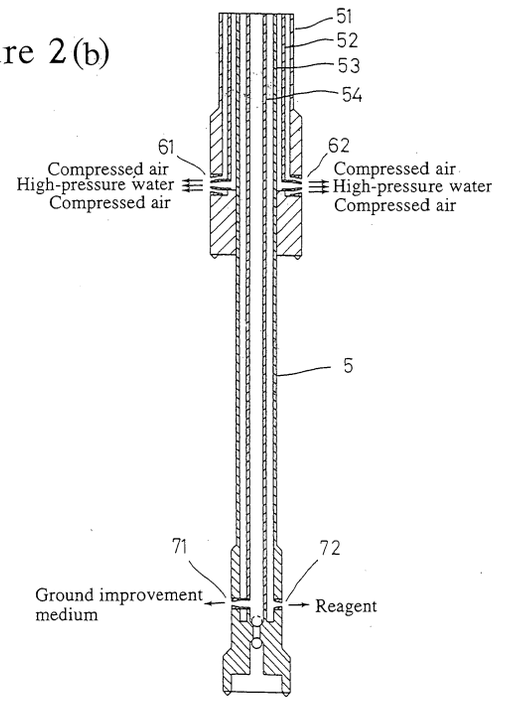
(54) Boring method and apparatus

(57) A boring method that is able to construct piles of a prescribed diameter and enables mud waste generated in the formation process to be disposed of as surplus earth. Upper and lower jetting units with jetting nozzles are provided on the lower end of a multi-cylinder rod. Compressed air and water are jetted from the upper jetting unit (61,62) to cut a ground improvement region and drain away mud waste produced in the process. The lower jetting unit (71,72) has jetting nozzles oriented in mutually opposite directions. One nozzle jets into cement milk into the ground to harden the earth, and the other nozzle supplies a reagent that hardens the cement milk, to accelerate the ground hardening and construct a pile of the prescribed diameter.

Figure 2(b)



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Description

Technical Field of the Invention

[0001] This invention relates to a boring method and apparatus able to construct piles of a prescribed diameter and enables mud waste generated in the formation process to be disposed of as surplus earth.

Background Art

[0002] When building structures and carrying out earthworks on ground that is soft, the ground is first improved prior to the construction work. Usually this is done by impregnating the earth with a material that hardens the ground.

[0003] There are various methods for improving the ground. One method that uses high-pressure delivery and mixing-agitation is widely employed due to its good workability and the fact that it can be reliably applied to a wide range of hardening. The method uses an apparatus called a boring machine.

[0004] The boring machine comprises a body unit, also called the bore unit, that raises, lowers and rotates a spindle, a multi-cylinder rod that supports the spindle, a high-pressure pump for high-pressure delivery of the ground hardening material that has been mixed by a mixer and agitator, a hydraulic unit that operates the high-pressure pump, a compressor that entrains air into the ground hardening material delivered by the high-pressure pump, and a water tank from which water is pumped to the mixer. As the multi-cylinder rod is rotated and raised by the bore unit, the mixture of hardening material and air is expelled at high pressure from nozzles provided on a monitor portion at the lower end of the rod.

[0005] In this way, there are formed pillar-shaped agitated portions of earth and hardener which harden to form solid piles in the ground. Earth that is displaced by the hardening material is ejected as mud.

[0006] Patent Document No. 1: Patent No. 2717503

[0007] Patent Document No. 2: Patent No. 2844184

[0008] In accordance with this method, the earth and the ground hardening material are mixed by the hardener material and air being jetted into the ground from nozzles, which gives rise to an air-junction effect that causes the cement milk used as the ground hardener to be sucked out of the borehole. Thus, a portion of the hardener material in the ground is sucked out of the borehole before it hardens.

[0009] Thus, since there is not enough hardener material to produce a pile having the required diameter, the ground is not impregnated with the hardener to a sufficient distance so the pile thus formed has a diameter that is smaller than the planned diameter. Moreover, the mud discharged from the borehole together with the cement milk has to be treated as industrial waste, making the site work more complicated and costly.

Summary of the Invention

[0010] This invention was accomplished to overcome these shortcomings of the prior art by providing a boring method and apparatus able to promote hardening of the ground hardener and prevent outflow of ground hardener material to thereby construct piles of a prescribed diameter and enable mud waste generated in the formation process to be disposed of as surplus earth.

[0011] For achieving these objects, a first aspect of the invention provides a boring method for improving ground and constructing a pile of a prescribed diameter in which a multi-cylinder rod is advanced into the ground and rotated and raised from its position in the ground while the ground is agitated by high-pressure jets of a ground improvement medium having cement milk as its main component from nozzles provided on the multi-cylinder rod, said method comprising:

providing upper and lower jetting units with jetting nozzles on a lower end of the multi-cylinder rod,
jetting compressed air and water from the upper jetting unit to cut a ground improvement borehole region within a prescribed formation length and drain away to the surface, via the borehole, mud waste thus produced,
providing the lower jetting unit with first and second jetting nozzles oriented in mutually opposite directions, using the first nozzle to jet into the ground improvement region a ground improvement medium having cement milk as its main component, and using the second nozzle to jet into the ground improvement region a reagent that hardens the cement milk from the first nozzle to accelerate ground hardening and construction of a pile of the prescribed diameter.

[0012] A second aspect of the invention provides a boring method, wherein the ground improvement region is cut by jetting compressed air and water from the upper jetting nozzles until the lower jetting unit reaches the ground improvement region, after which the ground improvement medium is jetted from the first nozzle of the lower jetting unit and the reagent is jetted from the second nozzle.

[0013] A third aspect of the invention provides a boring method, wherein the reagent is water-glass based sodium silicate.

[0014] The invention also attains the above objects by providing a boring apparatus for improving ground and constructing a pile of a prescribed diameter in which a multi-cylinder rod is advanced into the ground and rotated and raised from its position in the ground while the ground is agitated by high-pressure jets of a ground improvement medium having cement as its main component from nozzles provided on the multi-cylinder rod, said apparatus comprising:

upper and lower jetting units with jetting nozzles provided on a lower end of the multi-cylinder rod, nozzles provided on the upper jetting unit that jet compressed air and water,

first and second jetting nozzles oriented in mutually opposite directions provided on the lower jetting unit, the first nozzle supplying a ground improvement medium having cement milk as its main component, and the second nozzle supplying a reagent that hardens the cement milk from the first nozzle.

[0015] In accordance with another aspect of the boring apparatus, the nozzle from which the ground improvement medium is jetted is positioned higher than the nozzle from which the reagent is jetted.

Brief Description of Drawings

[0016]

Figure 1 shows an aspect of a boring apparatus that uses the method of the invention.

Figure 2 (a) shows a horizontal cross-sectional view of the monitor portion of the boring apparatus, and Figure 2 (b) shows a vertical cross-sectional view.

Figure 3 illustrates the operating sequence of the boring method.

Figure 4 also illustrates an operating sequence of the boring method.

Figure 5 also illustrates an operating sequence of the boring method.

Figure 6 also illustrates an operating sequence of the boring method.

Figure 7 (a) shows a horizontal cross-sectional view of the monitor portion according to another aspect, and Figure 7 (b) shows a vertical cross-sectional view.

Best Modes for Carrying out the Invention

[0017] Embodiments of the invention will now be described with reference to the drawings. Figure 1 shows a boring machine that uses the method of the invention, and Figures 2 (a) and (b) show the monitor portion of the boring machine. In Figure 1, boring machine 1 includes a drive unit 2 that incorporates a hydraulic pump, and a bore unit 4 that raises and lowers and rotates a multi-cylinder rod 3. The lower end of the multi-cylinder rod 3 is coupled to a monitor section 5. As shown in Figure 2 (a) and (b), the monitor section 5 is composed of four cylinders 51, 52, 53 and 54 that are concentrically associated with the multi-cylinder rod 3 and are raised, lowered and rotated with the rod 3. The upper and lower parts of the monitor section 5 are each provided with pairs of nozzles 61 and 62, and 71 and 72; the upper and lower nozzles are, for example, spaced 1 to 2 meters apart.

[0018] The upper nozzles 61 and 62 are provided on the outer cylinders 51 and 52 of the monitor section 5, and the lower nozzles 71 and 72 are provided on the inner cylinders 53 and 54. The upper nozzles 61 and 62 are provided facing away from each other on opposite sides of the monitor section 5, and are used to supply water under very high pressure from between the cylinders 52 and 53, and compressed air from between the cylinders 51 and 52.

[0019] The inner cylinders 53 and 54 extend further downwards than the outer cylinders 51 and 52. The nozzle 71 is in communication with the inside of the cylinder 54 to supply a ground improvement medium in which the main component is cement. The nozzle 72 is in communication with the space between the cylinders 53 and 54 to supply a reagent that hardens a ground improvement medium in which the main component is cement milk. Water-milk based sodium silicate can be used as the reagent that hardens the cement milk. For this, a solution can be prepared in which the ratio of sodium silicate to water is 30 to 50%.

[0020] Constructing a pile by the boring method of the invention will now be described.

[0021] The multi-cylinder rod 3 is used to bore a hole of a prescribed depth in the ground 8. Then, the multi-cylinder rod 3 is rotated as it is raised at a prescribed speed, for example 1 meter each 15 or 16 minutes. While this is happening, jets of compressed air and high-pressure water 9 are emitted from the upper nozzles 61 and 62, cutting the ground 8, as shown in Figure 3. The lifting effect around the rod 3 causes mud waste 10 produced by the cutting of the ground 8 to be discharged from the borehole 11 to the surface.

[0022] At this stage, the cement-based ground improvement medium and the reagent are not yet sprayed from the nozzles 71 and 72. When the lower nozzles 71 and 72 reach the depth at which the upper nozzles 61 and 62 start jetting, ground improvement medium 12 having cement milk as the main component starts jetting into the agitated ground 81 from the lower nozzle 71, and at the same time a reagent 13 that hardens the cement milk starts jetting from the lower nozzle 72 (Figure 4). The reagent 13 jetted from the nozzle 72 is water-glass based sodium silicate, and it is jetted into the ground continuously or at intervals.

[0023] Compressed air and high-pressure water 9 jetting from the upper nozzles 61 and 62 cut the ground 81 as the ground improvement medium 12 and water-glass based sodium silicate reagent 13 are jetted from the nozzles 71 and 72, respectively (Figure 5). The hardening of the ground improvement medium 12 is accelerated by the reagent 13. While this is happening, the monitor section 5 is being rotated and gradually raised with the multi-cylinder rod 3. Mud waste 10 flowing up out of the borehole 11 does not include ground improvement medium, and can therefore be treated as ordinary surplus earth.

[0024] When the upper nozzles 61 and 62 reach the upper end of the ground improvement region, the jetting

of compressed air and high-pressure water 9 from the nozzles is stopped, following which the lower nozzles 71 and 72 are raised to the ground improvement region, jetting the ground improvement medium 12 and reagent 13 (Figure 6). At that stage, mud discharged from the borehole is treated as industrial waste.

[0025] In this way, hardening of the cement milk constituting the ground improvement medium 12 jetted from the lower nozzle 71 is accelerated by the reagent 13 jetted from the lower nozzle 72. This prevents an air junction from forming, so there is no outflow of the ground improvement medium 12. Thus, with the hardening of the ground improvement medium 12 being accelerated by the reagent 13, preventing any outflow of the ground improvement medium, the ground is fully impregnated, enabling the construction of a large-diameter 82.

[0026] A monitor section 15 according to another aspect of the invention is illustrated by Figure 7, in which other parts that are the same as those in Figure 2 have been given the same reference numerals. In the case of this monitor section 15, nozzles 71 and 72 are located at different heights so that jetting of the reagent 13 from the nozzle 72 takes place a set time after the ground improvement medium 12 is jetted from the nozzle 71. To some extent, this ensures that the reagent 13 is fully mixed with the ground improvement medium 12.

[0027] It is to be understood that the invention is not limited to the aspects described in the foregoing. For example, while in the foregoing reagent used to harden the cement milk is water-glass based sodium silicate, another reagent can be used instead. This is just one example of how the gist of the invention can be changed and modified to the extent that such changes and modifications do not depart from the scope of the invention.

Claims

1. A boring method for improving ground and constructing a pile of a prescribed diameter in which a multi-cylinder rod is advanced into the ground and rotated and raised from its position in the ground while the ground is agitated by high-pressure jets of a ground improvement medium having cement milk as its main component from nozzles provided on the multi-cylinder rod, said method comprising:

   providing upper and lower jetting units with jetting nozzles on a lower end of the multi-cylinder rod,
   jetting compressed air and water from the upper jetting unit to cut a ground improvement borehole region within a prescribed formation length and drain away to the surface, via the borehole, mud waste thus produced,
   providing the lower jetting unit with first and second jetting nozzles oriented in mutually opposite directions,
   using the first nozzle to jet into the ground improvement region a ground improvement medium having cement milk as its main component, and
   using the second nozzle to jet into the ground improvement region a reagent that hardens the cement milk from the first nozzle to accelerate ground hardening and construction of a pile of the prescribed diameter.

2. A boring method according to the first aspect, wherein the ground improvement region is cut by jetting compressed air and water from the upper jetting nozzles until the lower jetting unit reaches the ground improvement region, after which the ground improvement medium is jetted from the first nozzle of the lower jetting unit and the reagent is jetted from the second nozzle.

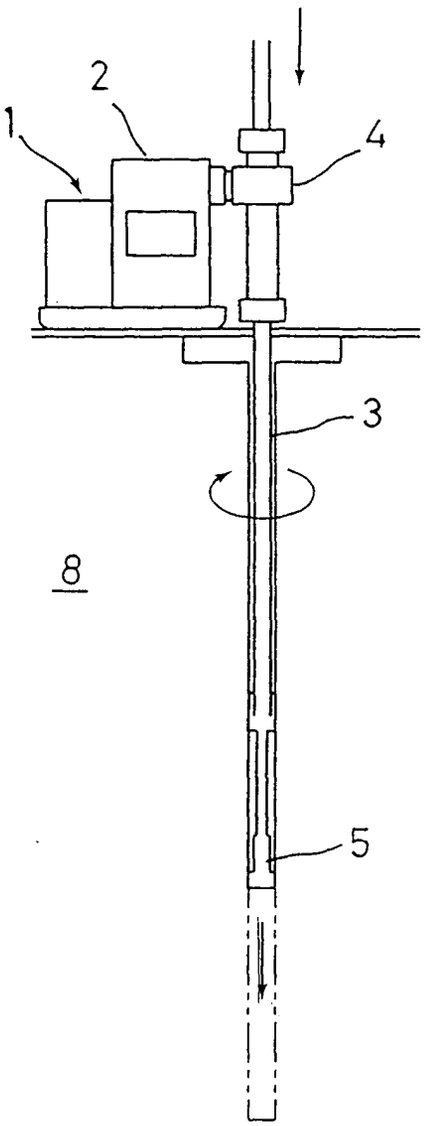
3. A boring method according to the first aspect, wherein the reagent is water-glass based sodium silicate.

4. A boring apparatus for improving ground and constructing a pile of a prescribed diameter in which a multi-cylinder rod is advanced into the ground and rotated and raised from its position in the ground while the ground is agitated by high-pressure jets of a ground improvement medium having cement as its main component from nozzles provided on the multi-cylinder rod, said apparatus comprising:

   upper and lower jetting units with jetting nozzles provided on a lower end of the multi-cylinder rod, nozzles provided on the upper jetting unit that jet compressed air and water,
   first and second jetting nozzles oriented in mutually opposite directions provided on the lower jetting unit, the first nozzle supplying a ground improvement medium having cement milk as its main component, and the second nozzle supplying a reagent that hardens the cement milk from the first nozzle.

5. A boring apparatus according to claim 4, wherein the nozzle from which the ground improvement medium is jetted is positioned higher than the nozzle from which the reagent is jetted.

Figure 1



① Boring

Figure 2(a)

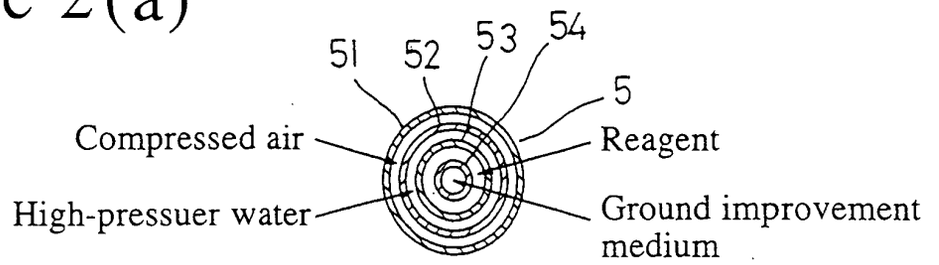


Figure 2(b)

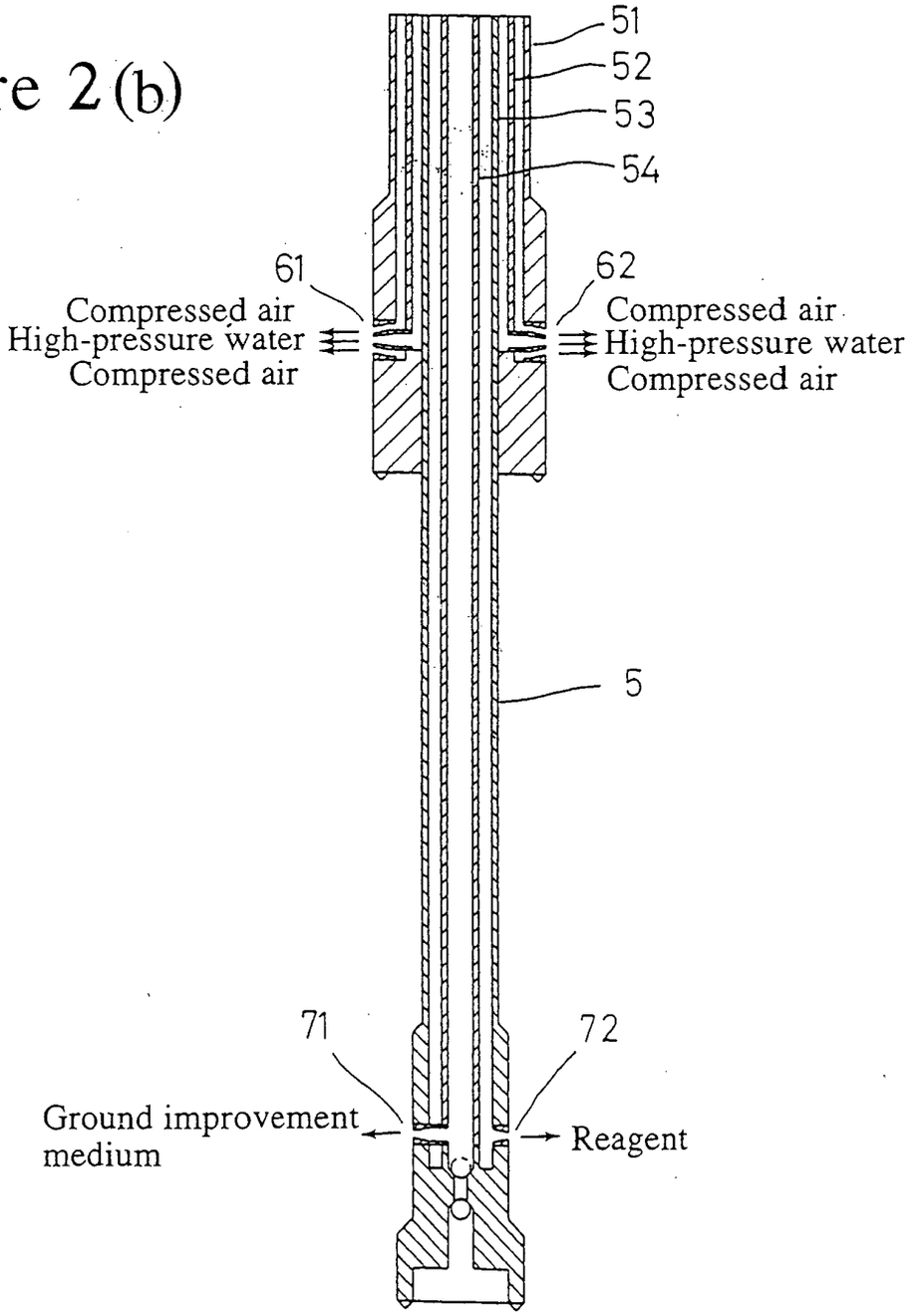
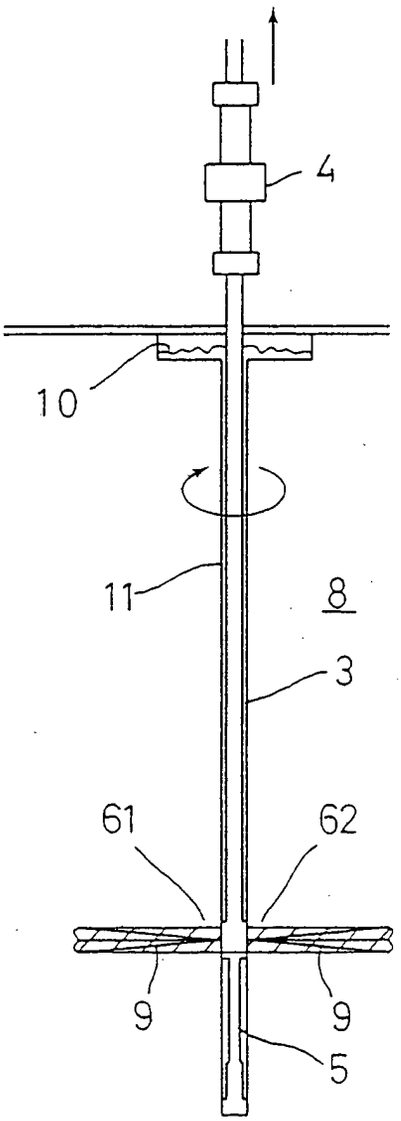


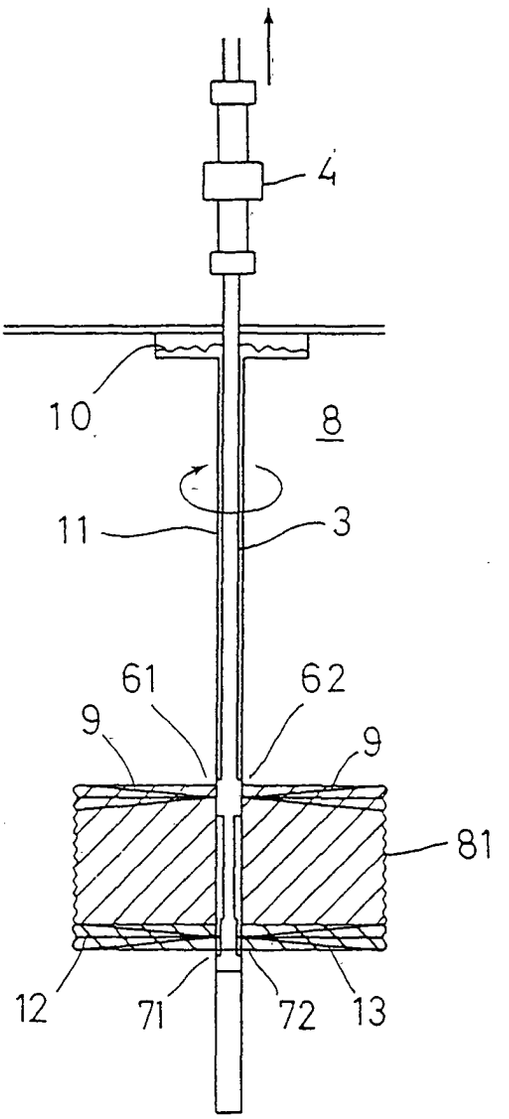
Figure 3



② Cutting

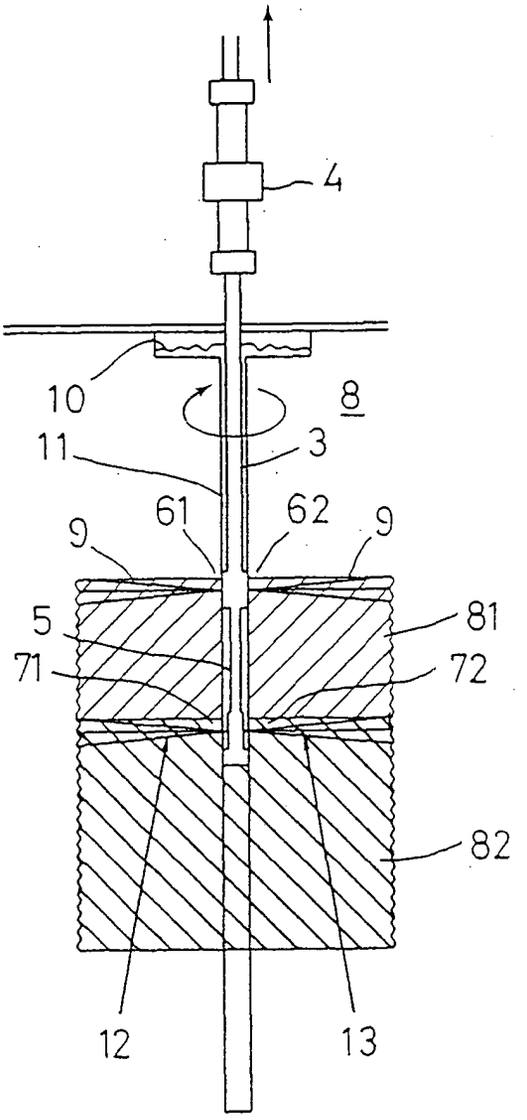
Upper end : High-pressure water and compressed air

Figure 4



③ Start of formation
Upper end : High-pressure water
and compressed air
Lower end : Ground improvement medium
Reagent

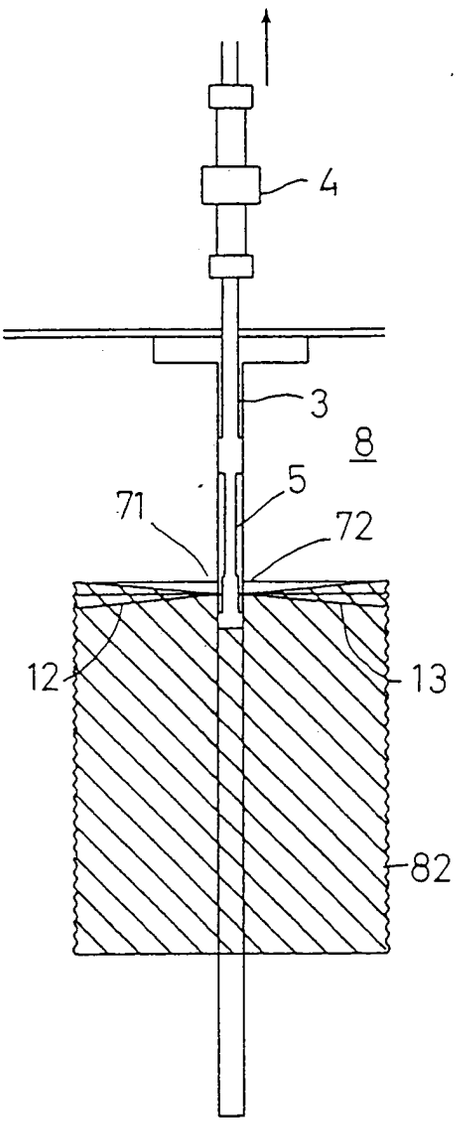
Figure 5



④ Completion of cutting

Upper end : High-pressure water
and compressed air
Lower end : Ground improvement medium
Reagent

Figure 6



⑤ Formation completion
Lower end : Ground improvement medium
Reagent

Figure 7(a)

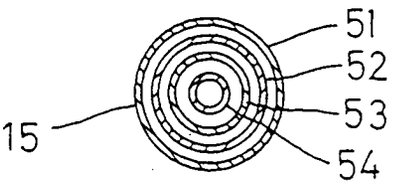


Figure 7(b)