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(54) GROUND IMPROVING METHOD

BODENVERBESSERUNGSVERFAHREN

PROCÉDÉ D'AMÉLIORATION DU SOL

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Description

TECHNICAL FIELD

[0001] The present invention relates to a technology of improving ground which forms an underground consolidated body by cutting a ground to be improved by injecting a cutting fluid thereto, feeding a solidification material, mixing a cut ground, the cutting fluid and the solidification material and agitating a mixture thereof.

BACKGROUND

[0002] One example of a method for improving ground in prior art (e.g. Patent Document 1) will be described hereinafter with reference to Fig. 8.

[0003] In Fig. 8, a rod-shaped jet device 11 is inserted into a drilling hole HD drilled in a ground G to be improved. The jet device 11 is provided with inject nozzles N for injecting a cutting fluid jet J to a side face in order to inject a jet flow of a cutting fluid (J: a cutting fluid jet) such as high-pressure water to an underground G. A plurality of inject nozzles N are provided at a point symmetrical with respect to a central axis CL of the jet device 11 (e.g. two inject nozzles shown in Fig. 8), and positions in a vertical direction of a plurality of the inject nozzles N (positions in upward and downward directions in Figs. 8 and 11) are the same.

[0004] The jet device 11 is provided with a flow passage for a cutting fluid (a pipe for a cutting fluid: not shown) inside thereof. A cutting fluid is fed from a feed device provided above the ground (not shown) to the flow passage for a cutting fluid in the jet device 11. The cutting fluid is injected as a cutting fluid jet J from the inject nozzles N in an outward radial direction (in a horizontal direction).

[0005] In Fig. 8, the jet device 11 is slowly pulled up above the ground (in an upward direction in Fig. 8) by injecting the cutting fluid jet J underground and rotating the jet device 11 in e.g. an arrowed direction R. Accordingly, the ground G is cut by the cutting fluid jet J, and an in-situ soil and the cutting fluid are mixed to form a diameter-expanded cutting hole HC having an inner wall surface W.

[0006] Meanwhile, a solidification material (e.g. cement) is delivered from a discharge port (not shown) provided around a lower end portion of the jet device 11 via a solidification material flow passage (not shown) in the jet device 11. Accordingly, the solidification material is mixed with a cut in-situ soil to form an underground consolidated body (not shown) by delivering the solidification material to said diameter-expanded cutting hole HC. Herein, cases where the solidification material is injected in an outward radial direction like the cutting fluid jet J or together therewith are considered as an example.

[0007] When the cutting fluid jet J cuts the ground G, slime is generated as a mixture of the cut in-situ soil and the cutting fluid. The slime, as shown in an arrowed direction AD, is discharged above the ground through a space S (a circular space) between the jet device 11 and an inner wall surface of the drilling hole HD.

[0008] Fig. 9 shows all flow lines of the cutting fluid jet J when the jet device 11 is pulled up by rotating the same a plurality of times on the same cross section in the ground G cut by the cutting fluid jet J. As shown in Fig. 9, all the flow lines of the cutting fluid jet J are expressed as a plurality of lines L extending parallel to each other at a predetermined interval of P/2 (P is a pitch defined as the amount of pulling up the jet device 11 while it is rotated one time) . In Fig. 9, since the cutting fluid jet J is injected from two nozzles N, the interval of flow lines of the cutting fluid jet J is 1/2 of the pitch P.

[0009] In Fig. 9, an in-situ soil (ground, bedrock, rock, etc.) found in a plurality of cutting fluid jets J extending parallel to each other at a predetermined interval (1/2 of pitch P) is cut by the jet J, the cut in-situ soil is mixed with a cut fluid and discharged above the ground as slime.

[0010] However, since the jet J is not injected to a region between a plurality of the cutting fluid jets J (at an interval of P/2), as shown in Fig. 10, a clod M whose representative size is large (the biggest size out of a size in a longitudinal direction, a size in a lateral direction and a size in an elevational direction) is not cut and remains in a region between a plurality of jets J ejected parallel to each other.

[0011] If the large clod M is not cut and remains in the ground, as shown in Fig. 11, it is difficult for the large clod M to pass a gap S (a circular space) between an inner wall surface of a drilling hole HD and the jet device 11. Accordingly, blocking of the gap S (the circular space) will prevent slime from being discharged above the ground.

[0012] Therefore, in the above described method for improving ground, a technology for preventing cutting of a clod M whose representative size is large to remain in the ground is being desired. Unfortunately, such a technology (a technology for preventing cutting of a clod M whose representative size is large to remain in the ground) has not been proposed yet.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0013] Patent Document 1: JP-A-7-76821

[0014] Documents JP 2013 036213 A, JP 2001 115442 A, JP H10204875A, JP H07109726 A disclose the use of two nozzles for ejecting the relevant fluid or material underground. In JP 2013 036213 A, the first nozzle and the second nozzle 3 are used for injecting hardening material liquid which is equivalent to the solidification material in the claimed invention. In JP 2001 115442 A, nozzles are used to eject either the fluid for cutting the ground or the ground improvement material for hardening the ground. Similarly, JP H10204875A and JP H07109726 A disclose the use of two nozzles.

[0015] Document GB 2227 037 A discloses the use of an upper injection means, a lower injection means and an auxiliary injection means. The upper injection means is designed for injecting super high pressure water and gas. The lower injection means is designed for injecting super high pressure ground hardening material and gas. The auxiliary injection means is for injecting only the super high pressure ground hardening material for increasing injection efficiency.

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0016] The present invention was made in view of the above situation, and has an object to provide a method for improving ground capable of preventing a clod whose representative size is large from remaining in the ground.

MEANS FOR SOLVING THE PROBLEM

[0017] The method for improving ground of the present invention comprises the steps of: cutting a ground by injecting a cutting fluid (e.g. high-pressure water or high-pressure air: including a case where a solidification material is injected) from jet devices (1, 10); feeding a solidification material; mixing a cut ground (G), the cutting fluid and the solidification material; and agitating a mixture thereof to form an underground consolidated body, wherein a plurality of nozzles (N1, N2) are located at an interval in a vertical direction in the jet devices (1, 10), and when the cutting fluid is injected, a cutting fluid (a cutting fluid jet J1) is injected from an upward nozzle (N1) in a downward skewed direction, and a cutting fluid (a cutting fluid jet J2) is injected from a downward nozzle (N2) in an upward skewed direction.

[0018] The method for improving ground according to the present invention preferably comprises a step of adjusting the angle of the nozzles (N1, N2) (θ: the inject angle of jets J1 and J2) .

[0019] In addition, the method for improving ground of the present invention preferably comprises a step of adjusting the interval V between the nozzles (N1, N2) in a vertical direction.

[0020] In the present invention, it is preferable that a partition forming material (jets J1, J2) is injected from an upward direction of the jet device (10) as a cutting fluid, and a solidification material (jets J3, J4) is injected from a downward direction of the jet device (10).

EFFECT OF THE INVENTION

[0021] The method for improving ground of the present invention comprising the above steps can provide a construction in which a plurality of nozzles (N1, N2) are located at an interval in a vertical direction, a cutting fluid (jet J1) is injected from the upward nozzle (N1) in a downward skewed direction and a cutting fluid (jet J2) is injected from the downward nozzle (N2) in an upward skewed direction. Accordingly, the method for improving ground can provide a shape for flow lines of cutting fluids (jets J1, J2) injected for a certain period of time on a plane at an optional position (Figs. 2 and 9: a plane containing a central axis CL of a jet device 1 and extending in a radial direction and a vertical direction: found in all directions at 360° degrees with respect to the central axis CL of the jet device 1) so that a plurality of straight lines (J1, J2) parallel to each other extending in a skewed direction intersect each other.

[0022] Therefore, even if a region (a clod G) which cannot be cut by a cutting fluid jet (J) is found instantaneously, the clod (G) is thereafter cut by another cutting fluid jet (a jet J1 or J2). In other words, even if a large clod (G) remains in the ground after it cannot be cut by a cutting fluid jet (a jet J1 or J2) instantaneously, the clod (G) is assuredly cut by any flow line of a cutting fluid jet (a jet J1 or J2).

[0023] Thus, according to the present invention, an extensive presence of a region (a clod G) which is not cut by jet flows (jets J) of a cutting fluid is prevented. Also, the method for improving ground of the present invention prevents a clod (G) whose representative size is large from extending parallel to flow lines of the jet flow (the jets J) of the cutting fluid and remaining in the ground, and it is possible to prevent a region (a clod M) which is not cut by a cutting fluid jet (J) from becoming too large (i.e. prevent the representative size from becoming too large).

[0024] Accordingly, the maximum size of the clod (M) which is not cut to remain in the ground becomes smaller and readily passes a gap S (a circular space) between a jet device (1) and an inner wall surface of a drilling hole (HD). Specifically, this means that the maximum size of the clod (M) which is not cut to remain in the ground does not prevent slime from being discharged above the ground.

[0025] In a case that the method for improving ground of the present invention is constructed so as to make the angle of nozzles (N1, N2) (θ: the inject angle of jets J1 and J2) is adjustable, it is possible to cut a construction ground (G) by using an efficient cutting diameter (D) according to the type of soil on the construction ground (G).

[0026] In the present invention, in a case it is constructed that the interval (V) in a vertical direction between the nozzles (N1, N2) is adjustable, it is possible to adjust a pitch (P) between flow lines of a jet flow (J) of a cutting fluid, and it is thus possible to adjust the maximum size of the clod (M) which is not cut by the jet flow (J) of the cutting fluid to remain in the ground according to the state of a construction site.

[0027] In the present invention, a partition forming material (jets J1, J2) is injected from an upward nozzle of a jet device (10) as a cutting fluid, and a solidification material (jets J3, J4) is injected from a downward nozzle of the jet device (10). Accordingly, a layer of the partition forming material (a separation layer LD) obtained by mix-

ing the partition forming material and a cut in-situ soil is formed upward, and a layer of the solidification material (LC) obtained by mixing the partition forming material, the cut in-situ soil and the solidification material is formed downward.

[0028] Thus, only a mixture of the partition forming material and the soil in the separation layer (LD) composed of the partition forming material is discharged above the ground as slime (a mixture of the partition forming material and the cut soil), and a rich-mixed solidification material in the layer of the solidification material (LC) is hardly discharged above the ground. Since the solidification material is not discharged above the ground, waste of a solidification material is reduced and the amount of slime to be treated as an industrial waste in a dedicated plant is reduced.

[0029] Also, since the solidification material (jets J3 and J4) is injected from the downward nozzle of the jet device (10), a mixture of the in-situ soil (clay) and the partition forming material is favorably mixed with the solidification material, even if the viscosity of the in-situ soil (e.g. clay) is high.

BRIEF DESCRIPTION OF DRAWINGS

[0030]

Fig. 1 is a schematic view showing a first embodiment of the present invention;
Fig. 2 is a schematic view showing the state in which a ground is cut;
Fig. 3 is a schematic view showing an example of a structure for adjusting the inject angle of a nozzle;
Fig. 4 is a schematic view showing an example different from a structure for adjusting the inject angle of a nozzle;
Fig. 5 is a schematic view showing one example of a structure for adjusting the interval of a nozzle;
Fig. 6 is a schematic view showing an example different from a structure for adjusting the interval of a nozzle;
Fig. 7 is a schematic view showing an embodiment of the present invention;
Fig. 8 is a schematic view showing a method for improving ground in prior art;
Fig. 9 is a schematic view showing the state in which a ground is cut by the method for improving ground in prior art;
Fig. 10 is a schematic view showing one example of a cut clod by the method for improving ground in prior art; and
Fig. 11 is a schematic view showing a problem in the method for improving ground in prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0031] An embodiment of the present invention will be described hereinafter, with reference to drawings of Figs. 1 to 7.

[0032] First, an example will be described with reference to Figs . 1 to 6.

[0033] In a prior art shown in Figs. 8 and 11, a pair of nozzles N have a common position in a vertical direction (in upward and downward directions in Figs. 8 and 11), and a cutting fluid (e.g. high-pressure water: a jet flow (a cutting fluid jet J) that can contain a solidification material) is injected in a horizontal direction.

[0034] Meanwhile, according to an embodiment shown in Figs. 1 to 6, the positions of nozzles N1, N2 in a vertical direction (in upward and downward directions in Fig. 1) are different, and a cutting fluid jet J is injected in a skewed direction with respect to a horizontal direction.

[0035] In Fig. 1, a rod-shaped jet device 1 for injecting a jet flow J (a cutting fluid jet) of a cutting fluid (e.g. high-pressure water) is inserted into a drilling hole HD drilled in a ground G to be improved.

[0036] The jet device 1 is provided with nozzles N1 and N2 on a side face thereof, and cutting fluid jets J1, J2 are injected from the nozzles N1 and N2. In this description, the jets J1 and J2 are collectively referred to as a jet J.

[0037] The nozzles N1 and N2 are disposed at an interval V in a vertical direction (in upward and downward directions in Fig. 1) .

[0038] In Fig. 1, a symbol CL represents a central axis of a jet device 1.

[0039] The cutting fluid jet J1 is injected from the upward nozzle N1 in a downward skewed direction relative to a horizontal direction, and a inject direction of the cutting fluid jet J1 is downward inclined by an angle θ with respect to a horizontal direction HO. The horizontal direction HO is a direction vertically extending with respect to a central axis CL of the jet device 1.

[0040] On the other hand, the cutting fluid jet J2 is injected from the downward nozzle N2 in an upward direction relative to the horizontal direction, and a inject direction of the cutting fluid jet J2 is upward inclined by an angle θ with respect to the horizontal direction HO.

[0041] In Fig. 1, a symbol D represents a cutting diameter of a region (a cutting hole HC) cut by jets J1 and J2, and the cut diameter of the cutting hole HC (the distance between the central axis CL of the jet device 1 and an inner wall of the cutting hole HC) is D/2.

[0042] It is possible to employ a known device for the jet device 1, and a cutting fluid is introduced from a feed device (not shown) provided above the ground to the jet device 1, and flows through a flow passage for a cutting fluid (not shown) in the jet device 1, and cutting fluid jets J1 and J2 are injected from the nozzles N1 and N2 in an outward radial direction (underground).

[0043] The jet device 1 injects the cutting fluid jets J1 and J2 to cut a ground G, and is rotated as shown in an arrowed direction R and pulled up toward a ground surface (upward in Fig. 1: in an arrowed direction U).

[0044] The amount of pulling up the jet device 1 (the amount of moving jet device 1 in an arrowed U direction during one rotation) is represented by a symbol P.

[0045] The ground G is cut by the cutting fluid jets J1 and J2 to form the cutting hole HC. As the ground G is cut, a solidification material (e.g. cement fluid) is delivered from a discharge port (not shown) provided around a lower end portion of the jet device 1 via a solidification material flow passage (not shown) in the jet device 1. Accordingly, the solidification material is mixed with an in-situ cut soil and a cutting fluid (e.g. high-pressure water) and filled in the cutting hole HC and then solidified to form an underground consolidated body (not shown).

[0046] In Fig. 1, slime generated when cutting the ground, as indicated by an arrowed direction AD, is discharged above the ground via a gap S (a circular space) between the jet device 1 and an inner wall surface of the drilling hole HD.

[0047] As described above, the nozzles N1, N2 are located at an interval V in a vertical direction. The cutting fluid jet J1 is injected from the upward nozzle N1 in a downward skewed direction, and the cutting fluid jet J2 is injected from the downward nozzle N2 in an upward skewed direction. For this purpose, when the jet device 11 is rotated on a cross section (an optional identical cross section) a plurality of times and pulled up, all flow lines of the cutting fluid jets J1, J2 are shown in Fig. 2.

[0048] Specifically, according to the first embodiment, flow lines of the cutting fluid jets J1 and J2 shown in Fig. 2 provide a shape obtained when a plurality of straight lines by the cutting fluid jet J1 (the same straight lines as the jet J1) parallel to each other extending from upper left to lower right and a plurality of straight lines by the cutting fluid jet J2 (the same straight lines as the jet J2) parallel to each other extending from lower left to upper right intersect on the right side of the jet device 1 in Fig. 2 on a cross section (an optional identical cross section).

[0049] Herein, the cross section (the optional identical cross section) refers to a plane containing a central axis CL (Fig. 1) of the jet device 1 in Figs. 1 and 2 and extending in a radial direction and a vertical direction (upward and downward directions in Fig. 2), which is found in the entire circumference at 360° degrees with respect to the central axis CL of the jet device 1.

[0050] The interval P (pitch) of a plurality of cutting fluid jets J1, J1 injected from upper left to lower right, or the interval P (pitch) of a plurality of jets J2, J2 injected from lower left to upper right on a plane on the right side of e.g. the jet device 1 in Fig. 2 refers to the amount of upward moving the jet device 1 during one rotation (the amount of pulling up the same), e.g. 2.5cm in the embodiment shown in the drawings.

[0051] In Fig. 2, the interval in upward and downward directions of the most downward flow line of the cutting fluid jet J1 and the most downward flow line of the cutting fluid jet J2 is equal to the distance V between the nozzles N1 and N2.

[0052] In Fig. 2, an in-situ soil (ground, bedrock, rock, etc.) found in flow lines of a plurality of the cutting fluid jets J1, J2 extending parallel to each other at a predetermined interval (pitch P) is cut by the cutting fluid jet.

[0053] An in-situ soil in a region not found on the flow lines of the cutting fluid jets J1, J2 or in a region α surrounded by the flow lines of the cutting fluid jets J1, J2 is not cut by the cutting fluid jets J1, J2. In Fig. 2, only one region α surrounded by the flow lines of the cutting fluid jets J1, J2 is shown by hatching.

[0054] Since the in-situ soil found in the region α is not cut by the cutting fluid jets J1, J2, the soil may remain in the ground while a clod M found in the region α is not cut.

[0055] However, on a cross section (an optional identical cross section) in Fig. 2, the largest clod which is not cut by the flow lines of a plurality of the cutting fluid jets J1, J2 on the cross section to remain in the ground corresponds to a clod M found in a rhombic region α in Fig. 2. The clod M found in the region α in Fig. 2 has a smaller representative size than those of clods shown in Figs. 10 and 11.

[0056] Since the clod M found in the region α in Fig. 2 has a smaller representative size, the clod M can readily pass a circular space S (Fig. 1) between the jet device 1 and the inner wall surface of the drilling hole HD together with slime. In other words, a clod M found in the region α in Fig. 2 whose representative size is small does not prevent the slime from being discharged above the ground.

[0057] Herein, main factors for determining a cutting diameter D of the cutting hole HC include the injection pressure of the cutting fluid jet J and the injection flow of the cutting fluid jet J. The number of cutting and the rotational speed of the jet device 1 also affect the cutting diameter D.

[0058] Inventors of the present invention found that a clay ground has a cutting diameter D of 4m or more, and a sand ground has a cutting diameter D of 5m or more.

[0059] In Fig. 1, the angle θ in the nozzles N1, N2 (the inject angle of jets J1, J2) is adjusted to adjust the injection pressure of said cutting fluid jet J and to determine the cutting diameter D.

[0060] As another parameter in addition to the above described parameters, the injection pressure of the cutting fluid jet J is a uniaxial compressive strength of soil in the construction ground G or more, for example, 300bar or more.

[0061] In addition, the injection flow Q of the cutting fluid jet J is expressed by an equation Q: Q=300 (liter/min.) $\times$ the number of nozzles.

[0062] In addition, the rotational speed of the jet device 1 is 5rpm, and the number of cutting is 1 to 2. Specifically, each time the jet device 1 is rotated half to one time, the jet device 1 is pulled up (or stepped-up).

[0063] In the embodiment shown in the drawings, as described above, the cutting diameter D can be determined by adjusting the angle θ in the nozzles N1, N2 (the inject angle of jets J1, J2) .

[0064] Consequently, in the embodiment shown in the drawings, the angle θ in the nozzles N1, N2 (the inject angle of jets J1, J2) can preferably be adjusted.

[0065] Figs. 3 and 4 show a structure for adjusting the

angle θ in nozzles N1, N2 (the inject angle of jets J1, J2).

[0066] First, the structure shown in Fig. 3 will be described.

[0067] Fig. 3 shows that a nozzle N1 is attached with respect to a central axis CL of a jet device 1. The jet device 1 includes a flow passage for a cutting fluid 1A, and a cutting fluid flows through the flow passage for a cutting fluid 1A. The cutting fluid is fed from a feed device above the ground (not shown), pressurized by a pressure device (not shown) and fed in an arrowed direction AB in Fig. 3 to be injected from the nozzle N1 and a nozzle N2 in an arrowed direction AC.

[0068] In Fig. 3, a symbol 1B represents a notch for providing a range of motion by adjusting the inject angle of the nozzle N1 provided at the jet device 1.

[0069] The structure for adjusting the inject angle shown in Fig. 3 is a structure for adjusting the inject angle of the nozzle N1, and includes a cover plate for adjusting a inject angle 2 and an insertion plate for adjusting a inject angle 3.

[0070] The cover plate for adjusting a inject angle 2 is a tabular body extending in upward and downward directions placed attached to the jet device 1 (only a casing of a pipe-shaped jet device 1 is shown in Fig. 3). An insertion portion 2A is provided at the jet device 1 of the cover plate for adjusting the inject angle 2 (on the left side of Fig. 3), and the insertion portion 2A is constructed so that the insertion plate for adjusting a inject angle 3 can be inserted. The insertion portion 2A forms an inner space of the cover plate for adjusting a inject angle 2, and a bottom portion 2B of the insertion portion 2A is an outer surface (an outer wall surface) of the casing of the jet device 1.

[0071] The size of the space formed by the insertion portion 2A in an elevational direction (a radial direction: right and left directions in Fig. 4) gradually decreases from an inlet thereof (a lower end portion of the cover plate for adjusting a inject angle 2) in an upward direction in Fig. 4. The angle (insertion angle) formed by the bottom portion 2B of the insertion portion 2A (the outer surface of the casing of the jet device 1) and an upper surface portion 2C of the insertion portion 2A is represented by a symbol φ1.

[0072] The cover plate for adjusting a inject angle 2 is pivotably supported with respect to a support shaft 2D of the jet device 1 around an upper end portion thereof, and is always energized by an energizing device (e.g. a spring) (not shown) in an arrowed direction F or in a direction for pressing the cover plate for adjusting a inject angle 2 on the jet device 1.

[0073] The nozzle N1 is fixed on said cover plate for adjusting a inject angle 2 to be integrally pivoted with the cover plate 2. Thus, when the cover plate for adjusting a inject angle 2 is pivoted from an initial position (when the cover plate for adjusting a inject angle 2 is pressed on an outer wall surface of the jet device 1: a position shown in Fig. 3) clockwise against said energizing force F, the nozzle N1 is pivoted around the support shaft 2D and pivoted in a direction for decreasing the inject angle θ.

[0074] The insertion plate for adjusting a inject angle 3 is overall a triangle pole body, comprising a bottom portion 3A which contacts with the outer wall surface of the jet device 1 and an upper surface portion 3B which gradually increases the thickness from an end portion toward a backward side (from upper to lower directions in Fig. 3). The angle of the end portion of the insertion plate for adjusting a inject angle 3 is represented by a symbol φ2. Herein, the relationship between the insertion angle φ1 of the insertion portion 2A of the cover plate for adjusting a inject angle 2 and the end portion angle φ2 of the insertion plate for adjusting a inject angle 3 is expressed by an equation: angle φ1 < angle φ2. Therefore, when the insertion plate for adjusting a inject angle 3 is inserted, the cover plate for adjusting a inject angle 2 and the nozzle N1 will be pivoted clockwise.

[0075] The insertion plate for adjusting a inject angle 3 can be inserted into the insertion portion 2A of the cover plate for adjusting a inject angle 2 (can be moved in an arrowed direction AE). By adjusting the amount of inserting the insertion plate for adjusting a inject angle 3 into the insertion portion 2A of the cover plate for adjusting a inject angle 2, the inject angle θ of the nozzle N1 can be adjusted when the cover plate for adjusting the inject angle 2 and the nozzle N1 are pivoted clockwise with respect to the support shaft 2D against an energizing force F.

[0076] Specifically, when the insertion plate for adjusting a inject angle 3 is inserted in a direction for pressing the same on the insertion portion 2A, the cover plate for adjusting a inject angle 2 and the nozzle N1 are pivoted clockwise to decrease the inject angle θ. Meanwhile, when the insertion plate for adjusting the inject angle 3 is moved in a direction so that it is removed from the insertion portion 2A, the cover plate for adjusting a inject angle 2 and the nozzle N1 are pivoted counterclockwise against the energizing force F to increase the inject angle θ.

[0077] While the method for adjusting the inject angle θ in the nozzle N1 is described above, the inject angle θ in the nozzle N2 can be adjusted according to the same structure.

[0078] Fig. 4 shows a structure for adjusting the inject angle different from the one shown in Fig. 3.

[0079] In Fig. 4, the center of the nozzle N1 in a inject direction is fixed on an output shaft 4A of a known stepping motor 4. The output shaft 4A of the stepping motor 4 is attached to the jet device (not shown) . An arrowed direction AC in Fig. 4 represents the inject direction of a cutting fluid jet J1.

[0080] In Fig. 4, by subjecting the stepping motor 4 to positive rotation or negative rotation by a proper angle, the nozzle N1 is pivoted by an optional central angle to adjust the inject angle θ of the nozzle N1.

[0081] The structure for adjusting the inject angle θ in Fig. 4 can be applied to the nozzle N2.

[0082] In the embodiment shown in the drawings, the

largest representative size of the clod M which is not cut by a cutting fluid jet J and instead is peeled off from a construction ground G is affected by the size of a pitch (a pitch for stepping up the jet device) represented by a symbol P in Fig. 2.

[0083] The pitch P is a parameter which varies according to the interval V in a vertical direction between the nozzles N1, N2. In other words, when the interval V in a vertical direction between the nozzles N1, N2 is adjusted, the pitch P can be adjusted.

[0084] Figs. 5 and 6 illustrate a structure for adjusting the interval V in a vertical direction between the nozzles N1, N2.

[0085] First, the structure in Fig. 5 will be described.

[0086] Fig. 5 is a schematic view showing an attaching portion of nozzles N1 and N2 of a jet device 1 viewed from a side face. The jet device 1 is divided into halves at a predetermined position (at a predetermined position in a vertical direction) between the nozzles N1, N2, and a spacer 5 of a thickness T is placed between the jet devices 101, 102 divided into halves.

[0087] Herein, an internal structure of the spacer 5 is the same as the jet devices 101 and 102, and fluid passages in the jet devices 101, 102 are connected by a fluid passage in the spacer 5 and connecting means (e.g. a swivel joint) (not shown) . Thus, the jet devices 101, 102 and the spacer 5 serve as a jet device to inject or deliver a cutting fluid (and a solidification material).

[0088] The jet devices 101, 102 and the spacer 5 are connected by a known technology (e.g. bonding, fastening means, etc.).

[0089] The interval V in a vertical direction between the nozzles N1, N2 can be adjusted by placing the spacer 5 between the jet devices 101 and 102.

[0090] If the interval V in a vertical direction between the nozzles N1, N2 is set at the minimum interval between the nozzles N1, N2 (the interval in a vertical direction) when the spacer 5 is not placed between the jet devices 101, 102, for example, the interval in a vertical direction between the nozzles N1, N2, is "V+T" when the spacer 5 is placed between the jet devices 101, 102.

[0091] Further, a plurality of spacers 5 having a different thickness T are prepared, and the range of the interval in a vertical direction between the nozzles N1, N2 can be adjusted accordingly.

[0092] Fig. 6 shows a structure for adjusting the interval V in a vertical direction different from the one in Fig. 5. In Fig. 6, the interval V in a vertical direction is adjusted by using a known rack and a pinion gear structure.

[0093] In Fig. 6, a rotating shaft 7A of a pinion gear 7 is attached to a jet device (not shown) to mesh with a rack 6. The rack 6 is fixed to the nozzle N1 to extend parallel to a central axis of the jet device 1 (Fig. 1). By subjecting the pinion gear 7 to positive rotation or negative rotation to move the rack 6 upward and downward, the nozzle N1 will move upward and downward. Accordingly, the interval in a vertical direction between the nozzles N1, N2 can be adjusted.

[0094] In Fig. 6, an arrowed direction AC represents a direction of a cutting fluid jet J1.

[0095] In addition, in Fig. 6 in which only the nozzle N1 is constructed to move upward and downward, only the nozzle N2 can be fixed to a rack 6 to move upward and downward. Further, when the nozzles N1, N2 are fixed to another rack, respectively, and the pinion gear 7 is rotated, the nozzles N1, N2 will move in a direction opposite to upward and downward directions to adjust the interval V in a vertical direction between the nozzles N1, N2.

[0096] According to the first embodiment shown in the drawings, the nozzles N1, N2 of the jet device 1 are located at an interval in a vertical direction, the cutting fluid jet J1 is injected from the upward nozzle N1 in a downward skewed direction, and the cutting fluid jet J2 is injected from the downward nozzle N2 in an upward skewed direction. Accordingly, if flow lines of the cutting fluid jets J1 and J2 are in a region on the right side of the jet device 1 in Fig. 2 on an optional position plane, they provide a plurality of straight lines parallel to each other extending from upper left to lower right and a plurality of straight lines parallel to each other extending from lower left to upper right.

[0097] Thus, as shown in Fig. 10, a region which is not cut by a cutting fluid jet never extends parallel to flow lines of the cutting fluid jet, and flow lines of another cutting fluid jet assuredly intersects the region which is not cut thereby.

[0098] Specifically, even if a region which is not cut by a cutting fluid jet is found instantaneously, the region will thereafter be cut by intersecting any of the cutting fluid jets J1, J2. Accordingly, a larger representative size of a region which is not cut by the cutting fluid jet is prevented.

[0099] Consequently, according to the first embodiment shown in the drawings, the largest clod M which is not cut by the cutting fluid jet to remain in the ground has a smaller representative size than the large clods M shown in Figs. 10 and 11, and readily passes a circular space (Figs. 1 and 11) between the jet device 1 and an inner wall surface of a drilling hole HD. As a result, discharge of slime above the ground is not prevented.

[0100] In the embodiment shown in the drawings, since the angle θ in the nozzles N1, N2 (the inject angle of the cutting fluid jets J1, J2) can be adjusted, the cutting diameter D can efficiently be adjusted according to the type of soil in a construction ground G.

[0101] Additionally, in the embodiment shown in the drawings, since the interval V in a vertical direction between the nozzles N1, N2 can be adjusted, the pitch P of jet flow lines shown in Fig. 2 can be adjusted. Therefore, according to the condition of a construction site, the largest representative size of the clod M which is not cut by a jet to remain in the ground can be adjusted.

[0102] Next, an embodiment of the present invention will be described with reference to Fig. 7.

[0103] In Fig. 7, jets J1, J2 are injected from an upward nozzle N1 of a jet device 10. As described in the first

embodiment shown in Figs. 1 to 6, the jet J1 is injected from the nozzle N1 in a downward skewed direction relative to a horizontal direction, and the jet J2 is injected from the nozzle N2 in an upward skewed direction relative to the horizontal direction.

[0104] Although Fig. 7 does not clearly show, as for the jets J1, J2, a radial direction inward (central) portion of a cross section thereof is a jet flow of a partition forming material, and its circumference is surrounded by a jet flow of a high-pressure air. However, even if the high-pressure air is not ejected, the second embodiment can be implemented.

[0105] For example, the partition forming material is a solution containing 5% by weight of a thickener (e.g. guar gum as a natural water-soluble polymer material) and 5% by weight of sodium silicate (water glass). The partition forming material is injected to the soil to be mixed with an in-situ soil to form a separation layer LD.

[0106] Meanwhile, jets J3, J4 injected from downward nozzles N3, N4 are jet flows of a solidification material.

[0107] By injecting the jets J3, J4, a solidification material is mixed with a mixture of the partition forming material and the cut in-situ soil.

[0108] In order to inject the solidification material by injecting the jets J3, J4 from the jet device 10 which is pulled up by rotating the same, even if the in-situ soil is e.g. a clay, a mixture of the in-situ soil (clay) and the partition forming material are favorably mixed with the solidification material.

[0109] Herein, a mixture of the in-situ soil (clay) and the partition forming material passes a circular space S between the jet device 10 and an inner wall surface of a drilling hole HD as shown in an arrowed direction AD as slime to be discharged above the ground. Nevertheless, since the mixture of the in-situ soil (clay) and the partition forming material contains no solidification material, it is not necessary for the mixture to be treated as an industrial waste, thereby no deterioration of working conditions.

[0110] As shown in Fig. 7, by cutting a ground G by injecting the partition forming material by injecting the jets J1, J2, a separation layer LD is formed in an upward region of a space IJ cut by the jets J1, J2 (a space filled with the in-situ soil and the partition forming material) . The separation layer LD serves as a divider so that the solidification material injected from the nozzles N3, N4 does not flow into a circular space S between the jet device 10 and the inner wall surface of the drilling hole HD.

[0111] By injecting a solidification material in a downward region of the space IJ cut by the jets J1, J2 by injecting the jets J3, J4, a layer LC of a rich-mixed solidification material (having a low W/C, the ratio of water to a solidification material) is formed in a downward region of the space IJ.

[0112] Herein, the downward jets J3, J4 collide with a cut wall W (an inner wall surface of a diameter-expanded cutting hole cut by the jets J1, J2). Then, if they are rolled up as shown in an arrowed direction AN, a solidification material might be mixed with the separation layer LD (comprising a mixture of the partition forming material and the cut soil). When the solidification material is mixed with the separation layer LD, the solidification material might be discharged above the ground as slime.

[0113] In order to prevent from the solidification material from being discharged above the ground, it is necessary for the downward jets J3, J4 to roll down downward as shown in an arrowed direction AG when they collide with the cut wall W. Thus, as shown in Fig. 7, the downward jets J3, J4 face downward by an angle β with respect to a horizontal direction HO.

[0114] Inventors of the present invention experimentally found that when the injection pressure of the downward jets J3, J4 is 100bar, said inclined angle β is preferably 15°, and when the injection pressure of the jets J3, J4 is 200bar, the inclined angle β is preferably 30°. Also, mixture of a solidification material with a separation layer LD was prevented.

[0115] According to the second embodiment in Fig. 7, as the jet device 10 is pulled up, the size of the layer LC of the solidification material in a vertical direction becomes larger (thicker), and the separation layer LD (the layer of the partition forming material) always moves in an upward direction of the layer LC of the solidification material.

[0116] To provide a separation layer LD composed of a partition forming material, a mixture of the partition forming material and soil is discharged above the ground as slime (a mixture of the partition forming material and the cut soil). But, a rich-mixed solidification material in the layer LC of the solidification material is hardly discharged above the ground. Since the solidification material is not discharged above the ground, waste of the solidification material is reduced, and the amount of slime to be treated as an industrial waste in a dedicated plant is reduced.

[0117] In addition, the solidification material is injected by the jets J3, J4 from the downward nozzles N3, N4 of the jet device 10, and the jet device 10 is pulled up by rotating the same. Consequently, even if the viscosity of an in-situ soil (e.g. clay) is high, a mixture of the in-situ soil (clay) and the partition forming material is favorably mixed with the solidification material.

[0118] Other constructions and effects of the second embodiment shown in Fig. 7 are the same as the constructions and effects of the first embodiment shown in Figs. 1 to 6.

[0119] It should be note that the explanations relating to the embodiments shown in the drawings are merely examples and that the technical scope covered by the present invention is not restricted by such the explanations of the embodiments shown in the drawings. The embodiments composed of substantially the same technical concept as disclosed in the claims of the present invention and expressing a similar effect are included in the technical scope of the present invention.

[0120] In the embodiment shown in the drawings, for

example, two nozzles are provided, but if nozzles are symmetrically disposed about a point with respect to a central axis CL of a jet device, 3 or more nozzles can be provided.

[0121] In addition, in the embodiment shown in the drawings, a solidification material is delivered from a discharge port provided in a downward direction of the jet device and delivered to a mixture of a cut in-situ soil and a cut fluid. However, like a cutting fluid jet J or together therewith, the solidification material may be injected in an outward radial direction.

EXPLANATION OF LETTERS OR NUMERALS

[0122]

1, 10, 11...Jet device
HC...Cutting hole
HD...Drilling hole
IJ...Cut space
J, J1, J2...Cutting fluid jet
LC...Layer of solidification material
LD...Layer of partition forming material (separation layer) N, N1, N2, N3, N4...Nozzle (inject nozzle)
S...Circular space
W...Cut wall (inner wall surface of cutting hole)

Figures:

[0123]

[Fig. 1]
[Fig. 2]
[Fig. 3]
[Fig. 4]
[Fig. 5]
[Fig. 6]
[Fig. 7]
[Fig. 8]
[Fig. 9]
[Fig. 10]
[Fig. 11]

Claims

1. A method for improving ground comprising the steps of:

   cutting a ground by injecting a cutting fluid from a first nozzle (N1) and a second nozzle (N2) of a jet device (10) ;
   injecting a solidification material from a third nozzle (N3) and a fourth nozzle (N4) of the jet device (10); mixing a cut ground, the cutting fluid and the solidification material; and agitating a mixture thereof to form an underground consolidated body, wherein
   the first nozzle (N1) is located above the second nozzle (N2) in a vertical direction on the jet device (10) ; the third (N3) and fourth nozzles (N4) are located below the second nozzle (N4) in the vertical direction; the cutting fluid is injected from the first nozzle (N1) in a downward skewed direction and from the second nozzle (N2) in an upward skewed direction; and the solidification material is injected from the third and fourth nozzles (N3, N4) at an angle downward.

2. The method for improving ground according to claim 1, wherein the angle downward of the third and fourth nozzles (N3, N4) is 15° or 30°.

3. The method for improving ground according to the claim 2, wherein the solidification material is injected with an injection pressure of 100bar when the angle downward is 15° and 200bar when the angle downward is 30°.

Patentansprüche

1. Verfahren zum Verbessern eines Untergrunds, das die folgenden Schritte umfasst:

   Schneiden eines Bodenmaterials durch Einspritzen eines Schneidfluids aus einer ersten Düse (N1) und einer zweiten Düse (N2) einer Strahlvorrichtung (10);
   Einspritzen eines Verfestigungsmaterials aus einer dritten Düse (N3) und einer vierten Düse (N4) der Strahlvorrichtung (10);
   Mischen des geschnittenen Bodenmaterials, des Schneidfluids und des Verfestigungsmaterials; und
   Rühren einer Mischung daraus, um einen verfestigten Körper im Untergrund zu bilden, wobei die erste Düse (N1) oberhalb der zweiten Düse (N2) in vertikaler Richtung an der Strahlvorrichtung (10) angeordnet ist;
   wobei die dritte (N3) und vierte Düse (N4) in vertikaler Richtung unterhalb der zweiten Düse (N4) angeordnet sind;
   wobei das Schneidfluid von der ersten Düse (N1) in einer nach unten schräg verlaufenden Richtung und von der zweiten Düse (N2) in einer nach oben schräg verlaufenden Richtung eingespritzt wird; und
   wobei das Verfestigungsmaterial von der dritten und vierten Düse (N3, N4) in einem Winkel nach unten eingespritzt wird.

2. Verfahren zur Bodenverbesserung nach Anspruch 1, wobei der Winkel der dritten und der vierten Düse (N3, N4) nach unten 15° oder 30° beträgt.

3. Verfahren zur Bodenverbesserung nach Anspruch 2, wobei das Verfestigungsmaterial mit einem Einspritzdruck von 100 bar eingespritzt wird, wenn der Winkel nach unten 15° beträgt, und mit einem Einspritzdruck von 200 bar eingespritzt wird, wenn der Winkel nach unten 30° beträgt.

Revendications

1. Procédé pour améliorer un sol comprenant les étapes consistant à :

couper un sol en injectant un fluide de coupe à partir d'une première buse (N1) et d'une deuxième buse (N2) d'un dispositif à jet (10) ;
injecter un matériau de solidification à partir d'une troisième buse (N3) et d'une quatrième buse (N4) du dispositif à jet (10);
mélanger un sol coupé, le fluide de coupe et le matériau de solidification ; et
agiter un mélange de ceux-ci pour former un corps souterrain consolidé, dans lequel la première buse (N1) est située au-dessus de la deuxième buse (N2) dans une direction verticale sur le dispositif à jet (10) ;
la troisième (N3) et la quatrième buse (N4) sont situées en dessous de la deuxième buse (N4) dans la direction verticale ;
le fluide de coupe est injecté par la première buse (N1) dans une direction inclinée vers le bas et par la deuxième buse (N2) dans une direction inclinée vers le haut ; et
le matériau de solidification est injecté par les troisième et quatrième buses (N3, N4) selon un angle vers le bas.

2. Procédé d'amélioration du sol selon la revendication 1, dans lequel l'angle de la troisième et de la quatrième buse (N3, N4) vers le bas est de 15° ou 30°.

3. Procédé d'amélioration du sol selon la revendication 2, dans lequel le matériau de solidification est injecté avec une pression d'injection de 100 bars lorsque l'angle vers le bas est de 15° et avec une pression d'injection de 200 bars lorsque l'angle vers le bas est de 30°.

Fig. 1

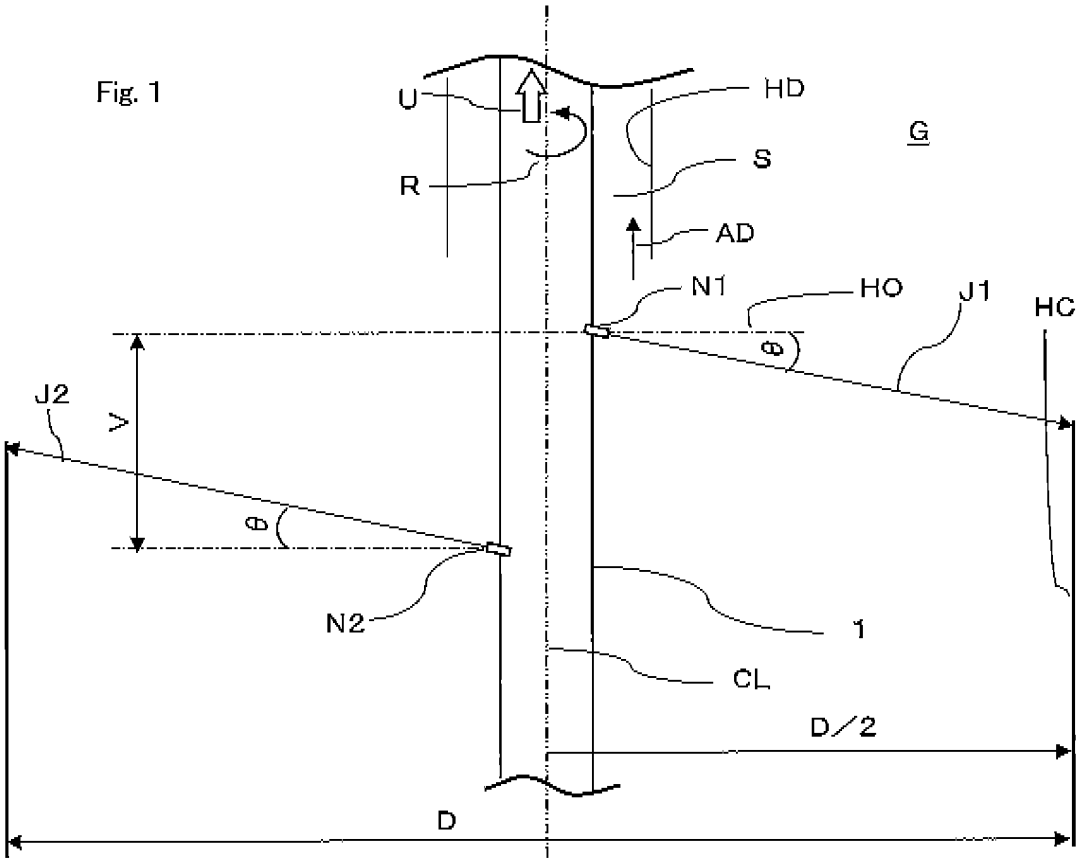


Fig. 2

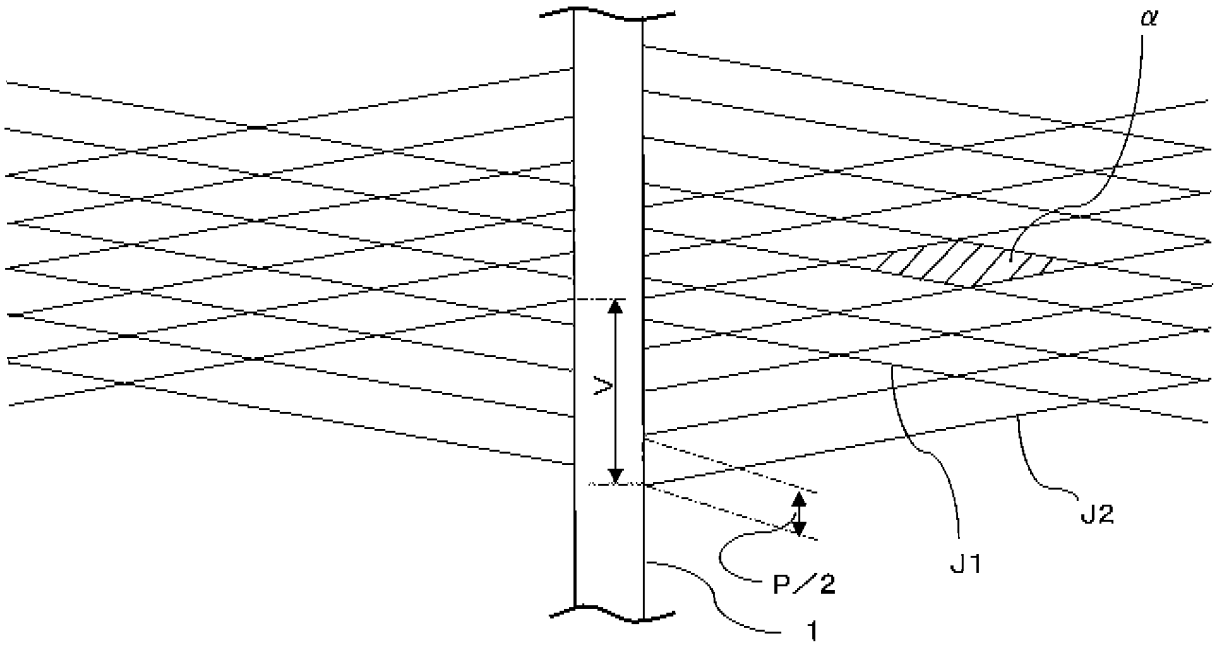


Fig. 3

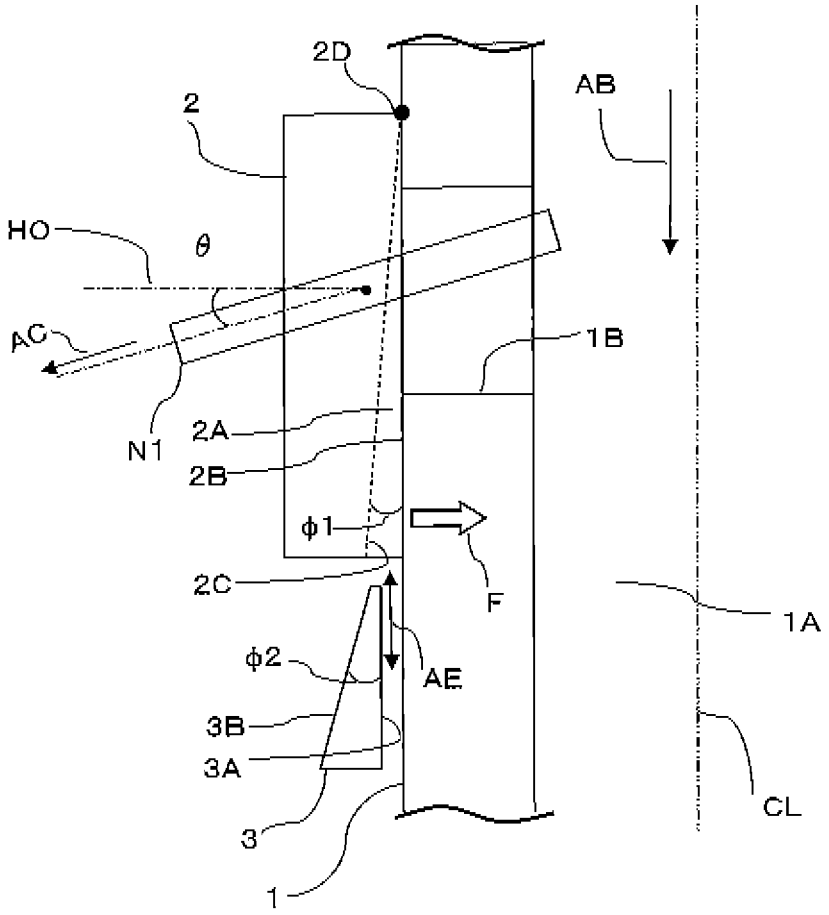


Fig. 4

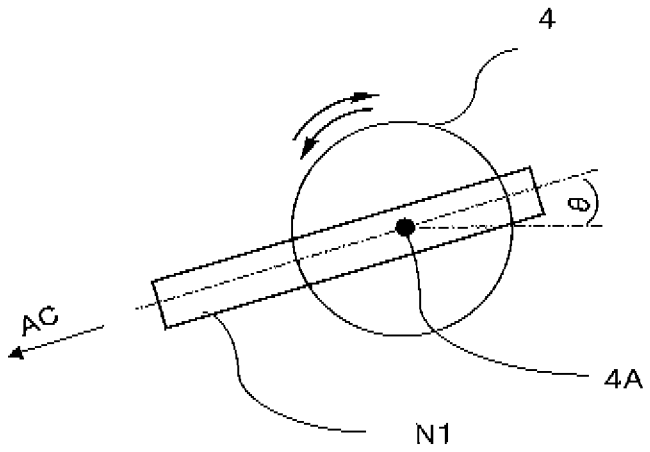


Fig. 5

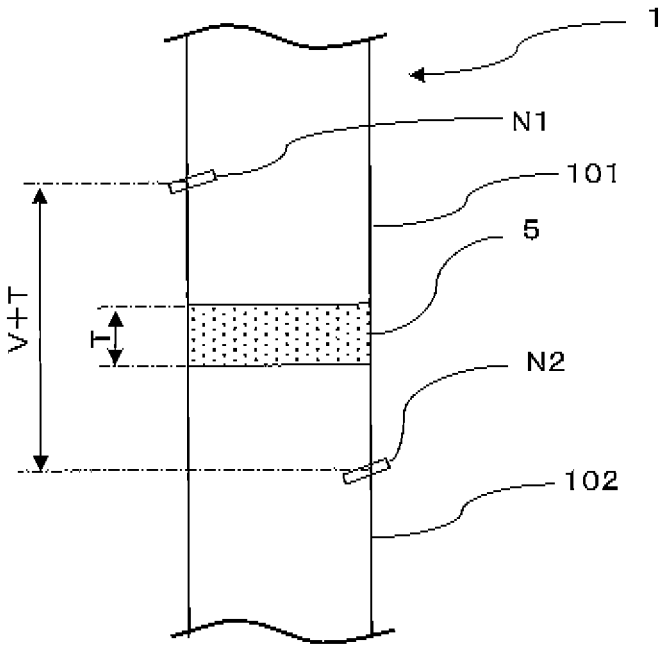


Fig. 6

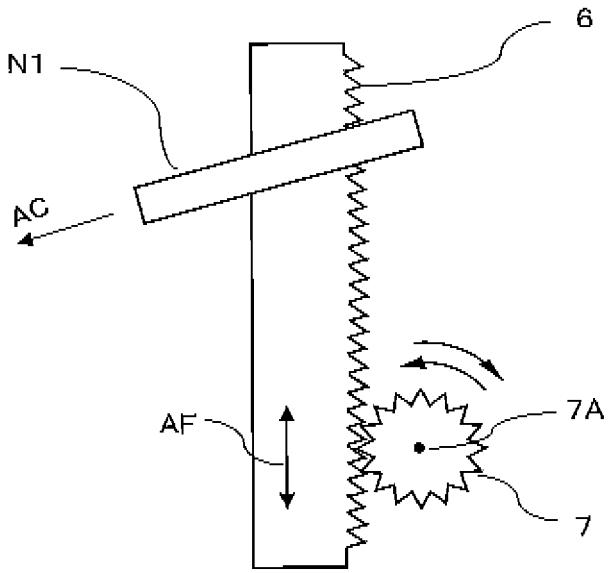


Fig. 7

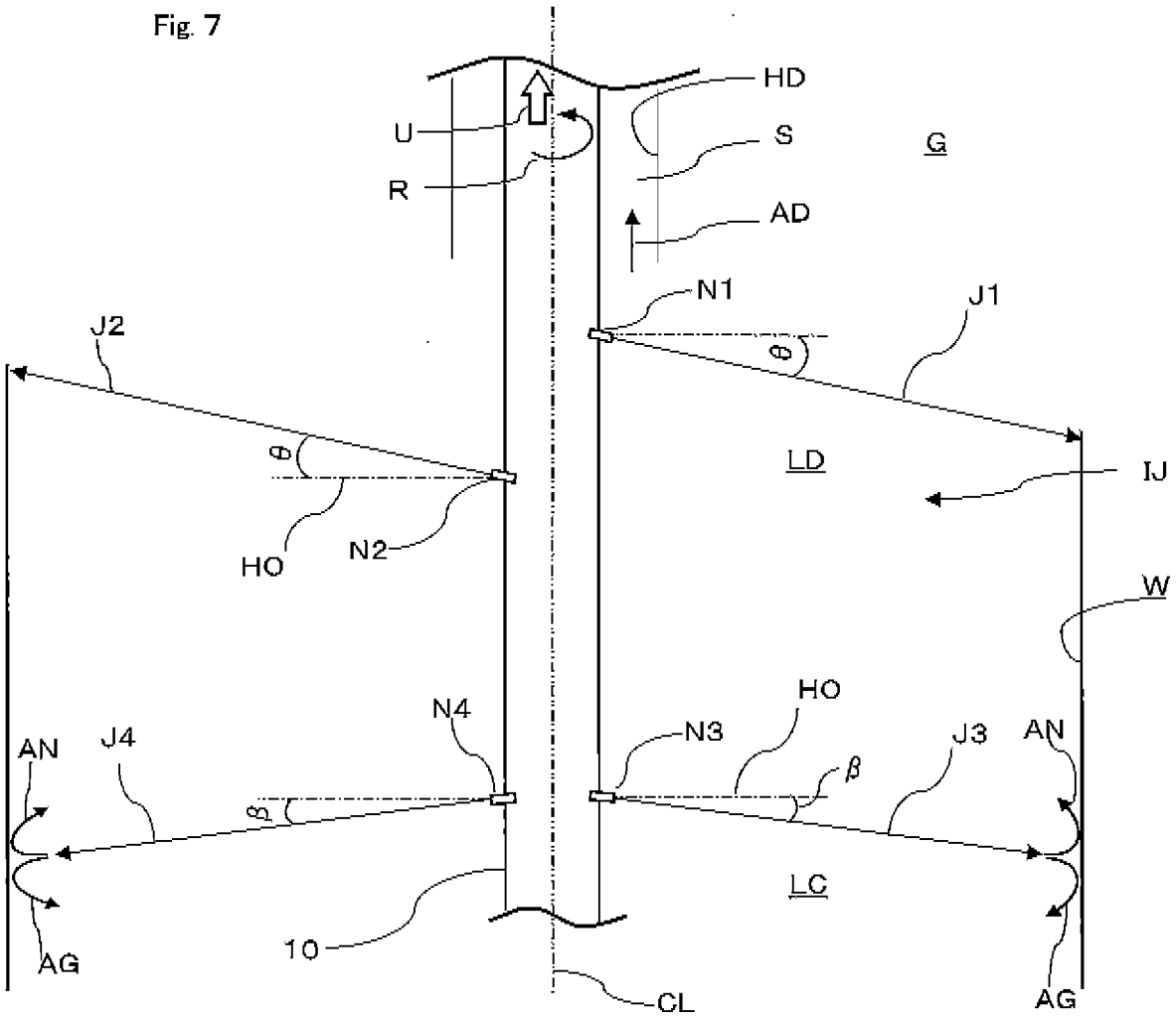

HD
U
S
G
R
AD
N1
J1
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θ
LD
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HO
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LC
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AG
CL
AG

Fig. 8

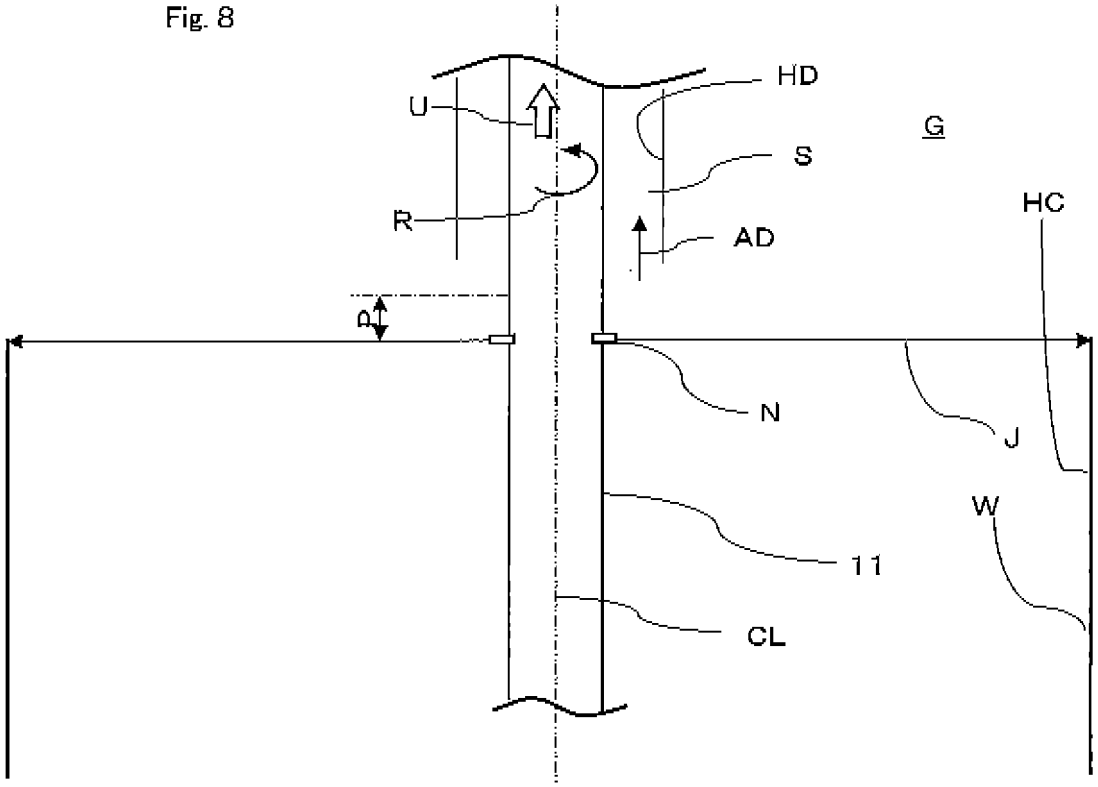


Fig. 9

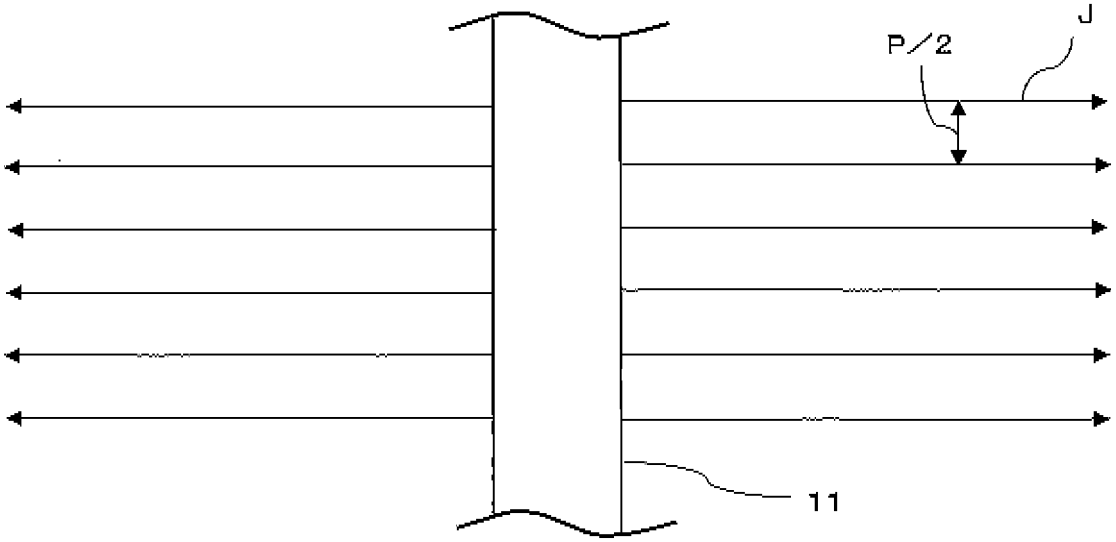


Fig. 10

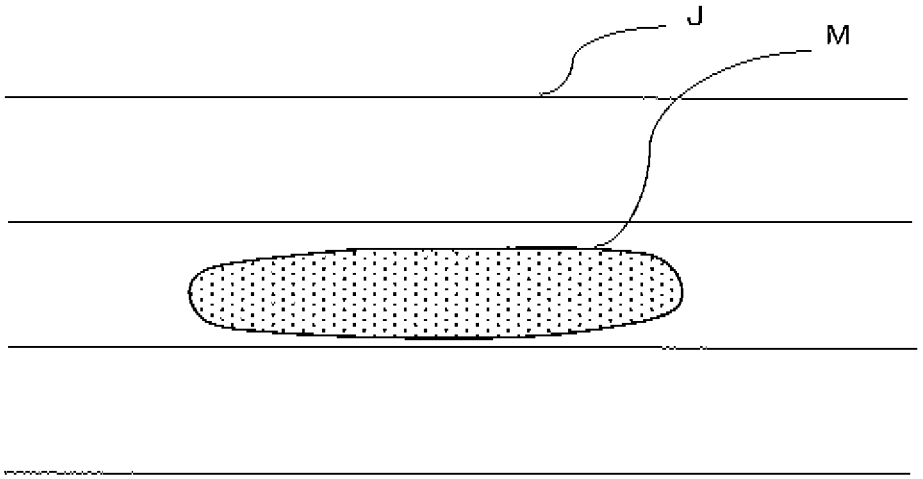
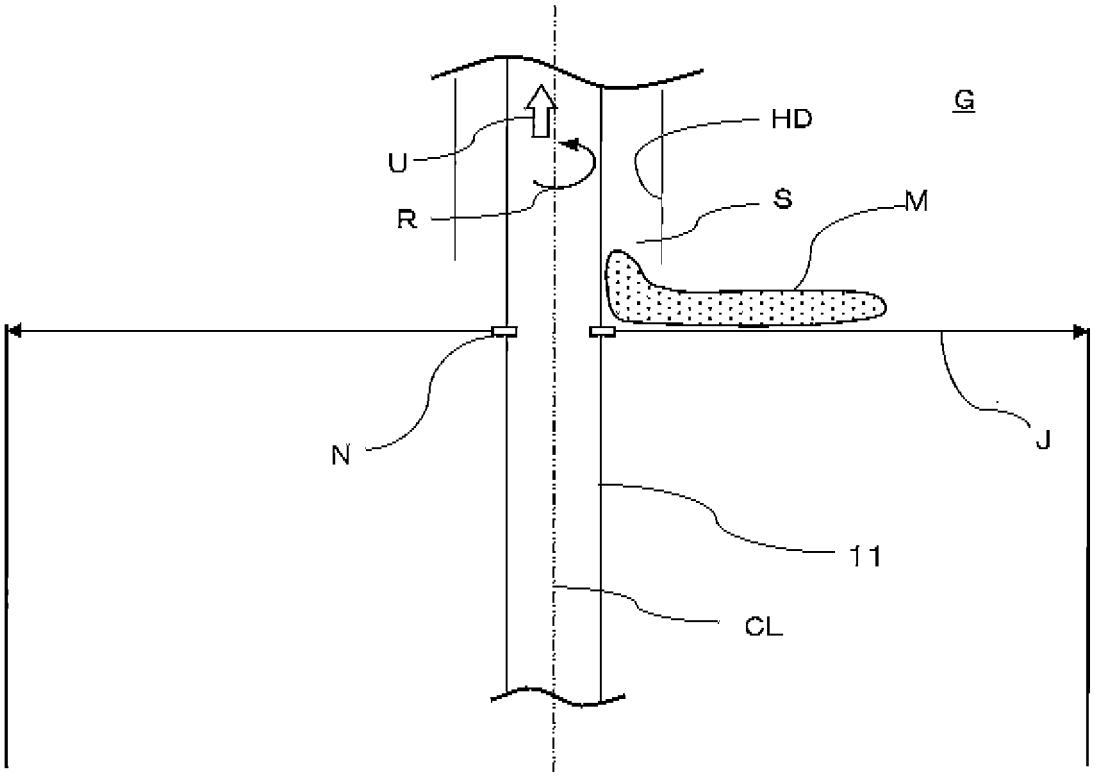


Fig. 11



REFERENCES CITED IN THE DESCRIPTION

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