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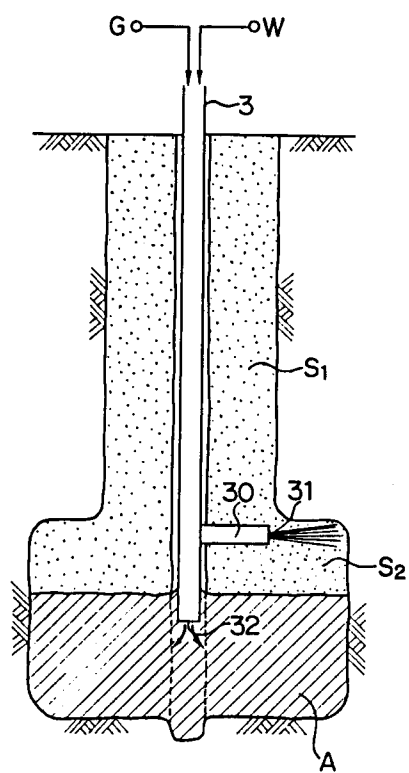
(54) **CONSTRUCTION METHOD OF IMPROVING OR STRENGTHENING GROUND.**

(57) A method of squeezing a self-hardening material of stiff consistency into the ground through a jet pipe inserted into the ground when improving or strengthening the soft ground. While or after softening the ground to be treated by jetting high pressurized water from a high pressurized fluid jetting

nozzle provided on the forward end of the jet pipe inserted into the soft ground, the self-hardening material of stiff consistency is squeezed into said softened ground to produce an improved part in the ground. A jet pipe having a jetting part projecting outward from the pipe may be used.

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FIG. 18



## [Technical Field]

The present invention relates to a construction work method for improving or strengthening the soft ground and in particular to a construction work method for improving the ground by grouting a self-curing material such as cements of a high viscosity or dry consistency into the ground which has been preliminarily loosened so that the self-curing material is poured into the ground.

## [Prior Art]

Various work methods of improving the ground of this type have been known. The typical work method is the chemical grouting method. In this method, a chemical liquid is grouted into the ground under a low pressure through a grouting pipe which has been inserted into the ground as is well known. In this case, it is the principle that the chemical liquid is penetrated and grouted into the ground under pressure without disturbing the ground.

On the other hand, high pressure jetting methods, a representative work method of which is a so-called jet grouting method have been widely executed recently. In this high pressure jetting method, a grout is grouted into the ground simultaneously with disturbing the ground with the high pressure of the grout or water.

This high pressure jetting method can also be referred to as a method of agitating the ground in a wide meaning. On the other hand, the genuine agitating method is conducted mainly for the viscous ground. A cement material is supplied through an agitating shaft having agitating blades or through a separate supply system while the agitating shaft is inserted into the ground. The ground area to be agitated is replaced with the cement material or agitated and mixed with sand while the ground is agitated.

However, the strength and durability of the improved ground is low since a material having a low viscosity, mainly water glass material is used for the penetration and pressure grouting in the former chemical pressure grouting work method. The reason why the strength of the improved ground is low is that the ratio of the improving material per unit volume is low and the improving material is nonuniform since the ground is not replaced with the improving material, but the improving material is penetrated or grouted into cracks in the ground.

There is another problem in that although penetration-grouting can be usually conducted for the sandy soil layer, the grout for penetration grouting will often be grouted into cracks due to slight changes in grouting conditions, resulting in

that the penetration grouting becomes impossible. On the other hand, if the grout is grouted into a viscous soil layer, it will be often grouted into cracks, resulting in penetration in unwanted directions. Accordingly, it is hard to positively improve only the desired area and loss of the material due to penetration in unwanted directions is high. The diameter of the improved body is ununiform along the axial direction so that the improved body may be often in the shape of tree or nerve.

In a second high pressure jetting method, the ground is extremely disturbed and much labor and long period of time is required for the treatment of the slime (muddy water). If cutting and grouting is tried to conduct uniformly or discharge of the slime is tried to sufficiently conduct, it would be necessary to lower the improving speed and an extended period time is taken.

Although desired strength of the improved ground is 30 kg/cm<sup>2</sup> or higher and 10 kg/cm<sup>2</sup> or higher for the sand ground and viscous ground respectively, there is a problem in that variations in strength is very large depending upon the properties of the ground and the positions of the improved body. Particularly, in case of the viscous ground, variation in strength is large due to leaving of lumps of earth which occur by insufficient cutting of the ground.

A third agitating method has a big problem in that a facility for this method becomes large in size. In case of the viscous ground, a mixture of earth particles and an improving material will be rotated together with agitating blades so that the agitating effect is not so high and the uniformity of the improving strength is low. On the other hand, an object of the agitating method is the viscous ground as mentioned above. Although it is not impossible to apply this agitating method to the sand ground, it can not be applied to the sand ground without using any huge agitating means since the resistance of the ground against an agitating shaft and agitating blades is high.

It is therefore a first object of the present invention to enhance the strength and uniformity of an improved body, to enable a simple and compact facility to execute the work and to form a firm improved body at a restricted or desired position by a consolidation effect.

It is therefore a second object of the present invention to increase the diameter of an improved body by extending the reach range of pressurized water from a pressurized water jetting nozzle.

It is a third object of the present invention to provide an uniform improved body having a large diameter.

## Disclosure of the Invention

In accordance with the present invention, an improved body is formed by grouting a self-curing material of dry consistency having a slump value of 15 cm or less into the loosened ground under pressure while or after loosening the ground by jetting pressurized water from a pressurized liquid jetting nozzle provided at the front end portion of a jetting pipe which is inserted into the ground.

In this case, the improved body can be formed by jetting pressurized liquid for loosening the ground to convert the ground into mud and by elevating and removing the resultant mud by pressure-grouting the self-curing material.

The time when the ground is loosened with the pressurized liquid may be shifted from the time when the self-curing material is grouted. The jetting and grouting pipe may be formed with a grouting opening at the front end portion thereof and be provided with a jetting nozzle at a position closer to the base portion than the grouting opening. Loosening of the ground may be conducted substantially simultaneously with pressure-grouting of the self-curing material during extracting of the jetting and grouting pipe.

The jetting pressure of the pressurized water from the pressurized liquid jetting nozzle may be 50 kg/cm G or higher.

The liquid for loosening the ground may have an enhanced cutting ability if water is added with a surfactant.

The material which will form the improved body may be formed by adding the self-curing material with the removed mud. It is preferable to separate the removed mud into a supernatant liquid and condensed mud and to reuse as a ground loosening liquid the only supernatant liquid or the supernatant liquid which is added to water. The condensed mud may be added to the self-curing material so that it can be reused as an improved body forming material.

If the jetting pipe has two passages, one passage can be used for supplying the ground loosening liquid and the other passage can be used for both supplying of bore cutting liquid when boring and supplying of the self-curing material after loosening of the ground.

If the jetting pipe has three passages, the first passage can be used for supplying the ground loosening liquid, the second passage can be used for supplying compressed air to enhance to ground cutting ability of the loosening liquid and to lift the mud upward and the third passage can be used for supplying the self-curing material after loosening of the ground.

If reinforcing steel rods are inserted into an area to be improved and buried in an improved body, a pile or wall can be provided. If improved bodies are linked, a column arrayed pillar or a column arrayed wall can be provided.

The present invention is based upon finding that if a self-curing material is grouted into the ground which has been loosened once, the consolidated area is enlarged and the strength of the improved body is enhanced in comparison with the case in which the ground is agitated simultaneously with grouting and a grout having a higher unit water quantity and a higher fluidity is used like jet grouting method, for example.

If pressurized water is jetted in accordance with the present invention, the target ground can be loosened. Loosening of the ground is achieved mainly by discontinuation of the bond between larger earth particles and finer earth particles around the larger earth particles which linking these larger earth particles. This discontinuation will increase the ratio of spaces, to which an improving material will subsequently grouted under pressure.

If an improving material (self-curing material) of dry consistency having a low slump value is grouted under pressure, the improving material is grouted into the loosened portion of the ground as if it is forced thereto. The improving material is grouted in such a manner that it will expand the loosened ground. At this time, the improving material is prevented from moving in unwanted directions since the slump value of the improving material is low. The loosened ground portion is replaced with the improving material as if that ground is charged with the improving material. The forcing pressure of the improving material consolidates the ground portion and more improving material is grouted into soft ground portion. On the other hand, less improving material is grouted into the ground portion having a higher strength since the loosening degree of that ground portion is low. As a whole an improved body having uniform strength and diameter can be thus formed.

On the other hand, the cost for the facility is lower than those of the high pressure jetting method and the agitating method since this method can be sufficiently executed by using a pipe having a small diameter of about 70 mm.

The resultant slime is not a mixed slime of cement with earth particles which are formed by the high pressure jetting method, but is a mixture of water and earth particles since pressurized water is used for loosening the ground. Accordingly, the treatment of the slime is advantageously easy. The cost for treating the slime can be remarkably reduced as a whole by separating the slime including only water and earth particles and by reusing water as pressurized water for loosening the ground and

the slurry containing earth particles which are added with a self-curing material such as cement.

The present invention can be easily applied to the sandy ground. In this respect, the present method is remarkably different from the prior art agitating method. The variation in strength of the improved body which is found in the high pressure jetting method is eliminated since loosening of a target area of the ground and pressure grouting of the improving material is conducted in different steps or stages.

It is necessary to increase the pressure of the pressurized water to extend the reaching distance of the pressurized water from the jetting nozzle. Increasing of the pressure enlarges the size of a pumping facility for the pressurized water. Even if the pressure is increased, this will not help extend the reaching distance so much since the energy of the water will be rapidly lowered in the ground.

In a second aspect of the present invention, there is provided a method of improving or strengthening the ground characterized in that it comprises providing a jetting pipe which is provided at the front end portion thereof with a projecting jetting portion which projects in an outer direction from the jetting pipe at least when pressurized water is jetted toward the ground to increase the diameter of the loosened ground, said projecting jetting portion being provided with a jetting nozzle for jetting pressurized water toward the ground in an outer direction with respect to the axis of an improved body to be formed, said jetting pipe being formed with a self-curing material grouting opening at a position closer to the front end thereof than said jetting nozzle, inserting said jetting pipe into a target ground to be improved; jetting pressurized water from said jetting nozzle with said projecting jetting portion projecting in an outer direction from said jetting pipe while rotating said jetting pipe around the axis thereof and extracting said jetting pipe in an axial direction thereof to loosening the ground which is located in an outer jetting direction from said nozzle for forming a loosened mud column of the ground, and grouting a self-curing material of dry consistency from said grouting opening into said loosened mud column during or after forming said loosened mud column, whereby to form an improved body.

There is also provided a method of improving or strengthening the ground characterized in that it comprises providing a jetting pipe which is provided on the outer peripheral surface at the front end portion thereof with a first jetting nozzle for jetting pressurized water in a radial direction and is provided at the front end portion thereof with a projecting jetting portion which projects in an outer direction from the jetting pipe at least when pressurized water is jetted toward the ground to in-

crease the diameter of the loosened ground, said projecting jetting portion being provided with a second jetting nozzle for jetting pressurized water toward the ground beyond the outer end of the projecting jetting portion in an outer direction with respect to the axis of an improved body to be formed, said jetting pipe being formed with a self-curing material grouting opening at a position closer to the front end thereof than said jetting nozzle, inserting said jetting pipe into a target ground to be improved; jetting pressurized water from said second jetting nozzle with said projecting jetting portion projecting in an outer direction from said jetting pipe while rotating said jetting pipe around the axis thereof and extracting said jetting pipe in an axial direction thereof to loosening the ground which is located in an outer jetting direction from said second jetting nozzle for forming a loosened mud column of the ground, and grouting a self-curing material of dry consistency from said grouting opening into said loosened mud column during or after forming said loosened mud column, whereby to form an improved body.

In this case, the reaching distance of the pressurized water from said first jetting nozzle may be made longer than the projecting length of the projecting jetting portion and said jetting pipe may be inserted into the ground while loosening the ground by jetting pressurized water from at least the first jetting nozzle.

The method may include inserting said jetting pipe into a casing while or after a bore having a radius which is larger than the distance between the front end of said projecting jetting portion and the axis of said jetting pipe is bored by using a casing; removing the casing; and loosening the ground by jetting the pressurized water from the first jetting nozzle so that the pressurized water reaches beyond a position where the outer surface of said casing was located and loosening the ground by jetting pressurized water also from a second jetting nozzle so that the reaching distance of the pressurized water is longer than that from the first jetting nozzle.

Said projecting jetting portion may be collapsible between a folded position and an externally extended position along the axis of the jetting pipe by an operation from the ground surface, the projecting jetting portion being folded when the jetting pipe is inserted and being extended when the pressurized water is jetted from the jetting nozzle provided on the projecting jetting portion.

In the first aspect of the present invention, the largest feature resides in that the diameter of the improved body is increased by jetting pressurized water from the projecting jetting portion.

In order to loosen the target ground body having a large diameter only by jetting pressurized

water from a pressurized water jetting nozzle provided on the outer periphery of the front end portion of the jetting pipe, it is necessary to increase the discharge amount of the water by increasing the pressure or to decrease the discharge amount by reducing the diameter of the nozzle opening. However, increasing the water discharge amount by increasing the pressure will increase the amount of discharged mud, resulting in that a discharged mud treating apparatus becomes larger in size and the cost for the treatment is increased. In case of decreasing the amount of the discharged water by reducing the nozzle diameter, the energy of the pressurized water is rapidly reduced after it has been discharged into the ground so that sufficient loosening effect can not be obtained.

If the jetting pipe is provided with the jetting portion which projects from the outer surface of the jetting pipe in the second aspect of the present invention, since the pressurized water is jetted from the projecting jetting portion, the diameter of the improved body can be made larger by the projecting length of the projected jetting portion (precisely, the distance from the outer surface of the pipe to the jetting nozzle) than that in the case in which the pressurized water is discharged from a simple pipe having no projecting jetting portion even if the pressure is not increased, or the nozzle diameter is not decreased, or the discharge rate of the pressurized water is not made excessive.

If the jetting pipe is used which is provided with the first jetting nozzle for jetting pressurized water in a radial direction on the outer periphery of the front end portion of the pipe and is provided with a projecting jetting portion which projects in an outer direction from the pipe on the base portion of the pipe with respect to the first jetting nozzle, said projecting jetting pipe being provided with a second jetting nozzle, a great advantage can be obtained. In other words, the ground can be loosened over a distance corresponding to the reaching distance from the first jetting nozzle if pressurized water is jetted from the first jetting nozzle when the jetting pipe is inserted into the ground. Therefore, the jetting pipe can be directly inserted into the ground without any necessity of boring using a casing. The present method is excellent in working readiness.

In the third aspect of the present invention, there is also provided a method of improving or strengthening the ground characterized in that it comprises providing a jetting pipe which is provided at the front end portion thereof with a projecting jetting portion which projects in an outer direction from the jetting pipe at least when pressurized water is jetted toward the ground to increase the diameter of the loosened ground, said projecting portion or the jetting pipe being provided

at a position below the projecting jetting portion with a jetting nozzle for jetting pressurized water so that the ground area which is at least as long as the projecting length of the projecting jetting portion is covered, and said jetting pipe is provided with a self-curing material grouting opening at a position closer to the front end thereof than a lowermost jetting nozzle; inserting the jetting pipe into the ground; jetting pressurized water from said jetting nozzle over a range between a given depth and the other depth to loosen at least the ground area corresponding to the projecting length of said projecting jetting portion for forming a loosened mud column; and thereafter grouting a self-curing material of dry consistency under pressure into said loosened mud column from said grouting opening at said depth or while the jetting pipe is extracted.

Said jetting nozzle may be provided on the projecting jetting portion in such a manner that it opens downward. Alternatively, said jetting nozzle may be provided on the outer surface of the jetting pipe at a position below the projecting jetting portion in such a manner it opens in a radial direction.

In the third aspect of the present invention, there is a feature in that the projecting jetting portion or the jetting pipe below the jetting portion is provided with a jetting nozzle for jetting pressurized water to cover the ground area over at least the length corresponding to the projecting length of the projecting jetting portion in addition to that the jetting pipe is provided with the projecting jetting portion.

If the projecting jetting portion which projects from the outer surface of the jetting pipe is provided and the projecting jetting portion is provided with the jetting nozzle in accordance with the third aspect, the reaching distance of the pressurized water from the axis of the jetting pipe can be made longer although the reaching distance of the pressurized water from the axis of the jetting pipe can be made longer although the reaching distances of the pressurized water from respective jetting nozzle are short. Accordingly, the ground can be positively loosened over at least a length corresponding to the projecting length of the projecting jetting portion without increasing the pressure of water, or reducing the nozzle diameter, or increasing the discharging rate.

If the jetting nozzle is provided on the outer surface of the jetting pipe at a position below the projecting jetting portion so that it opens in a radial direction, there is no advantage in respect of reaching distance. If the jetting pipe can not be inserted into the ground in this or former case, this means that the projecting jetting portion is resisted by the unloosened ground at this depth position.

The loosening of the ground can be qualified based upon the resistance of the ground against the insertion of the pipe. If the jetting pipe can not be inserted into the ground, the ground can be positively loosened over at least a length corresponding to the projecting length of the projecting jetting portion by reducing the rotational speed, or the lowering speed of the jetting pipe, or increasing the pressure or the flow rate of the pressurized water from the jetting nozzle. Since the projecting jetting portion has an agitating effect to some extent similarly to the agitating blade in both cases, there is an advantage that the loosening ability of the ground can be enhanced.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view illustrating a first step of a first embodiment in order of working steps;  
 Fig. 2 is a schematic view illustrating a second step of the first embodiment in order of working steps;  
 Fig. 3 is a schematic view of illustrating a third step of the first embodiment in order of working steps;  
 Fig. 4 is a schematic view illustrating a fourth step of the first embodiment in order of working steps;  
 Fig. 5 is a schematic view illustrating pressure grouting of a self-curing material;  
 Fig. 6 is a schematic view illustrating the moving process of an improving agent;  
 Fig. 7 is a schematic view of another embodiment;  
 Fig. 8 is a schematic view of another improving example;  
 Fig. 9 is a schematic view of a further example;  
 Fig. 10 is a schematic view of a further example;  
 Fig. 11 is a schematic view of an example of reutilization of mud;  
 Fig. 12 is a sectional view showing main components of triple pipe;  
 Fig. 13 is a schematic view of an example in which grouting is conducted;  
 Fig. 14 is a sectional view of a column arrayed pile;  
 Fig. 15 is a plan view of the column arrayed pile;  
 Fig. 16 are schematic views showing the steps of another improving method using an apparatus having agitating blades;  
 Fig. 17 is a schematic view showing a state in which a mud column is formed in the ground;  
 Fig. 18 is a schematic view showing a work condition in a second aspect of the present invention;  
 Fig. 19 is a schematic view showing a work condition of another example;

Fig. 20 is a schematic view of a work condition of a further example;

Fig. 21 is a longitudinal sectional view showing an example of a jetting pipe;

Fig. 22 is a longitudinal sectional view showing a casing boring;

Fig. 23 is a longitudinal sectional view showing a subsequent extracting process;

Fig. 24 is a view showing a improved jetting pipe;

Fig. 25 is a view showing another improved jetting pipe;

Fig. 26 is a view showing a further different jetting pipe;

Fig. 27 is a schematic view showing a further example of a jetting pipe having agitating blades;

Fig. 28 is a schematic view showing a blade expanding type jetting pipe;

Fig. 29 is a view showing an expanded condition of the blade expanding type jetting pipe;

Fig. 30 is a schematic view showing another improved ground;

Fig. 31 is a schematic view showing a further example of reutilization of mud;

Fig. 32 are plan views showing column arrayed walls or column arrayed walls;

Fig. 33 is a longitudinal view of an improved body in accordance with a method of present invention;

Fig. 34 is a horizontal sectional view of the improved body;

Fig. 35 is a longitudinal sectional view showing an improved body in accordance with the jet grouting method; and

Fig. 36 is a horizontal sectional view of the same.

#### BEST MODES FOR EMBODYING THE INVENTION

The present invention will be described by way of embodiments with reference to drawings.

#### [EMBODIMENTS]

Now, the present invention will be described by way of examples with reference to drawings. Figs. 1 through 4 show a first example of a first embodiment. A jetting pipe 2 having a nozzle 1 at the front end thereof is inserted into the ground to a given depth as shown in Fig. 1. Thereafter, pressurized water W is jetted from the jet nozzle 1 under a pressure depending upon the properties of the ground (soil, softness, etc.) and the desired diameter of an improved body, preferably a pressure of 50 kg/cm<sup>2</sup> or more, more preferably a pressure of 80 to 350 kg/cm<sup>2</sup> to loosen the target

ground when the jetting pipe 2 is extracted while rotating as shown in Fig. 2. The loosened ground portion is represented by a reference character S.

Then, after completion of this step, a pressure grouting pipe 2A is inserted into the loosened target portion as shown in Fig. 3 and a self-curing improving material G having a slump value (Japanese Industrial Standards JIS A 1101) of 5 to 15 cm, more preferably 8 to 15 to form an improved body as shown in Fig. 4.

A manner for grouting the improving material G under pressure is shown in Figs. 5 and 6. Reference numerals 1 to 3 in Fig. 6 show the lapse of time. It is understood from these drawings that the improving material of the present invention is penetrated into the ground in an outer radial direction similar to paste when the improving material is grouted under pressure.

In the present invention, self-curing improving materials such as cement mortars, cement clays, limes may be used. Improving materials having a high viscosity are used as mentioned above.

Cement mortars are most preferable among these improving materials. Various additives such as other organic materials including fine particle slag, bentonite, foaming agents, frothing agents, antiseptating agents and water reducing agents may be added to the cement mortar. A water-glass or a curing agent for the same may be further added to the cement mortar at a given ratio.

In the first example, the jetting pipe 2 and the pressure-grouting pipe 2A are separately used. In a second example shown in Fig. 7, a jetting pipe 20 which is a coaxial double pipe, including inner and outer pipes 21 and 22 is used. The ground is cut by means of a cutting bit 29 at the front end thereof while rotating the pipe 20 and forcing the pipe 20 in a downward direction so that the jetting pipe 20 is inserted into the ground to a given depth.

In a subsequent course of extracting of the jetting pipe 20 while rotating, pressurized water is jetted from jetting nozzles 24 provided on the peripheral wall of the pipe at the base end thereof for loosening the target ground. Simultaneously with this, the improving material G is pressure grouted from a grouting opening 25 which opens at the front end of the pipe 20.

A reference numeral 26 denotes a plug for closing a space between the inner and outer pipes 21 and 22.

Concept of consolidation working will be described with reference to Fig. 7. After the ground which has been loosened once is filled with the improving material G by grouting, the grouting is further continued. The subsequent improving material will force the previously discharged improved material in an outer radial direction, resulting in that

the improved ground including a solidified area Z2 disposed in the center and a consolidated area Z1 of the improving material therearound is formed as shown in Fig. 7.

Alternatively, the ground can be loosened by jetting pressurized water while the jetting pipe is inserted if a double pipe or double passage pipe is used like the second example. Loosening of the ground in the course of lowering the pipe is applicable to the first example.

Although a continuous improved body is formed in the above-mentioned examples, discontinuous improved stages can be formed as shown in Fig. 8. In this case, reinforcing of the whole of the ground by a branched skeleton is aimed.

The pressure of the pressurized water in the present invention usually means the pressure which is detected by a gauge provided in the vicinity of a pressure grouting pipe or on the discharge side of a grouting pump. The pressure is preferably 50 kg/cm<sup>2</sup> or higher as mentioned above. In some cases, the pressure is preferably 100 kg/cm<sup>2</sup> or higher. The rate of the jetted water is preferably 5 to 15 l/minute. The jetting pipe having an outer diameter of 80 mm or less may be used in the present invention. This is same as the grouting tube. In order to conduct grouting, a hose and the like may be used.

The present invention can be applied to various construction works such as reinforcing of a sand area 30 in a sub base course of a track 31 shown in Fig. 9 and a soft ground below a concrete building 40 as shown in Fig. 10. A reference numeral 32 denotes ballast.

The pressurized liquid for loosening the ground is preferably water in view of availability and cost. Cutting ability for the ground can be enhanced by adding a surfactant to water. After the slurry which is generated by the loosening of the ground is separated into supernatant liquid and condensed mud, the supernatant liquid may be used for the pressurized liquid. For example, as shown in Fig. 11, a mud pit 50 is formed on the ground in the vicinity of the base of the pressure jetting pipe 20, mud 51 which is formed by the replacement with the improving material G and is elevated between the pressure jetting pipe 20 and the bore wall is pumped out by a pump 52 up to the pit 50 in which it is separated into supernatant liquid 51A and condensed mud 51B. The supernatant liquid 51A is added to pressurized water W by a pump 54 or only supernatant liquid 51 is supplied so that it may be used for cutting the ground. On the other hand, the condensed mud is supplied to a mixing drum 56 via a hopper 55 and it is mixed with the improving material G in the drum 56. Thereafter the mud 51B may be supplied to the pressure jetting



pipe 20 by a pump 57 as a filling or replacing modifier material. If the supernatant liquid is used for cutting the ground in such a manner, the cutting ability is excellent since it contains fine particles. If the condensed mud is reused, the slurry treatment efficiency is then lowered. The mud 51 may be added to the improving material G without any treatment thereof.

Since the used pipe which is a single pipe and has both functions of the jetting pipe 2 and the grouting pipe 2A which are independently provided the foregoing case, the ability of execution of working is excellent. In case of the double pipe shown in Fig. 7, the outer pipe can be used for supplying the liquid for loosening the ground and the inner pipe can be used for supplying the improving material G and for supplying bore cutting water prior to the supplying of the material G.

A triple pipe 60 shown in Fig. 12 may be used. The triple pipe 60 includes an outer pipe 61, an intermediate pipe 62 and an inner pipe 63. A jetting nozzle 60 is mounted upon the outer wall and an annular air discharging slot is formed around the nozzle 64. If compressed or pressurized air of 5 kg/cm<sup>2</sup> or more is discharged from the narrow annular discharging slot 65, the mud 51 is smoothly discharged up to the ground surface by the smoothly air lift effect and the cutting ability of the ground is enhanced.

If it is desired that improving material G be positively or more grouted, the improving material G which was initially poured or grouted at a lower pressure can be grouted at a higher pressure by closing the passage for supplying the improving material G with a lid 27 as shown in Fig. 27 when the ground does not accept more grout G. The grouting degree, that is, the consolidation of the ground can be controlled while monitoring the pressure by a pressure gauge 28 at this time. It is desired that the consolidation be conducted prior to curing of the improving material G since the grout is cured or semi-cured within several hours.

Since an improved ground having a high strength can be obtained in accordance with the present invention, a pile structure having a high strength can be formed. A column arrayed pile or column arrayed wall can be formed by linking such piles. In this case, it is preferable to reinforce the improved ground by inserting one or plural reinforcing steel rods or properly shaped steel rods (hereinafter referred to as reinforcing rods). For example, as shown in Figs. 14 and 15, the column arrayed pile or column wall can be formed by burying reinforcing rods 70 including one or plural reinforcing rods or properly shaped steel members in each of improved ground Z and by overlapping the improved grounds Z. The jetting pipe which was used for feeding the improving material is left

in the ground as the reinforcing rods so that it can be used for reinforcing the improved ground.

The present invention can be embodied in combination with mechanical agitating mixing means.

For example, the ground is cut and bored to a given depth by means of a cutting rod 80 having a cutting bit 82 at the front end thereof as shown in Fig. 16. Of course, cutting and boring is preferably achieved while loosening the peripheral ground by an jetting nozzle 83 which is provided below the cutting bit 82. Then, the improving material G is dropped by gravity or is grouted under pressure in the course of extracting as shown in Fig. 18. This provides a improved ground as shown in Fig. 19. The rod 80 may be provided with agitating blades above the cutting bit 82 so that they project from the rod 80.

In the foregoing first embodiment, the reaching distance of the pressurized water is limited even if the jetting energy of the pressurized water is increased. Accordingly, it is hard to provide an improved ground having a large diameter.

Therefore, it is preferable to adopt a second embodiment which will be described hereafter if an improved ground having a large diameter is obtained.

A first example of the second embodiment will be described with reference to Figs. 1, 17 and 18. As shown in Fig. 1, a loosening pipe 2 having a cutting bit at the front end face thereof and pressurized water jetting nozzles 1 on the peripheral wall of the front end portion thereof is inserted into the ground to a predetermined depth. Thereafter, pressurized water W is jetted for loosening the target ground to form a loosened mud column under a pressure depending upon the properties of the ground (soil, softness, etc.) and the desired diameter of the ground to be improved, preferably 50 kg/cm<sup>2</sup> or higher, more preferably 80 to 350 kg/cm<sup>2</sup> in the course of extracting the loosening pipe 2 while rotating of the pipe 2 as shown in Fig. 17. The primary loosened area is represented by a reference character S1. If the improved area is below the level of the ground water, the reaching distance of the pressurized water is remarkably short. Even if water is jetted under a pressure of 200 kg/cm<sup>2</sup>, for example, extending of the reaching distance can be achieved by making the jetting pipe 2 of a double pipe and jetting air around the pressurized water like jet grouting method since the diameter of the improved ground is about 40 cm.

If this working step is completed, the jetting pipe 3 is forced into the loosened mud column as shown in Fig. 18. The jetting pipe 3 is provided in the vicinity of the front end thereof with a projecting jetting portion 30 which projects from the pipe in an

outer radial direction at least when water is jetted to increase the diameter of the improved ground. The projecting jetting portion 30 is provided with a jetting nozzle 31 for jetting pressurized water upon the loosened ground in an outer radial direction. The jetting pipe 3 is further formed at the front end beyond the projecting jetting portion 30 with a grouting opening 32 for grouting a self-curing material.

After the jetting pipe 3 has been inserted into the improved target ground, the pipe 3 is extracted from the ground in an axial direction and rotated around the axis of the pipe as shown in Fig. 18. In the course of this extraction of the pipe, the ground which is in the outer jetting direction of the jetting nozzle 31 is loosened with the jetting pressurized water from the jetting nozzle 31 while the projecting jetting portion 30 projects in an outer radial direction. Thus loosened area will be referred to as secondary loosened area and is represented by a reference character S2.

While the loosened ground is formed, a improved body A is formed by pressure grouting the above mentioned self-curing material G of dry consistency. Formation of the improved body A is conducted up to the ground surface or a predetermined depth position.

In this case, pressure grouting of the self-curing grout is conducted while the jetting pipe 3 is gradually extracted upward from the bottom of the mud column in such a manner that the self-curing grout G is gradually deposited upon the bottom. Grouting should be conducted while a predetermined depth of the immersion of the jetting pipe 3 in the self-curing material G is kept. The immersion depth is preferably 30 cm or more, more preferably 50 cm or more.

In the first example of the second embodiment, the loosening pipe 1 and jetting pipe 3 are separately used. A second example in which formation of the primary and secondary loosened areas S1 and S2 and grouting of the self-curing material G is conducted by the same jetting pipe 3A is illustrated in Figs. 19 and 20.

The jetting pipe 3A in the second example of the second embodiment comprises inner and outer pipes 33 and 34 shown in Fig. 21, for example, as main components. A passage member 35 is provided between the inner and outer pipes 33 and 34 in such a manner that a passage for the self-curing material G is formed in the inner pipe 33 and passages of the pressurized water for the first and second jetting nozzles 31A and 31B are formed.

The first jetting nozzle 31A is provided on the outer periphery of the jetting pipe 3A. An outwardly radially projecting jetting portion 30 is integral with the outer pipe 34 above the first jetting nozzle 31A

similarly to the above mentioned first example. The radially projecting jetting portion 30 is provided with a second jetting nozzle 31B for jetting pressurized water in an outer radial direction beyond the outer end of the projecting jetting portion 30. The jetting pipe 3A is further formed with a self-curing material grouting opening 32 at the front end thereof below the first jetting nozzle 31A.

If such a jetting pipe 3A is used, the jetting pipe 3A is inserted to a predetermined depth of the ground while jetting pressurized water from the first jetting nozzle 31A as shown in Fig. 19. At this time, cutting and boring water is discharged from the grouting opening 32. If the jetting pipe 3A reaches at the predetermined depth, pressurized water is jetted from only the second jetting nozzle 31B and the self-curing material G is grouted from the grouting opening 32 while rotating and extracting the jetting pipe 3A as shown in Fig. 20 so that the secondary loosened area S2 is formed around the primary loosened area S1. An improved ground A having a predetermined length is formed of the self-curing material G.

Figs. 22 and 23 show a third example of the second embodiment. Prior to insertion of the jetting pipe 3 into the ground, boring is preliminarily conducted by using a casing having a diameter which is larger than the distance between the front end of projecting jetting portion 30 and the axis of the jetting pipe. Thereafter, the jetting pipe 3 is inserted into the casing 4 and the casing 4 is then removed. The ground is loosened by jetting pressurized water from the jetting nozzle 31 and the self-curing grout G is pressure grouted from the grouting opening 32 while rotating and extracting the jetting pipe 3.

In accordance with the present invention, a plurality of, for example two radially projecting jetting portions which are spaced in a longitudinal direction of the pipe may be provided as shown in Fig. 24. In this case, insertion area for the projecting jetting portion 30A is formed by loosening of the ground by pressure water from the first jetting nozzle 31A. The insertion area for the radially projecting branch 30B is formed by the pressurized water from the second jetting nozzle 31B. Finally, pressurized water from the third jetting nozzle 31C forms an improved ground having a diameter larger than the projecting length of the projecting jetting portion 30B. In this example, it is not necessary to insert the jetting pipe 3 again after the ground is firstly loosened by the loosening pipe 1 unlike the first example of the second embodiment. Insertion of the jetting pipe 3 loosening of the ground and grouting of the self-curing material from the grouting opening 32 after reaching at the lowermost position can be carried out by using only the jetting pipe 3C.

Developing this concept, an example shown in Fig. 25 is possible in which, for example, cone shaped projecting jetting portion 30C is provided and jetting nozzles 31E ... which are provided on the sloped surface thereof are used for loosening the ground so that the jetting pipe 31 can be inserted and pressurized water is jetted toward the peripheral ground from jetting nozzles 31D on the outermost periphery thereof.

Alternatively, jetting nozzles 31E which face downward may be provided on the lower surface of a radially projecting jetting portion 30 and may be used for loosening the ground so that the jetting pipe 3C can be inserted as shown in Fig. 26.

Fig. 27 shows an example in which an agitating blade 40 is provided above the projecting jetting portion 30. The agitating blade 40 will further loosen the loosened ground. The blade can be used as an indexing member for determine the resistance of the ground since it can be determined that the loosened ground does not have a pre-determined value if the resistance of the ground against the rotation of the jetting pipe 3C is excessively high.

Although the projecting jetting portion initially projects in an outer radial direction from the pipe in the foregoing examples, it suffices for the projecting jetting portion to project in a outer direction from the pipe at least when it jets pressurized water to enlarge the diameter of the loosened ground. As shown in Figs. 28 and 29, the jetting portion does not project from the pipe up to a given depth. For example, a blade having a blade expanding link mechanism blade 41 is provided below a given depth. The expanding link mechanism blade can be expanded as shown in Fig. 29 at the time when the diameter is desired to be increased.

Forcing the outer pipe 42 downward from the ground surface enables the blade to be expanded. A reference numeral 43 denotes a bore cutting blade.

If the diameter of the improved body is increased only over a given length of the pipe in a depth direction of the ground, the diameter of the bore in the vicinity of the ground surface may be smaller while the diameter of the formed improved ground may be larger as shown in Fig. 30.

In the example of Fig. 24, 27, 16, an improved ground is formed by pressure grouting the self-curing grout from the grouting opening 32 of the jetting pipe which has been inserted to a given depth. Although it is possible to pressure grout the self-curing material by means of the separate exclusively used pressure grouting pipe. Easiness of execution of work is remarkably lowered.

If the lowermost jetting nozzle is separated from the self-curing grout grouting opening 32 at

a distance of at least about 50 cm, preferably 1 m or more in the foregoing examples, no interference between the pressurized water and the self-curing grout G arises resulting in that an excellent improved ground can be obtained.

Also in the second embodiment, mud which was generated by loosening of the ground and pressure grouting of a self-curing material is separated into supernatant liquid and condensed mud and thereafter the supernatant liquid may be used. This example is shown in Fig. 31.

In other words, a mud pit 50 is provided in the vicinity of the base or upper end of the pressure jetting pipe 3. The mud 51 which has been lifted between the pressure jetting pipe 20 and the bore wall by the replacement with the self-curing material G is pumped out by a pump 52 and is separated into supernatant liquid 51A and condensed mud 51B. The supernatant liquid 51A is temporarily reserved in a tank 58 by a pump 54 so that it will be used as pressurized water for forming next loosened mud column. Using the supernatant liquid for cutting the ground makes the cutting efficiency higher since it contains fine particles.

On the other hand, the condensed mud 51B is supplied to a mixing drum 56 via a hopper 55, where it is mixed with the self-curing material G. Thereafter the mixture can be supplied to the pressure jetting pipe 20 as filling or replacing self-curing grout by the pump 57. If the condensed mud is reused, the treatment of the muddy water is correspondingly reduced. The mud 51 can be directly added to the self-curing material G without being treated.

Since an improved ground having a high strength can be obtained in accordance with the present invention, a pile having a high strength can be formed. Various column arrayed piles or column arrayed walls (continuous wall) can be formed as shown in Fig. 32 by linking these columns. In this case, it is preferable to reinforce the improved ground by inserting one or plural reinforcing rods or properly shaped steel members into the improved ground as well as forming the improved ground of only the self-curing material. When a column arrayed pile or a column arrayed wall is formed, the plural jetting pipes are held by a single lifting machine since each of the pipes has a small diameter and a light weight. An improvement in the ground can be achieved by jetting pipes simultaneously.

After the ground has been loosened in the foregoing example, only grouting of the self-curing grout may be conducted while jetting of the pressurized water from the jetting pipe is stopped and the jetting pipe is fixed at the depth position.

In a third embodiment of the present invention, a mud column is formed while inserting a jetting

pipe having a projecting jetting portion into the ground without preliminarily forming a mud column.

A first example of the third embodiment will be described with reference to Figs. 19 and 20. A jetting pipe 3A has a bore cutting bit at the front end face thereof and a pressurized water jetting nozzle 31A on the peripheral wall in the vicinity of the front end thereof. The jetting pipe 3A is further provided with a projecting jetting portion 30 which projects in an outer radial direction at least when the diameter of the loosened ground is increased by jetting. The projecting jetting portion 30 is provided with a jetting nozzle 31B for jetting pressurized water outwardly with respect to an axis and the jetting pipe 3A is formed with a self-curing grout grouting opening 32 at the front end below the jetting nozzle 31A.

Such a jetting pipe 3A is inserted into the ground at a predetermined depth while rotating the pipe and jetting pressurized water from the first jetting nozzle 31A as shown in Fig. 19 so that the reaching distance is as long as or longer than the length of the projecting jetting portion 30. At this time, bore cutting water may be discharged from the grouting opening 32 according to needs. The ground is loosened by jetted pressurized water and a mud column which is referred to as primary loosened area S1 is formed.

If the jetting pipe reaches a given depth, a secondary loosened area S2 is formed around the primary loosened area S1 by jetting pressurized water from only the second jetting nozzle 31B and the self-curing material G is grouted from the grouting opening 32 while rotating and extracting the jetting pipe 3A. An improved body A having a predetermined length is formed of the self-curing material G.

The pressurized water W from both jetting nozzles 31A and 31B may be at a pressure of 80 to 350 kg/cm<sup>2</sup> depending upon the nature of the ground (soil, softness, etc.) and the diameter of the desired improved body similarly to the foregoing examples.

#### (Experimental Example)

The present inventors made experiments for improvement in crushed stone dust buried ground as follows: ground loosening liquid: pressurized water (pressure 200 kg/cm<sup>2</sup>), the rate of jetted water: 80 liter/minute, cutting speed: 30 minutes/m, used improving materials: cement, bentonite, sand cement-bentonite mortar. On the other hand, an improvement was made by so-called CCP work as a comparative example.

After several days since the execution of work, solidified body was dug out for observing the improved condition thereof. The resultant body of the

present invention had the configuration shown in Figs. 33 and 34. In contrast to this, a resultant solidified body of the comparative example was irregular in configuration as shown in Figs. 35 and 36. A multiplicity of lumps of earth were left in the solidified body as shown in the drawing so that the uniformity of the body was poor. The experiments showed that an improved solidified body having an ideal configuration could be provided in accordance with the present invention in comparison with the prior art.

#### Industrial Utilization

As mentioned above, the present invention provides an advantage in that a uniform and firm improved body having an enhanced strength can be formed at a limited or desired position due to solidification effect by execution of work using a simple and compact facility. Further an improved body of the ground having a large diameter can be positively formed.

#### Claims

1. A method of improving or strengthening the ground comprising,
  - grouting a self-curing material of dry consistency into the loosened ground while or after loosening the target ground by jetting pressurized water from a pressurized liquid jetting nozzle provided on an jetting pipe at the front end thereof, which is inserted into the ground.
2. A method of improving or strengthening the ground as defined in Claim 1 in which said self-curing material of dry consistency has a slump value which is 15 cm or less.
3. A method of improving or strengthening the ground as defined in Claim 1 in which the time when the ground is loosened with pressurized liquid is different from the time when a self-curing material is grouted.
4. A method of improving or strengthening the ground as defined in Claim 1 in which said jetting pipe is formed with a grouting opening at the front end thereof and is provided with a jetting nozzle at the position closer to base end side thereof than the grouting opening and in which loosening of the ground and grouting of the self-curing material is simultaneously carried out during extracting of the jetting pipe.
5. A method of improving and strengthening the ground as defined in Claim 1 in which the

jetting pressure of the pressurized liquid from the pressurized liquid jetting nozzle is 50 kg/cm<sup>2</sup> or more.

6. A method of improving and strengthening the ground as defined in Claim 1 in which said liquid for loosening the ground includes water and a surfactant which is added to water. 5
7. A method of improving and strengthening the ground as defined in Claim 1 in which said jetting pipe has two passages therein, one of the passages being used for supplying the liquid to loosen the ground and the other passage being used for supplying bore cutting water during boring of the ground and for supplying the self-curing material after loosening of the ground. 10 15
8. A method of improving and strengthening the ground as defined in Claim 1 in which said jetting pipe has two passages therein, a first passage being used for supplying the liquid for loosening the ground, a second passage being used for supplying compressed air for enhancing the cutting ability of the ground with the loosening liquid, and a third passage being used for supplying the self-curing material after loosening of the ground. 20 25
9. A method of improving and strengthening the ground as defined in Claim 1 in which reinforcing rods are inserted into a target area of the ground to be improved and are buried in an improved body to form a pile or wall. 30 35
10. A method of improving and strengthening the ground as defined in Claim 1 in which the target ground is loosened by jetting of pressurized liquid so that the ground is converted into mud and the mud is lifted upward and is removed by grouting of a self-curing material for forming an improved body. 40
11. A method of improving and strengthening the ground as defined in Claim 10 in which the removed mud is added to the self-curing material to make a material which will form an improved body. 45 50
12. A method of improving and strengthening the ground as defined in Claim 10 in which the removed mud is separated into supernatant liquid and condensed mud and the supernatant liquid is directly reused or added to water for reutilization as liquid for loosening the ground. 55
13. A method of improving and strengthening the ground as defined in Claim 10 in which the removed mud is separated into supernatant liquid and condensed mud and said condensed mud is added to the self-curing material for the reutilization of a material which will form an improved body.
14. A method of improving or strengthening the ground characterized in that it comprises providing a jetting pipe which is provided at the front end portion thereof with a projecting jetting portion which projects in an outer direction from the jetting pipe at least when pressurized water is jetted toward the ground to increase the diameter of the loosened ground, said projecting jetting portion being provided with a jetting nozzle for jetting pressurized water toward the ground in an outer direction with respect to the axis of an improved body to be formed, said jetting pipe being formed with a self-curing material grouting opening at a position closer to the front end thereof than said jetting nozzle, inserting said jetting pipe into a target ground to be improved; jetting pressurized water from said jetting nozzle with said projecting jetting portion projecting in an outer direction from said jetting pipe while rotating said jetting pipe around the axis thereof and extracting said jetting pipe in an axial direction thereof to loosening the ground which is located in an outer jetting direction from said nozzle for forming a loosened mud column of the ground, and grouting a self-curing material of dry consistency from said grouting opening into said loosened mud column during or after forming said loosened mud column, whereby to form an improved body.
15. A method of improving or strengthening the ground characterized in that it comprises providing a jetting pipe which is provided on the outer peripheral surface at the front end portion thereof with a first jetting nozzle for jetting pressurized water in a radial direction and is provided at the front end portion thereof with a projecting jetting portion which projects in an outer direction from the jetting pipe at least when pressurized water is jetted toward the ground to increase the diameter of the loosened ground, said projecting jetting portion being provided with a second jetting nozzle for jetting pressurized water toward the ground beyond the outer end of the projecting jetting portion in an outer direction with respect to the axis of an improved body to be formed, said

jetting pipe being formed with a self-curing material grouting opening at a position closer to the front end thereof than said jetting nozzle, inserting said jetting pipe into a target ground to be improved;

jetting pressurized water from said second jetting nozzle with said projecting jetting portion projecting in an outer direction from said jetting pipe while rotating said jetting pipe around the axis thereof and extracting said jetting pipe in an axial direction thereof to loosening the ground which is located in an outer jetting direction from said second jetting nozzle for forming a loosened mud column of the ground, and grouting a self-curing material of dry consistency from said grouting opening into said loosened mud column during or after forming said loosened mud column, whereby to form an improved body.

16. A method of improving or strengthening the ground as defined in Claim 15 in which the reaching distance of the pressurized water from said first jetting nozzle is made longer than the projecting length of the projecting jetting portion and said jetting pipe is inserted into the ground while loosening the ground by jetting pressurized water from at least the first jetting nozzle.

17. A method of improving or strengthening the ground as defined in Claim 2 including inserting said jetting pipe into a casing while or after a bore having a radius which is larger than the distance between the front end of said projecting jetting portion and the axis of said jetting pipe is bored by using a casing; removing the casing; and loosening the ground by jetting the pressurized water from the first jetting nozzle so that the pressurized water reaches beyond a position where the outer surface of said casing was located and loosening the ground by jetting pressurized water also from a second jetting nozzle so that the reaching distance of the pressurized water is longer than that from the first jetting nozzle.

18. A method of improving or strengthening the ground as defined in Claim 14 or 15 in which said projecting jetting portion is collapsible between a folded position and an externally extended position along the axis of the jetting pipe by an operation from the ground surface, the projecting jetting portion being folded when the jetting pipe is inserted and being extended when the pressurized water is jetted from the jetting nozzle provided on the projecting jetting portion.

19. A method of improving or strengthening the ground characterized in that it comprises

providing a jetting pipe which is provided at the front end portion thereof with a projecting jetting portion which projects in an outer direction from the jetting pipe at least when pressurized water is jetted toward the ground to increase the diameter of the loosened ground, said projecting portion or the jetting pipe being provided at a position below the projecting jetting portion with a jetting nozzle for jetting pressurized water so that the ground area which is at least as long as the projecting length of the projecting jetting portion is covered, and said jetting pipe is provided with a self-curing material grouting opening at the position closer to the front end thereof than a lowermost jetting nozzle;

inserting the jetting pipe into the ground;

jetting pressurized water from said jetting nozzle over a range between a given depth and the other depth to loosen at least the ground area corresponding to the projecting length of said projecting jetting portion for forming a loosened mud column; and

thereafter grouting a self-curing material of dry consistency under pressure into said loosened mud column from said grouting opening at said depth or while the jetting pipe is extracted.

20. A method of improving and strengthening the ground as defined in Claim 19 in which said jetting nozzle is provided on the projecting jetting portion in such a manner that it opens downward.

21. A method of improving and strengthening the ground as defined in Claim 19 in which said jetting nozzle is provided on the outer surface of the jetting pipe at a position below the projecting jetting portion in such a manner it opens in a radial direction.

FIG. 1

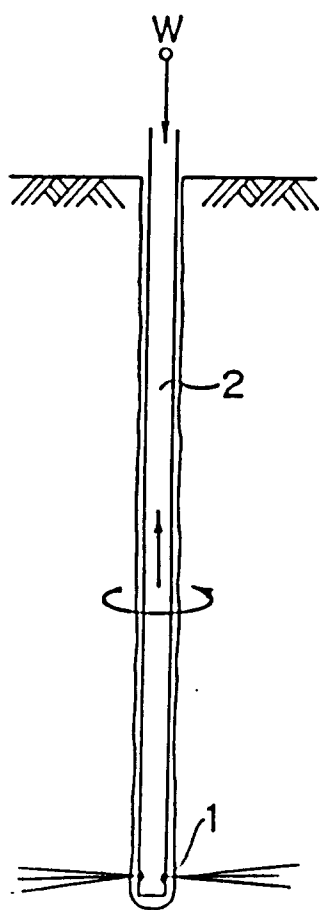


FIG. 2

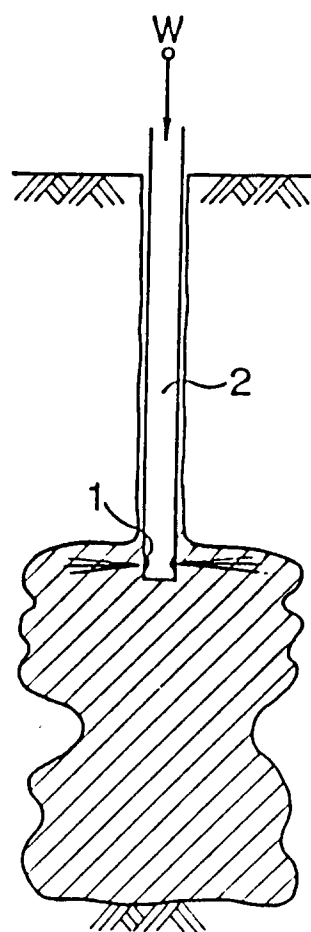


FIG. 3

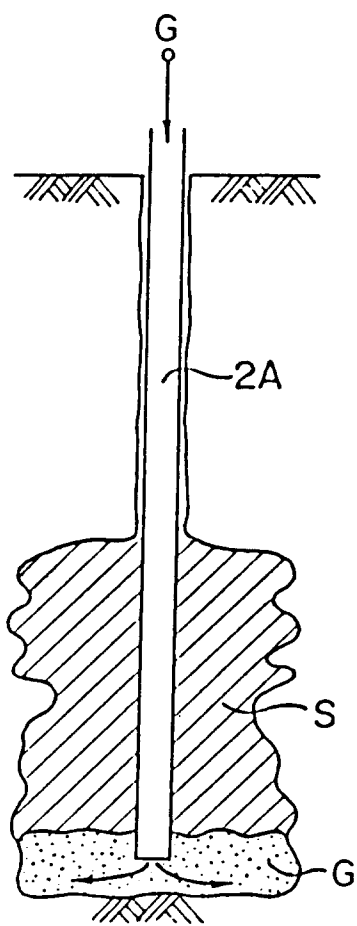


FIG. 4

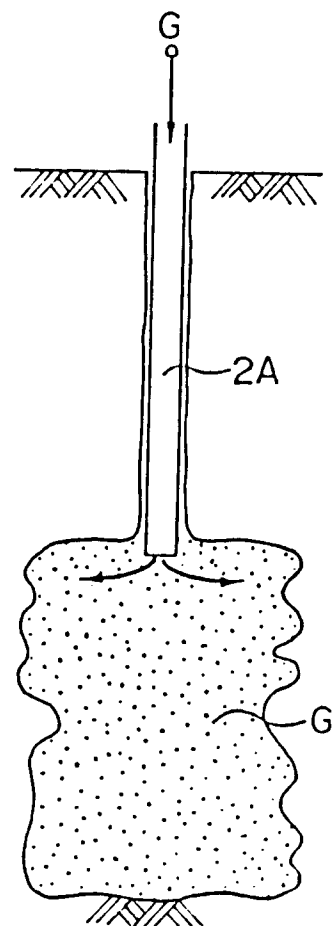




FIG. 5

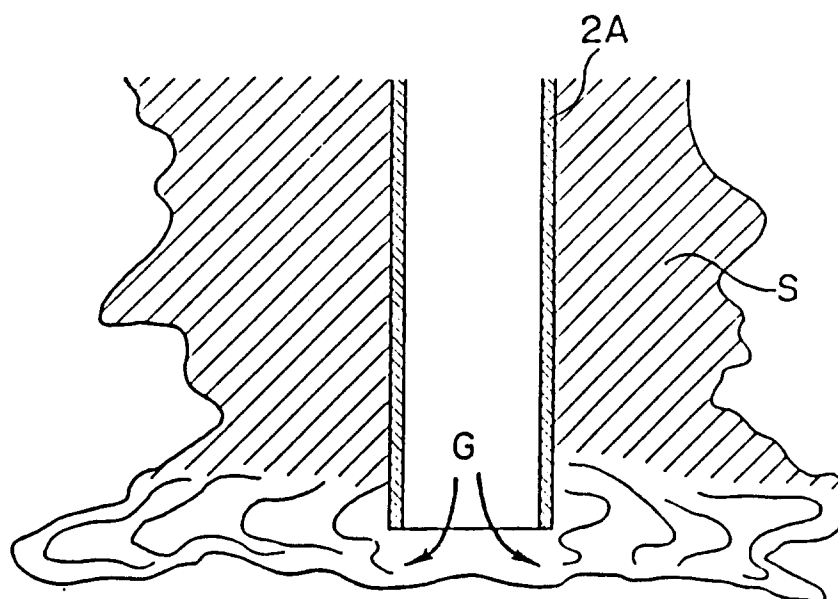


FIG. 6

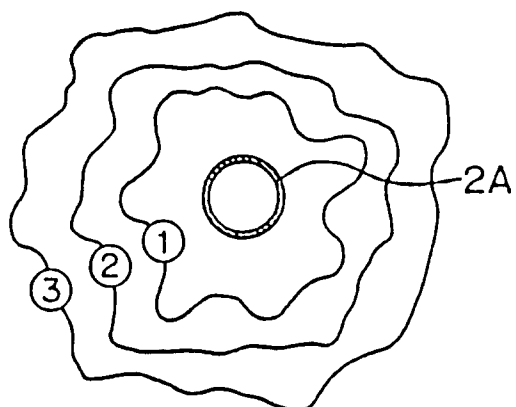


FIG. 7

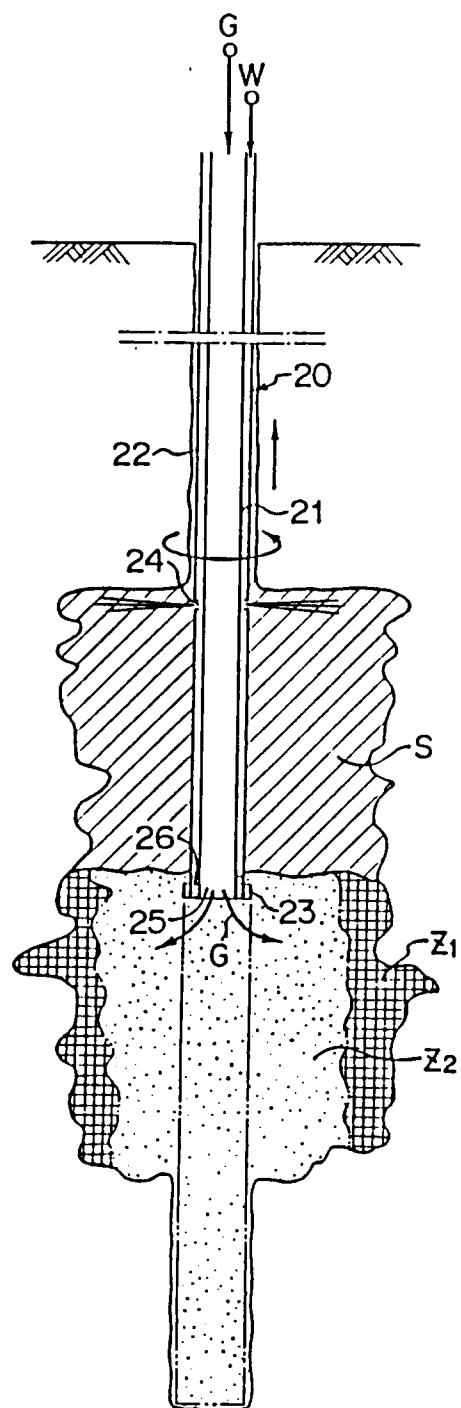


FIG. 8

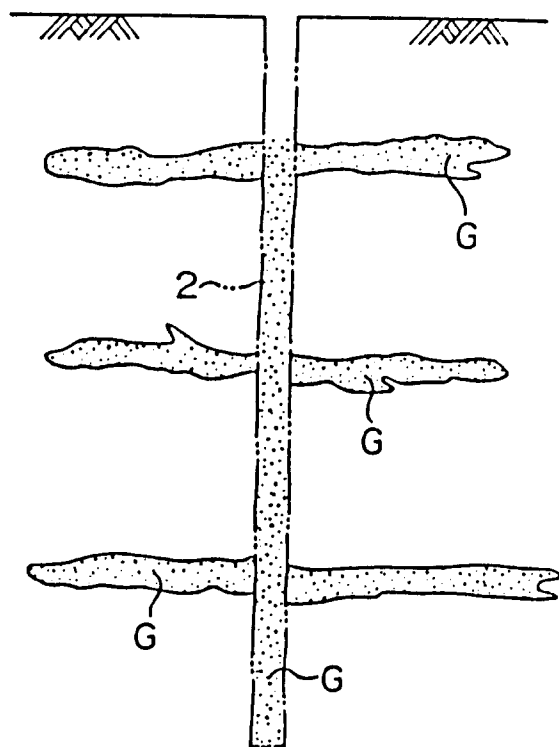


FIG. 9

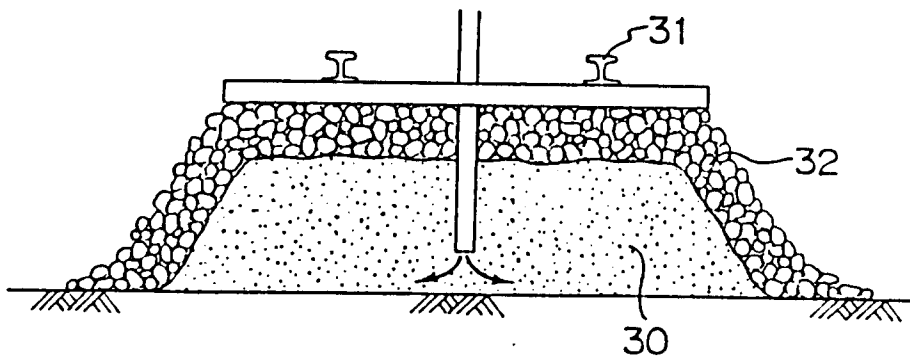


FIG. 10

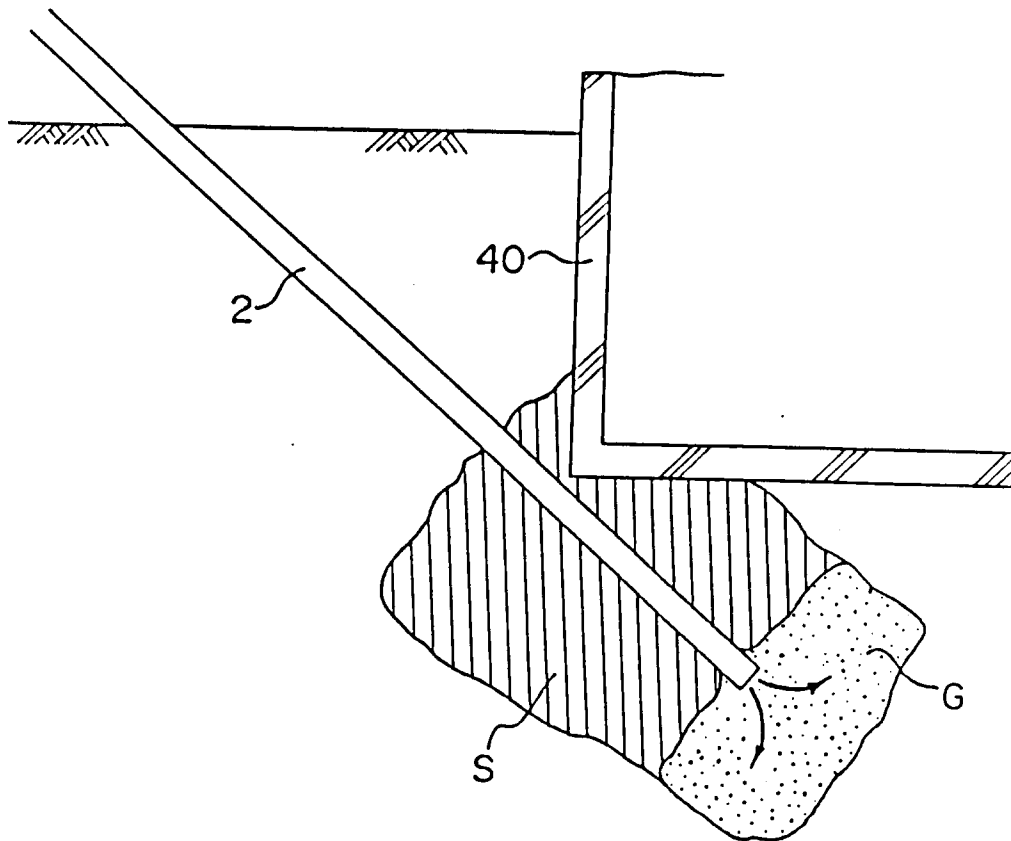


FIG. 11

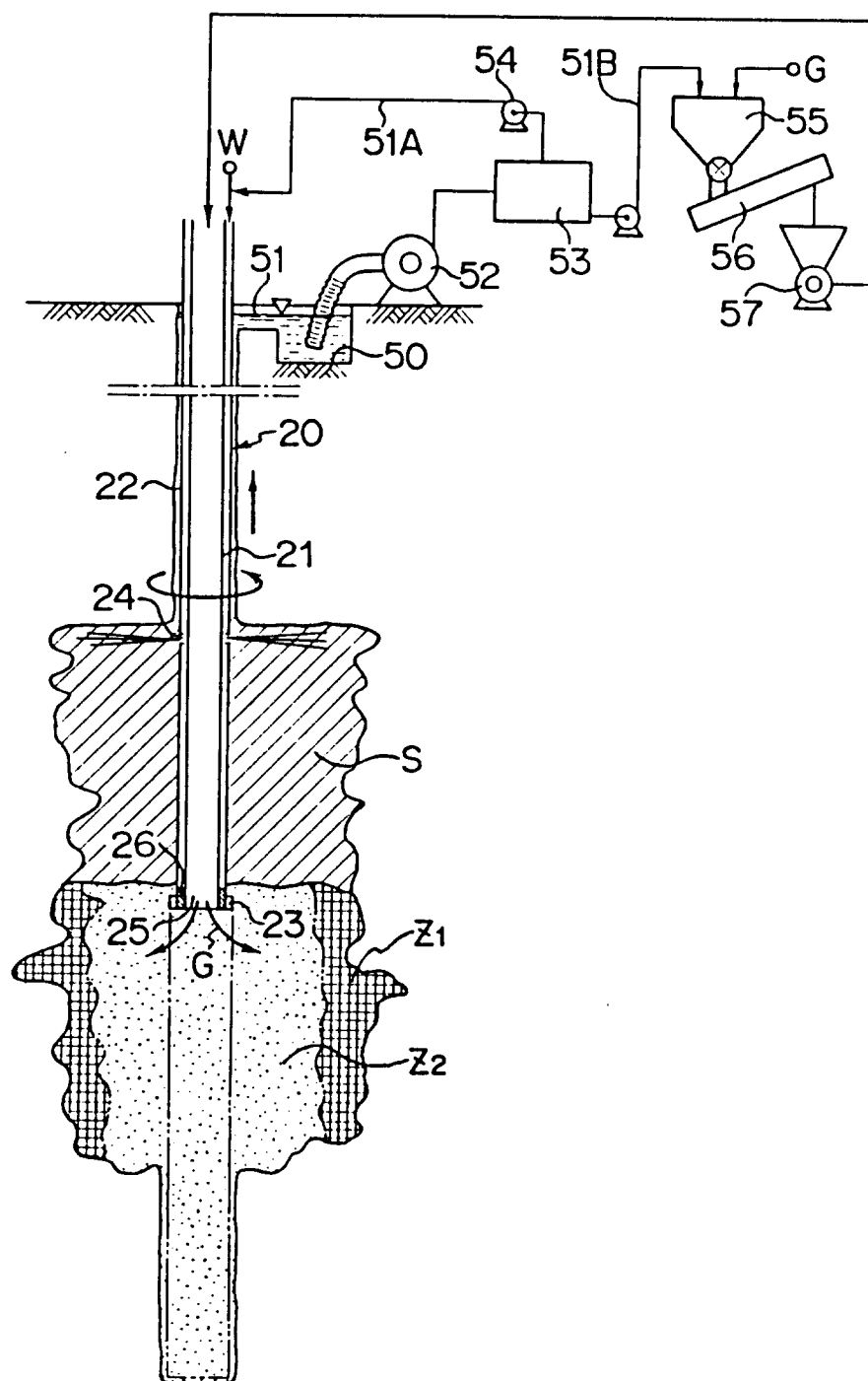


FIG. 12

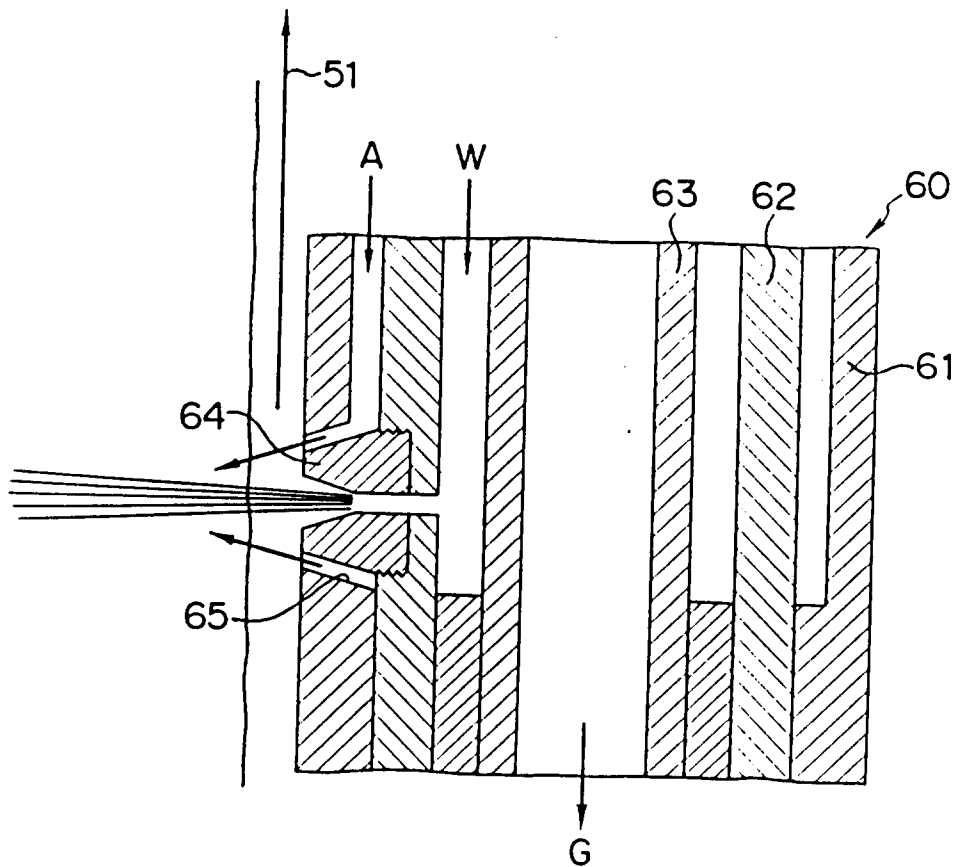


FIG. 13

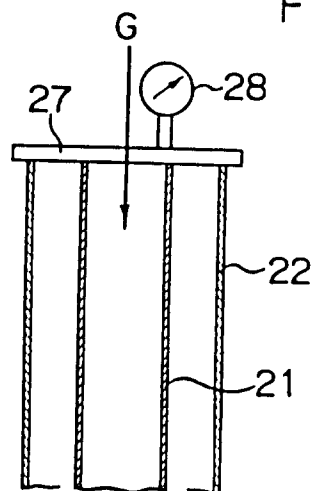


FIG. 14

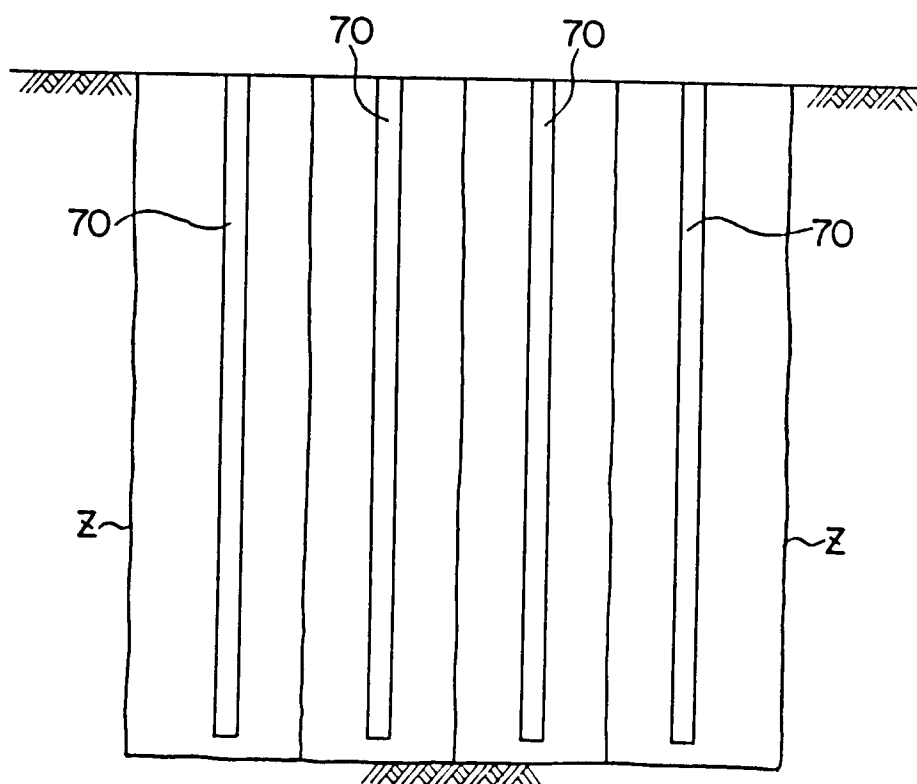


FIG. 15

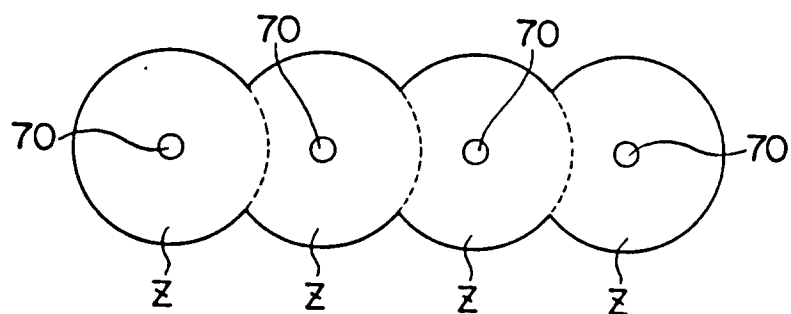


FIG. 16

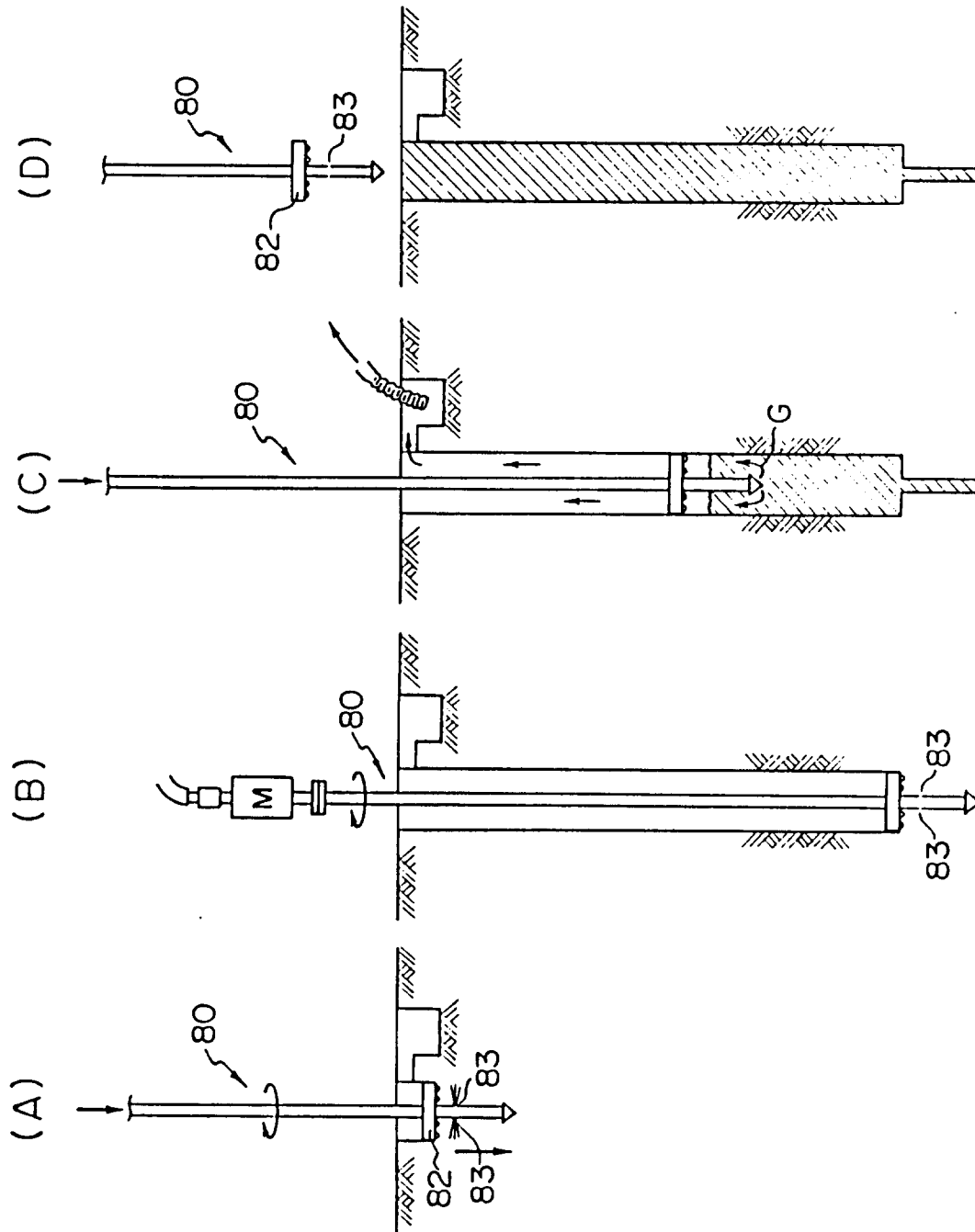




FIG. 17

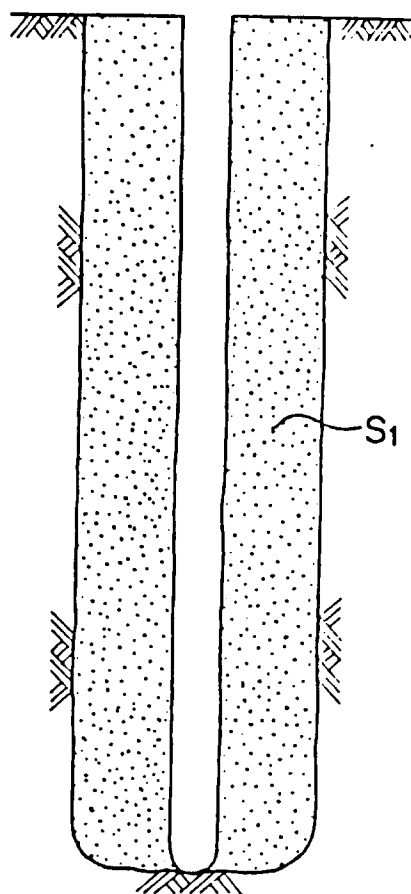


FIG. 18

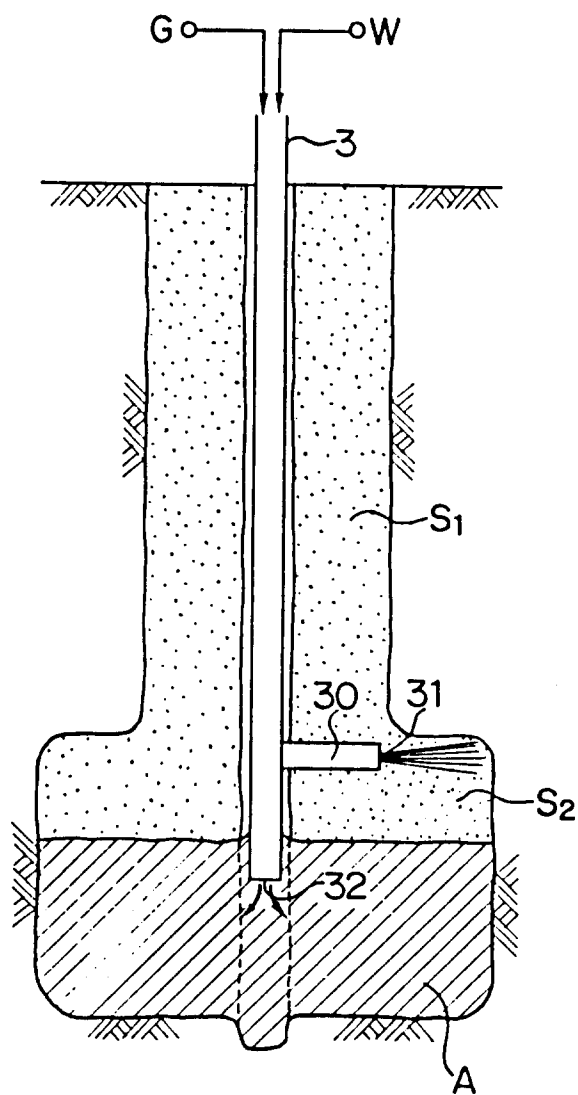


FIG. 19

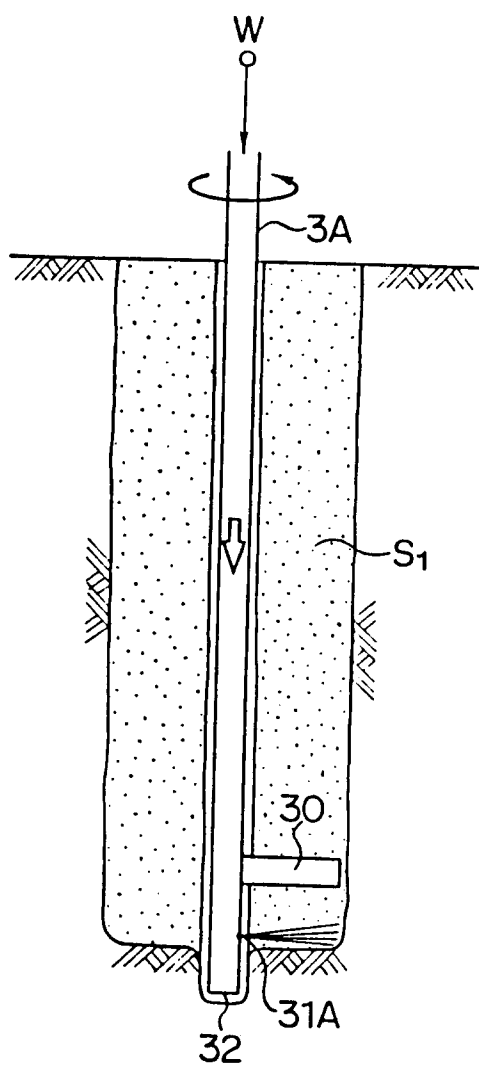


FIG. 20

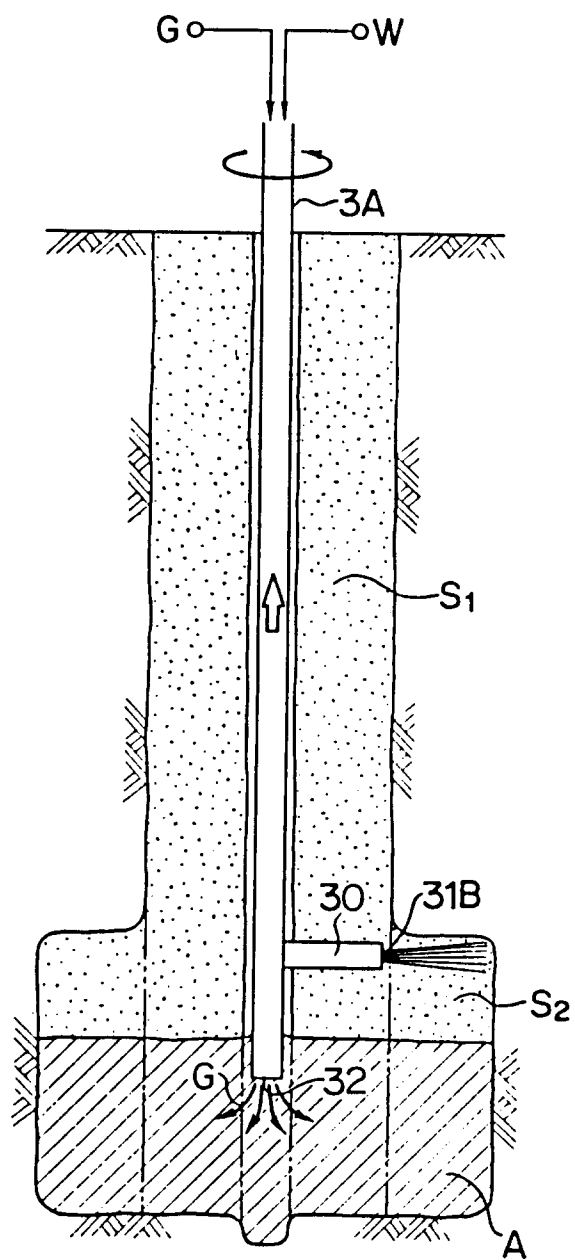


FIG. 21

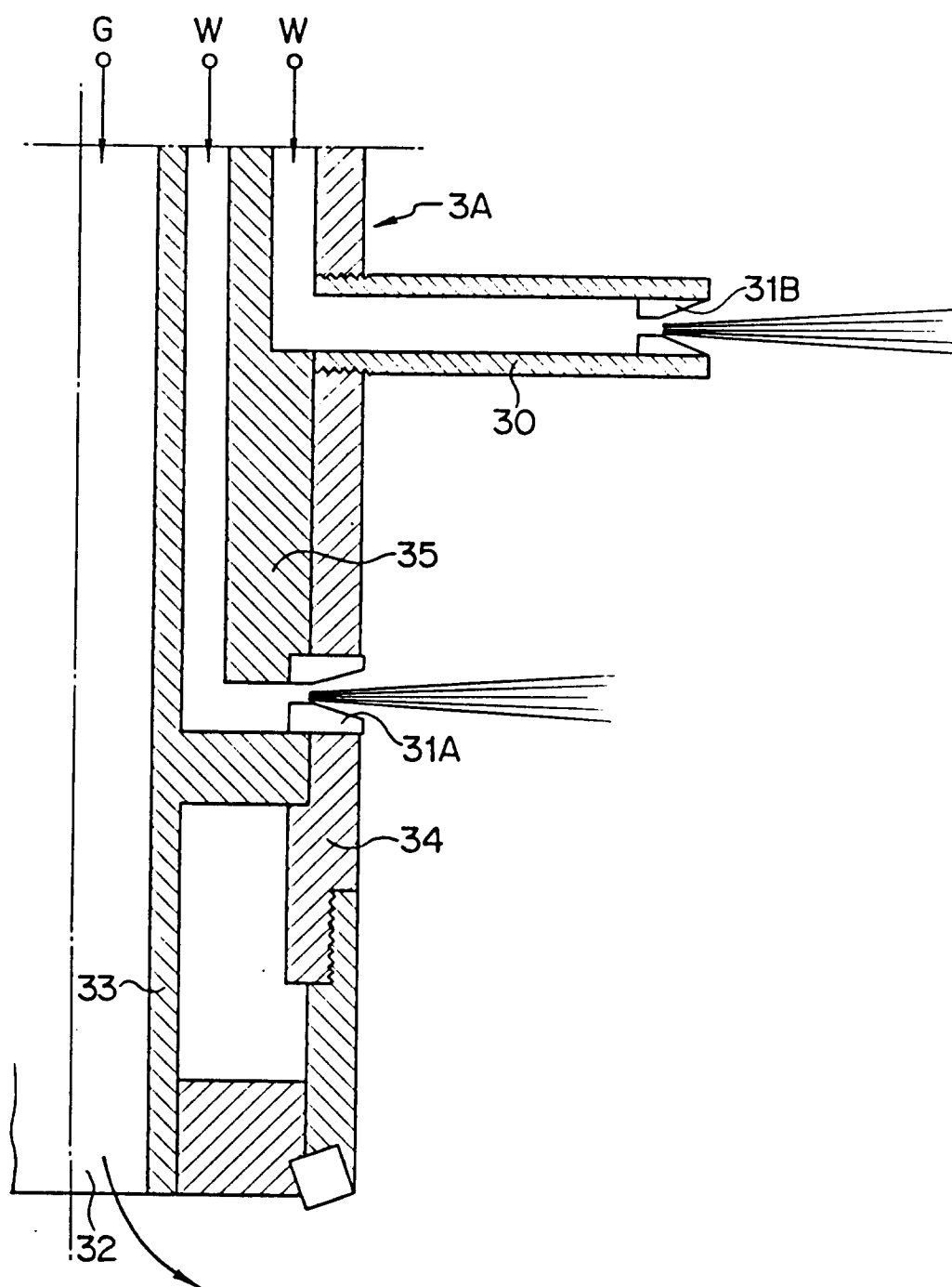


FIG. 22

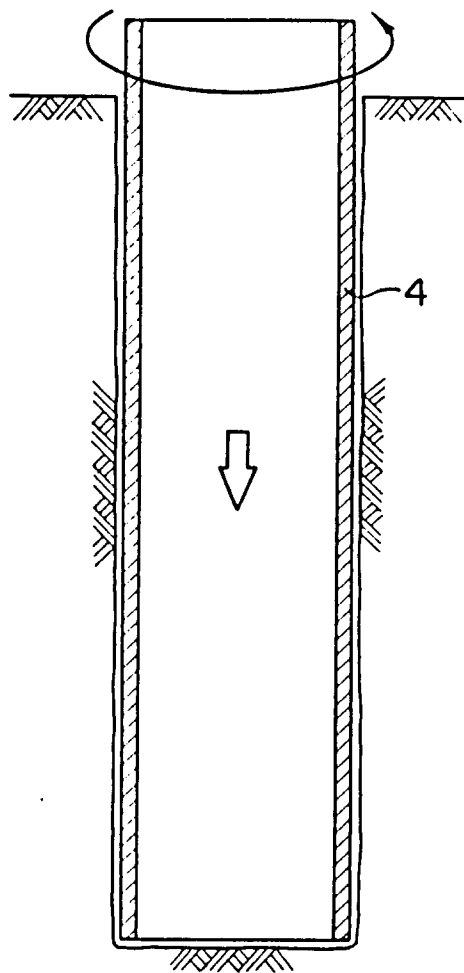


FIG. 23

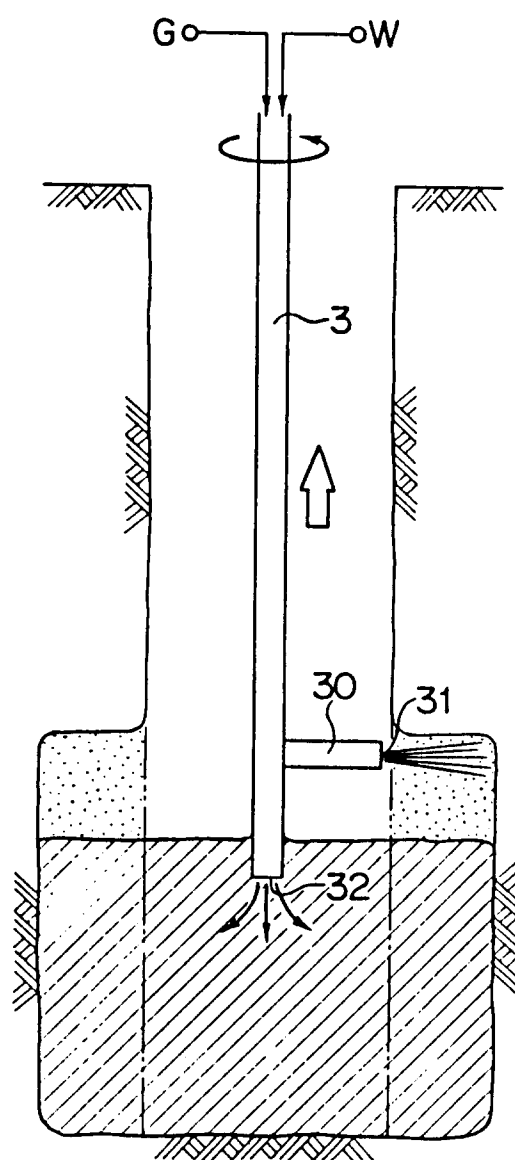


FIG. 24

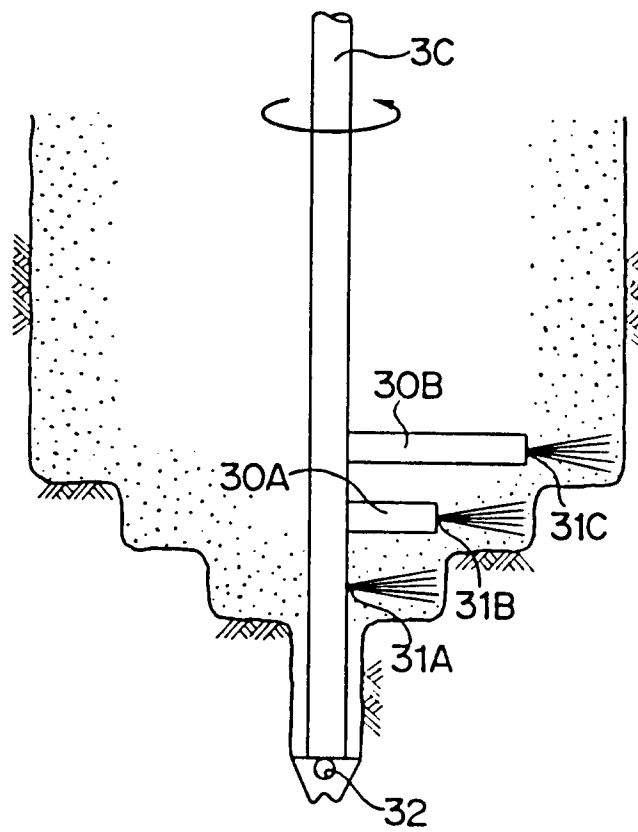




FIG. 25

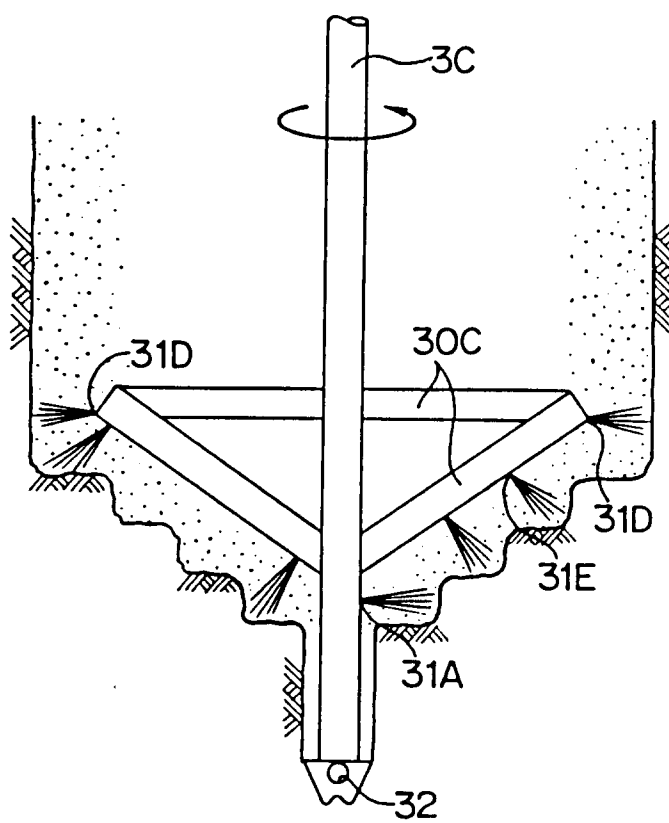


FIG. 26

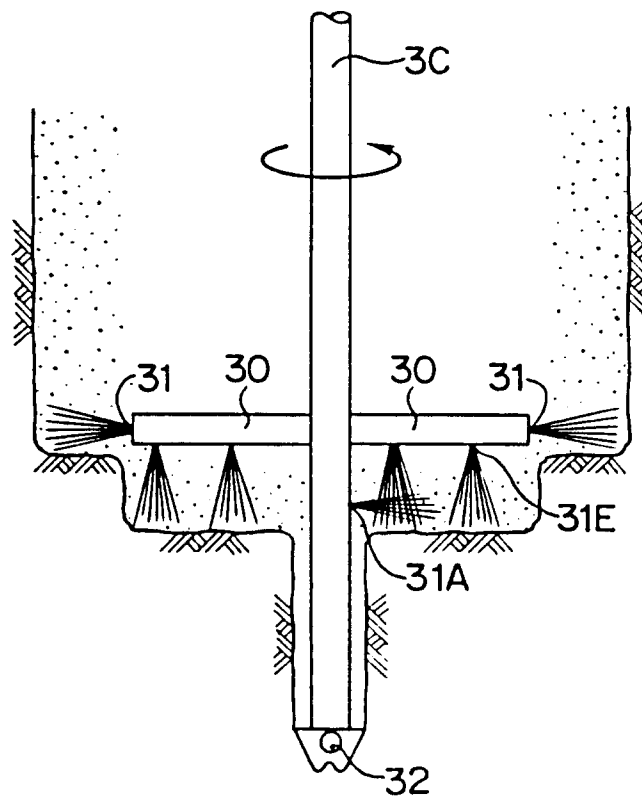


FIG. 27

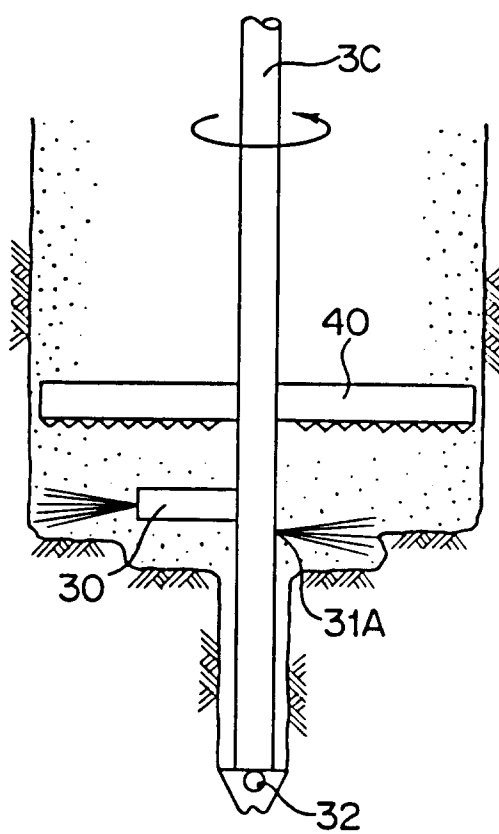


FIG. 28

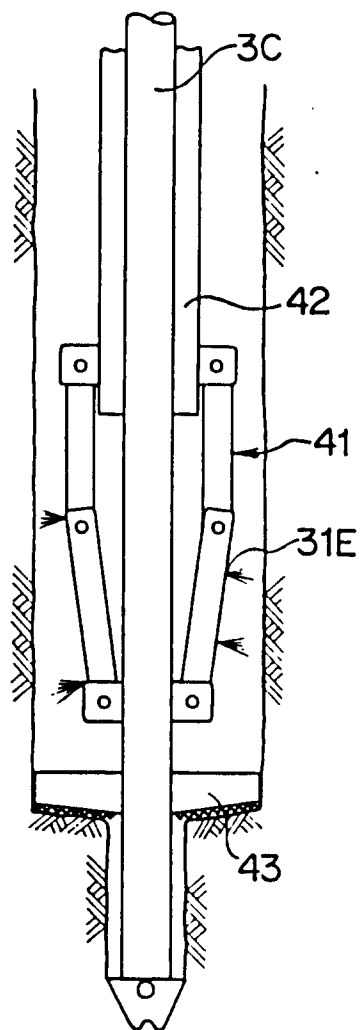


FIG. 29

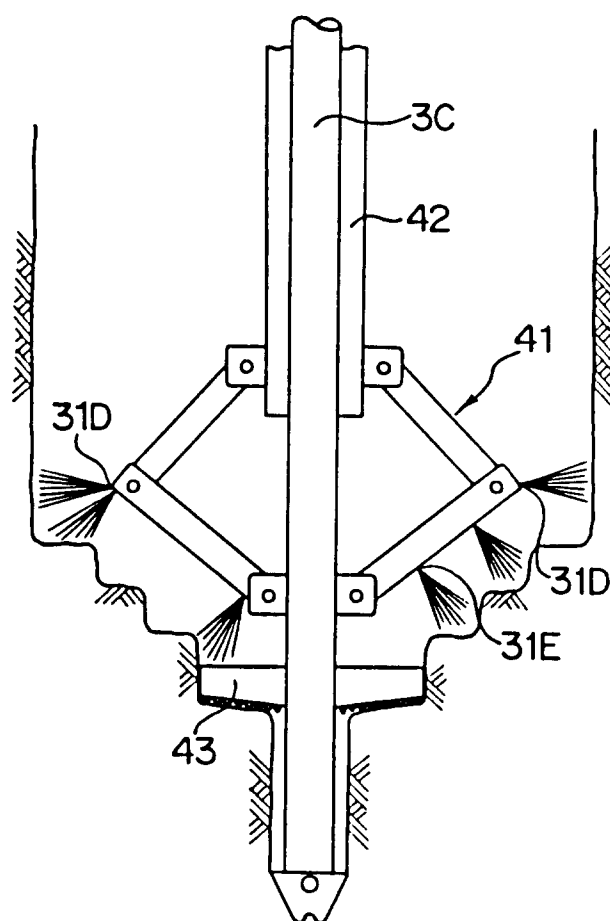


FIG. 30

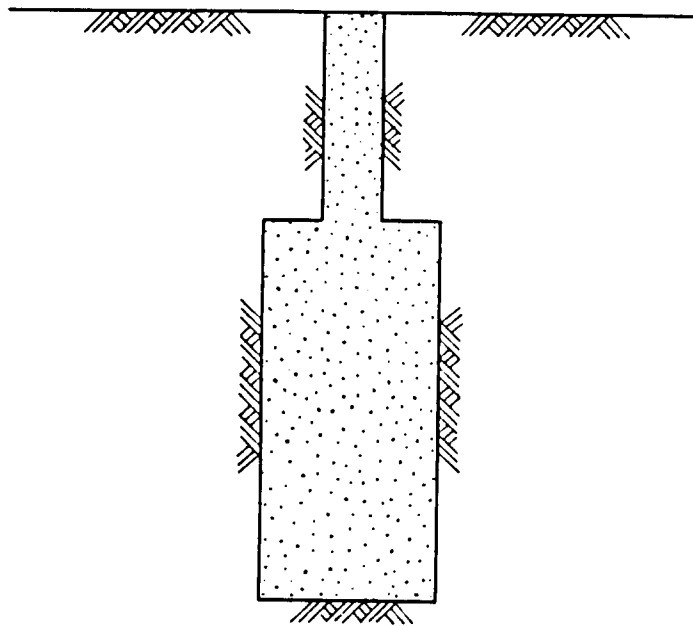


FIG. 31

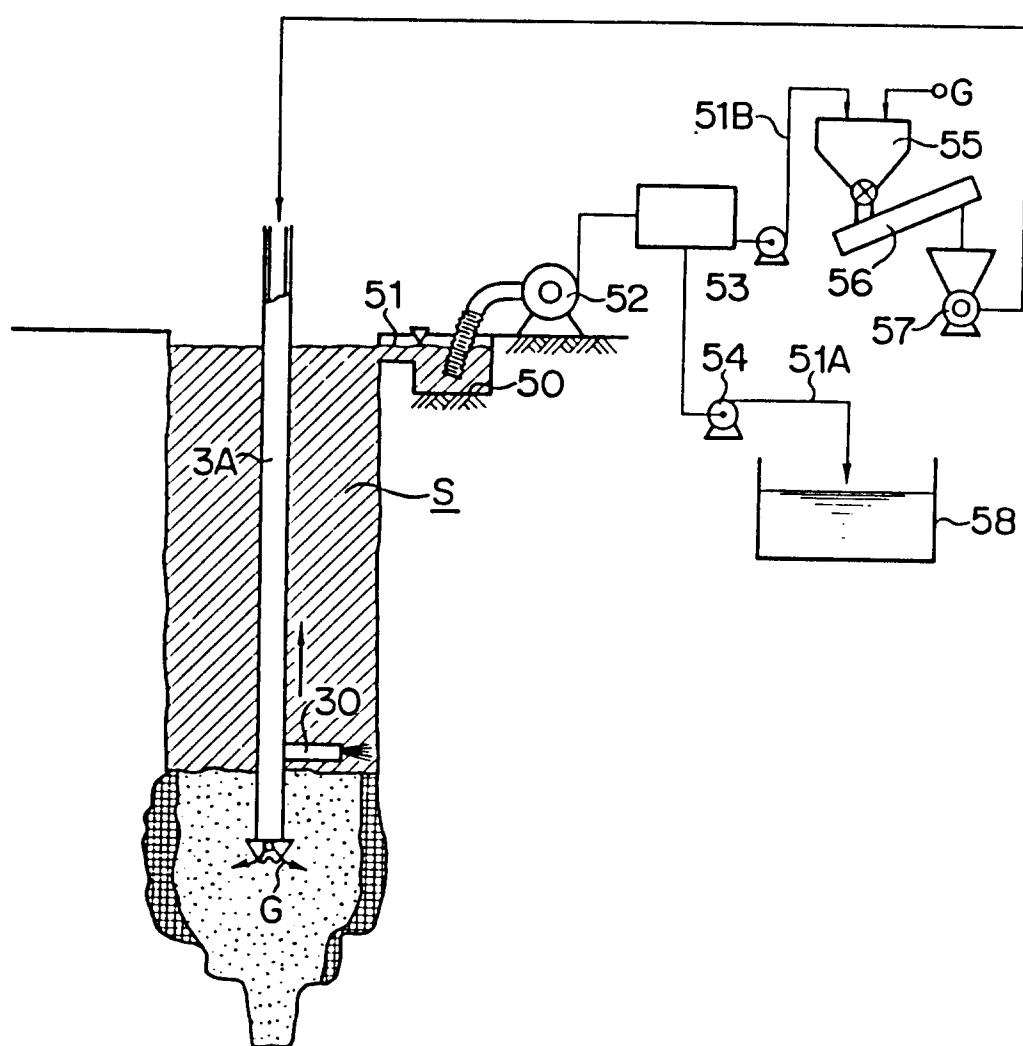
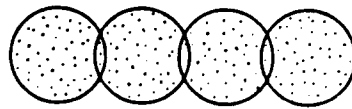
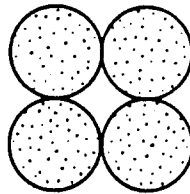


FIG. 32

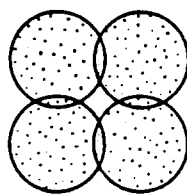
(A)



(B)



(C)



(D)

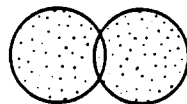




FIG. 33

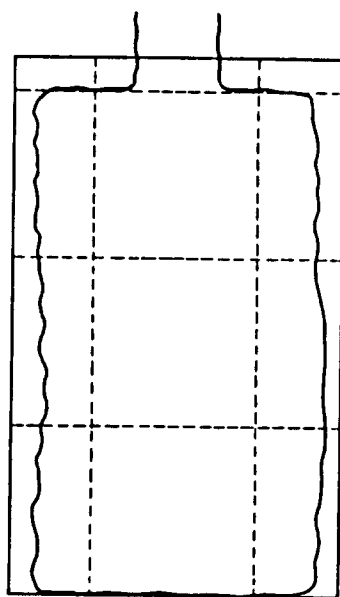


FIG. 34

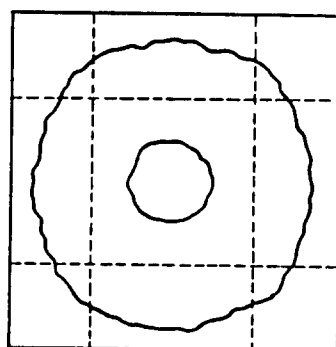


FIG. 35

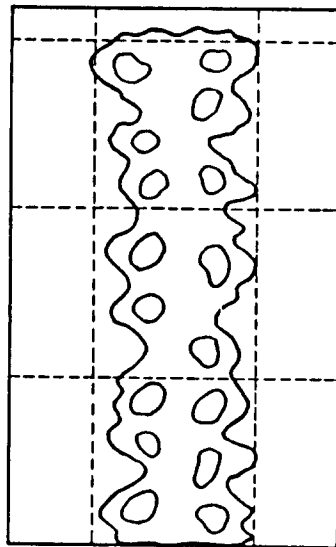
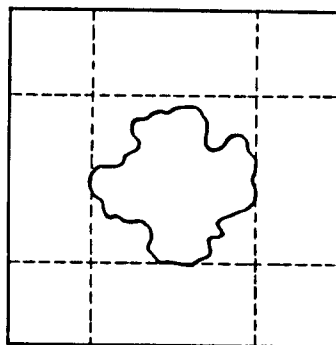


FIG. 36



# INTERNATIONAL SEARCH REPORT

International Application No PCT/JP91/01688

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int. Cl <sup>5</sup> E02D3/12		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
IPC	E02D3/12, 101	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>		
Jitsuyo Shinan Koho 1926 - 1992 Kokai Jitsuyo Shinan Koho 1971 - 1992		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT</b> <sup>9</sup>		
Category <sup>*</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
X	JP, A, 50-113013 (Ayumu Nakanishi), September 4, 1975 (04. 09. 75), (Family: none)	1, 2, 10
A	JP, A, 50-113013 (Ayumu Nakanishi), September 4, 1975 (04. 09. 75), (Family: none)	3, 4, 6-8, 11-21
A	JP, A, 60-19816 (Nihon Sogo Bosui K.K. and another), February 1, 1985 (01. 02. 85), (Family: none)	3, 4, 7, 8, 14-21
Y	JP, A, 50-113013 (Ayumu Nakanishi), September 4, 1975 (04. 09. 75), (Family: none)	5, 9
Y	JP, A, 60-19816 (Nihon Sogo Bosui K.K. and another), February 1, 1985 (01. 02. 85), (Family: none)	5
A	JP, A, 1-102122 (Osaka Bosui Kensetsusha	8, 11-13
<sup>*</sup> Special categories of cited documents: <sup>10</sup> "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "8" document member of the same patent family		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search		Date of Mailing of this International Search Report
February 21, 1992 (21. 02. 92)		March 10, 1992 (10. 03. 92)
International Searching Authority		Signature of Authorized Officer
Japanese Patent Office		

## FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

Y	K.K.), April 19, 1989 (19. 04. 89), (Family: none)  JP, A, 54-415 (Sanshin Kensetsu Kogyo K.K.), January 5, 1979 (05. 01. 79), (Family: none)	9
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☐ **V. OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE <sup>1</sup>**

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers , because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim numbers , because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

☐ **VI. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING <sup>2</sup>**

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees