

(19)



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(11)

**EP 0 741 227 B1**

(12)

## EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention  
of the grant of the patent:  
**13.08.2003 Bulletin 2003/33**

(51) Int Cl.7: **E21B 7/28, E21D 1/06**

(21) Application number: **95203177.1**

(22) Date of filing: **20.11.1995**

(54) **Borehole boring method and machine**

Werkzeug und Verfahren zum Bohren eines Bohrloches

Procédé et outil de forage d'un trou

(84) Designated Contracting States:  
**DE FR GB**

(30) Priority: **01.05.1995 JP 10746495**

(43) Date of publication of application:  
**06.11.1996 Bulletin 1996/45**

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## Description

**[0001]** The invention relates to a borehole boring method by: drilling in a ground 1 a pilot hole 6 having a diameter smaller than a target borehole 7a and inserting a guide rod 7 into said pilot hole, mounting a drilling unit 8 on said guide rod, said drilling unit having a drilling tool 19d, 19e for drilling said ground, means 20 for rotating said drilling tool, means 21 for driving said drilling tool and means 62 for fixing a main body of said drilling unit relative to said ground, and causing said drilling tool to advance along said guide rod to bore said target borehole, and a borehole boring machine provided with a first drilling unit 3 for drilling in a ground 1 a pilot hole 6 smaller than a target borehole 7a, a guide rod 7 for being inserted on a side of an end thereof into said pilot hole formed by said first drilling unit, and a second drilling unit 8 having means 62 for fixing a main body of said second drilling unit relative to said ground and a drilling tool for drilling said ground, said second drilling unit being guided by said guide rod to bore said target borehole, said second drilling unit further comprising a main body having a stationary unit (10) fixable against a wall of said target borehole via said guide rod and a movable unit (12) movable along a length of said guide rod, said movable unit being connected to said stationary unit and being provided with a non-rotating portion (16) limited in rotation about a wall of said guide rod and said wall of said target borehole, and a rotating portion (18) rotatable about said walls of said guide rod and target borehole, means (60,61) for fixing said stationary unit against said wall of said target borehole, said drilling tool mounted on a rotating portion of said movable unit for boring said target borehole in said ground, means for rotating said drilling tool, and means for causing said movable unit to advance, said advance-causing means being connected at an end thereof to a non-rotating portion of said movable unit and at an opposite end thereof to said stationary unit.

**[0002]** Such method and apparatus are known from DE-40 28 596.

**[0003]** Conventional techniques for boring boreholes such as shafts in mines, conduct boreholes for dams, vertical boreholes for general foundation work and vertical boreholes for rock boring foundation work include, for instance, a first example shown in Figs. 24A and 24B, a second example depicted in fig. 25 and a third example illustrated in fig. 26.

**[0004]** The first conventional technique shown in figs. 24A and 24B is called "raise boring". According to the first conventional technique, as is illustrated in fig. 24B, a reaming bit 172 as a drilling tool is mounted on a lower end of a rod 171 and a drilling unit main body 175 is arranged on an upper end of the rod 171. This drilling unit main body is provided with a rotating-and-advancing force producing unit 173 for applying advancing force to lift the rod 171 while rotating the same and also with a large base plate 174 for supporting reaction force

during boring.

**[0005]** According to the first conventional technique, as is depicted in fig. 24A, the drilling unit main body 175 is fixed in an upper gallery 176 which defines an upper space and, as is shown in fig. 24B, the reaming bit 172 is mounted on the rod 171 in a lower gallery which defines a lower space. In this arrangement, the rotating-and-advancing force producing unit 173 of the drilling unit main body 175 is driven to lift the reaming bit 172 from the lower gallery 177 toward the upper gallery 176 while rotating the same, so that a vertical borehole is formed. Crushed soil and rock 178 which has occurred by the drilling is conveyed to an outside by shuttle cars or the like. As a known technique relating to raise boring, reference may be had, for example, to the technique disclosed in Japanese Patent Application Laid-Open (Kokai) No. SHO 57-112593.

**[0006]** The second conventional technique depicted in FIG. 25 is called "reverse circulation drilling". According to this second conventional technique, a bit 182 as a drilling tool is mounted on a lower end of a drill pipe 181. On an upper end of the drill pipe 181, a rotary table 183 for rotating the drill pipe 181 is arranged. The resultant whole assembly is suspended and held via a hook by an unillustrated large crane. Further, the drill pipe 181 is provided with water feeding means, a mud discharge pipe 185 and an unillustrated suction pump. The water feeding means comprises an unillustrated submerged pump which feeds water 186 to prevent falling of a ground 180. The mud discharge pipe 185 serves to discharge mud, which has occurred by boring, to an outside. To provide advancing force upon drilling, the weight of the drill pipe 181 is set heavy.

**[0007]** According to the second conventional technique, the water 186 is continuously fed and the rotary table 183 is driven to rotate the drill pipe 181. While lowering the crane, the ground is drilled by the bit 182. Using the own weight of the drill pipe 181 as advancing force, the bit 182 is caused to gradually drill and advance downwards so that a vertical borehole is bored. Incidentally, as a known technique pertaining to the reverse circulation drilling, reference may be had, for example, to the technique disclosed in Japanese Patent Application Laid-Open (Kokai) No. SHO 55-45902.

**[0008]** Further, the third conventional technique illustrated in FIG. 26 is called "rotary casing driver". The rotary casing driver according to this third conventional technique is equipped with an internally hollow casing tube 193 having a cutter 192 as a drilling tool at a free end thereof, a casing driver main body 194 for rotating the casing tube 193, a weight base 195 connected to the casing driver main body 194 to support reaction force during boring, and a large crane 197 for applying pressing force to hold the weight base 195 standstill and carrying a hammer glove 196 suspended from a free end of the crane to grab crushed soil and rock, which has occurred by the boring, and then to discharge the same to an outside.

**[0009]** In the third conventional technique, the casing driver main body 194 is driven to rotate the casing tube 193. Reaction force during the boring is supported by the weight base 195 and the crane 197. Crushed soil and rock, which has accumulated within the casing tube 193 by the drilling, is grabbed by the hammer glove 196 suspended in the casing tube 193 and is then taken out, whereby a vertical borehole is bored. Incidentally, as a known technique relating to the rotary casing driver, reference may be had, for example, to the technique disclosed in Japanese Utility Model Application Laid-Open (Kokai) No. SHO 60-40545.

**[0010]** FIG. 27 is a side view illustrating a still different example of conventional borehole boring methods and machines, and FIG. 28 is a side view showing on an enlarged scale a drilling unit depicted in FIG. 27.

**[0011]** In this conventional technique, as illustrated in FIG. 27, a boring machine 240 for boring a target borehole 219 in a ground 218 is equipped with fixing means 240 for holding a main body of the boring machine by pressing a wall of the borehole 219 and also with a drilling tool 241 arranged below the main body.

**[0012]** The above-mentioned fixing means 240 are each composed, as also shown in FIG. 28, of an extendible plate 222 capable of pressing the wall of the borehole 219 in the ground 218 and a hydraulic cylinder 221 for causing the corresponding extendible plate 222 to extend so that the extendible plate 222 is pressed against the ground 218 and also for causing the extendible plate 222 to contract so that the extendible plate 222 is separated from the ground 218. The fixing means 240 composed in combination of these hydraulic cylinders 221 and extendible plates 222, respectively, are arranged in three directions within a horizontal plane. It is to be noted that only two sets of these fixing means are shown in FIGS. 27 and 28. Further, these fixing means 240 are mounted on a stationary unit 233.

**[0013]** Connected to a lower part of the stationary unit 233 is a movable unit 234 which is rotatable via bearings. By these stationary unit 233 and movable unit 234, the main body of the boring machine 220 is constructed.

**[0014]** The movable unit 234 is also rotatable by rotating means, i.e., an electric motor 236. Further, by advancing means, i.e., a hydraulic cylinder 235 connected at one end thereof to the stationary unit 233 and at an opposite end thereof to the movable unit 234, the movable unit 234 is downwardly movable relative to the stationary unit 233 which remains in a fixed state. In addition, this movable unit 235 is provided at a lowest position thereof with a center cutter 237, and at a position higher than the center cutter 237 with an outer peripheral cutter 238, which forms a fixed drilling bit, and also an outermost peripheral cutter 239 forming a movable drilling bit which can extend and contract in a radial direction. These center cutter 237, outer peripheral cutter 238 and outermost peripheral cutter 239 make up the drilling tool 241 which can drill soil, sand, rocks and the like.

**[0015]** Crushed soil and rock drilled by the drilling machine 241 is sucked into a hopper 226 through an earth discharge pipe when a vacuum sucker 224 is actuated. The crushed soil and rock is externally discharged through a lower part of the hopper 226. Incidentally, a lower end portion of the earth discharge pipe 225 is inserted through a cylindrical opening 233a, which is formed in the stationary unit 233 of the boring machine 220 and has a sufficiently large diameter, to a point where the lower end portion faces a rear wall of the center cutter 237. At a position above the borehole 219, a derrick 223 has been arranged upright. This derrick 223 is provided with a laser verticality meter 227 which serves to detect any off-centering between a central axis of the boring machine 220 and that of the borehole 219 as the target borehole. Also provided is a hook 231 which serves to lift or lower the boring machine 220 and the like in a suspended position.

**[0016]** Further, a TV camera 240a which can monitor the above-mentioned fixing means 240, advancing means and drilling tool 241 is arranged on an upper wall of the stationary unit 233 of the boring machine 220. On the ground, a monitoring and operating panel 228, a power unit 229 and a generator 230 are arranged near the derrick 223. The monitoring and operating panel 228 can be inputted with video signals from the TV camera 240a and detections signals from the laser verticality meter 227. The power unit 229 serves as a drive source for the hydraulic cylinder 221 constructing the fixing means 240, the hydraulic cylinder 235 constructing the advancing means and also the hydraulic cylinder for causing the outermost peripheral cutter 239 to extend to contract. The generator 230 serves as a drive source for the electric motor 236 and the like.

**[0017]** The above-mentioned boring machine 220, the derrick 223 including the laser verticality meter 227, the earth discharge means including the vacuum sucker 224, the hopper 226 and the earth discharge pipe 225, the monitoring and operating panel 228, the power unit 229, the generator 230 and the like make up a borehole boring machine for boring the target borehole 219 in the ground 218.

**[0018]** According to the conventional technique shown in FIGS. 27 and 28, boring is performed using the thus-constructed borehole boring machine as will be described hereinbelow.

**[0019]** For example, a large hole is bored in advance right underneath the derrick 223. The boring machine 220 is lowered in a suspended position into the hole by means of the hook 231 of the derrick 223. In this position, the hydraulic cylinders 221 of the fixing means 240, said hydraulic cylinders being shown in FIG. 28, are caused to extend so that the extendible plates 222 are pressed within a horizontal plane against a wall of the above-mentioned hole. As a consequence, the stationary unit 233 of the boring machine 220 is fixed.

**[0020]** Next, the electric motor 236 is driven so that, while the movable unit 234 is being rotated, the hydrau-

lic cylinder 235 making up the advancing means is caused to extend. As a result, the center cutter 237, outer peripheral cutter 238 and outermost peripheral cutter 239 descend into the ground 218 while being rotated, so that the borehole 219 is bored in the ground 218. When the movable unit 234 has descended by a stroke of the hydraulic cylinder 235 of the advancing means, the electric motor 236 is stopped.

**[0021]** When the hydraulic cylinders 221 of the fixing means 240 are caused to contract in this position, the extendible plates 222 are separated from the wall of the borehole 219 in the ground 218. The hydraulic cylinder 235 of the advancing means is hence caused to contract, for example, by the own weight of the stationary unit 233, whereby the stationary unit 233 descends toward the movable unit 234.

**[0022]** The hydraulic cylinders 221 of the fixing means 240 are next caused to extend again so that the extendible plates 222 are pressed against the wall of the borehole 219 formed by the boring. As a result, the stationary unit 233 of the boring machine 220 is fixed.

**[0023]** The electric motor 236 is next driven so that, while the movable unit 234 is being rotated, the hydraulic cylinder 235 of the advancing means is caused to extend. As a result, similarly to the foregoing, the borehole 219 is bored over a length corresponding to the stroke of the hydraulic cylinder 235. By repeating similar operations, the borehole 219 of the desired length can then be bored.

**[0024]** During the above-described boring, crushed soil and rock which has been collected on the rear wall of the center cutter 237 by the boring is sucked into the hopper 226 via the earth discharge pipe 225 by actuating the vacuum sucker 224, and is discharged to an outside through the lower part of the hopper 226.

**[0025]** In the course of the above-mentioned boring, off-centering, that is, a misalignment between the central axis of the boring machine 220 and that of the target borehole 219 may arise or the boring machine 220 may tilt depending on the degree of hardness or softness of the earth and the degree of non-uniformity of the earth of the ground 218. In this case, a signal for correcting the off-centering or inclination is outputted from the monitoring and operating panel 228 in response to a detection signal outputted from the laser verticality meter 227. Responsive to the former signal, the relevant one of the hydraulic cylinders 221 which make up the fixing means 240 is selectively caused to extend or contract.

**[0026]** Further, operations and the like of the fixing means 240 and the drilling tool 241 can be monitored at the monitoring and operating panel 228 by video signals outputted from the TV camera 240a.

**[0027]** However the above-described conventional techniques are individually accompanied problems as will be described hereinbelow.

**[0028]** Namely, the first conventional technique shown in FIGS. 24A and 24B requires extra work to form the upper gallery 176 for the arrangement of the boring

machine main body 175 and also the lower gallery 177 for mounting the reaming bit 172 on the rod 171. This leads to more boring steps and hence to a higher boring cost. Further, the borehole to be bored must be smaller than the base plate 174 so that a limitation is imposed on the diameter of a borehole to be bored.

**[0029]** Further, the second conventional example illustrated in FIG. 25 requires advance setting of the weight of the drill pipe 181 and the like at a greater value to produce advancing force and although not illustrated in the drawing, also requires a large crane. The machine is therefore large and heavy as a whole, so that the work required to transport it to a boring site involves difficulties. In addition, the second conventional example also requires water feeding means for feeding the great deal of the water 186 to avoid falling of the ground 180 as well as mud discharge means composed of the mud discharge pipe 185 for discharging a great amount of mud, an unillustrated suction pump and the like. It is therefore impossible to perform boring unless such water feeding means and mud discharge means can be arranged. This leads to more boring steps and hence to a higher boring cost, even if boring is feasible. Moreover, the suction pump which makes up the water feeding means and the mud discharge means is basically limited in capacity so that the amount of mud, which can be discharged, is limited. This results in a limitation to the diameter of a borehole which can be bored with the drill pipe 181.

**[0030]** In the third conventional technique depicted in FIG. 26, on the other hand, the crane 197 and the weight base 195 have to be designed large in shape and heavy in weight so that during boring, reaction force can be supported. The work required to transport the crane 197 and the like to a boring site therefore involves difficulties. This leads to more boring steps and hence to a higher boring cost. Moreover, a limitation is imposed on the diameter of the casing tube 193 in its fabrication so that the diameter of a borehole, which can be bored, is limited.

**[0031]** As has been described above, raise boring - which is the first conventional technique of the borehole coring method and machine for boring a vertical borehole - requires the upper and lower galleries and therefore cannot perform boring in an ordinary ground. Reverse circulation drill, the second technique, and rotary casing driver, the third technique, each requires a machine which is large in overall shape and extremely heavy in weight in order to support reaction force during boring or to ensure advancing force for the drilling tool. The work required to transport the boring machine to a boring site therefore involves difficulties, leading the problem that more steps are needed for boring and the boring cost becomes higher.

**[0032]** In addition, all the above-described conventional techniques are generally used for boring boreholes whose diameters are up to 2 to 3 meters or so, resulting in the further problem that a limitation is imposed on the diameter of a target borehole to be bored.

Upon building, for example, power transmission towers in a mountainous region, it is necessary to form, as their foundation holes, boreholes as large as 3 to 4 meters in diameter in the ground. To bore such large boreholes, the machine according to the each of the above-described conventional techniques has to be designed still greater in overall shape and still heavier in weight. Fundamentally speaking, it is however difficult to construct such a machine. Even if construction of such a boring machine is feasible, it is still necessary to transport such a large and heavy boring machine to a boring site upon boring boreholes in the mountainous region which is not convenient for transportation. This transportation is more difficult so that practical use of any of the conventional techniques cannot be expected. It is therefore the current situation that boring of foundation boreholes for each tower built in such a mountainous region are performed by workers' hand boring. More boring steps are therefore needed. No improvements however appear to be feasible in the efficiency of boring work, leading to an increase in the boring cost.

**[0033]** Further, according to the conventional technique shown in FIGS. 27 and 28, the holding of the boring machine 220 is achieved by merely pressing the extendible plates 222 against the wall of the borehole 219 after its boring and fixing the boring machine there. Under the influence of the quality of the ground 218 and/or due to differences in stroke among the hydraulic cylinders 221, which make up the fixing means 240, upon fixing, relatively large off-centering tends to occur between the central axis of the target borehole 219 and that of the boring machine 220 and/or the boring machine 220 tends to undergo relatively large tilting, as boring work proceeds. In such a case, a lot of time is needed for controlling the operation to adjust and correct the position of the boring machine 220. It is therefore difficult to expect any improvement in the efficiency of the boring work.

**[0034]** In addition, there is no choice other than forming a reflecting surface of the laser verticality meter 227 on a part of the boring machine 220 which may produce large vibrations. It is therefore difficult to detect the above-mentioned off-centering and/or tilting. This makes it difficult to bore a borehole having verticality of high accuracy.

**[0035]** The present invention has been completed in view of the above-described current situation of the conventional techniques.

**[0036]** A first object of the present invention is to provide a borehole boring method and machine, which make it possible to construct a boring machine small in its entire shape and light in weight and moreover to readily bore a borehole of a large diameter.

**[0037]** A second object of the present invention is to provide a borehole boring method and machine, which can control occurrence of off-centering and/or tilting of a boring machine main body in the course of boring work.

**[0038]** A third object of the present invention is to provide a borehole boring machine which permits efficient discharge of drilled soil and rock irrespective of the condition of a ground and the depth of boring.

**[0039]** To achieve the above-described first and second objects, a borehole boring method is characterized by the features of claim 1.

**[0040]** Similarly, to achieve the above-described first and second object, the borehole boring machine according to the present invention is characterized by the features of claim 8.

**[0041]** Similarly, the borehole boring machine according to claim 15 of the present invention is characterized in that in the above-described invention according to claim 8, said machine is additionally provided with means for discharging, to an outside of the ground, drilled earth occurred by drilling said ground with said drilling tool of said second drilling unit.

**[0042]** Further, to achieve the third object in particular, the borehole boring machine according to claim 16 of the present invention is characterized in that in the above-described invention according to claim 15, said drilling tool of said second drilling unit is an earth drill bucket and said earth drill bucket also serves as said drilled-earth discharging means.

**[0043]** The borehole boring method according to claim 12 of the present invention and the borehole boring machines according to claim 8 and 15 can each support reaction force upon boring a borehole by fixing the main body of the boring machine, which bores the target borehole, against the wall of the target borehole and also by the guide rod which guides the boring machine. Accordingly, the boring machine itself does not require to take into consideration support of such large reaction force as in each of the above-described conventional techniques and can be made smaller in size and lighter in weight.

**[0044]** This has made it possible to achieve the first object of the present invention, that is, reductions in the overall shape and weight of the boring machine.

**[0045]** Further, it is also possible to perform control so that swinging of the boring machine is reduced upon boring work.

**[0046]** Accordingly, it is possible to perform accurate boring along the direction of extension of the guide rod and hence to achieve the second object of the present invention, that is, prevention of occurrence of off-centering of the central axis of the boring machine relative to that of the target borehole and also of tilting of the boring machine.

**[0047]** In the borehole boring machine according to claim 16 of the present invention, the earth drill bucket as the drilling tool also serves as the drilled-earth discharging means and irrespective of the condition of the ground and the depth of the boring, drilled earth can be deposited in the earth drill bucket in a quantity corresponding to the capacity of the earth drill bucket.

**[0048]** Discharge of the drilled earth to an outside can

therefore be achieved by lifting the boring machine from the target borehole. Without the need for arrangement of any special drilled-earth discharge means, it is thus possible to achieve especially the third object of the present invention, that is, efficient discharging work of earth.

**[0049]** The above and other objects, features and advantages of the present invention will become apparent from the following description and the appended claims, taken in conjunction with the accompanying drawings, in which:

FIGS. 1A through 1F schematically illustrate one embodiment of a borehole boring method according to the present invention;

FIG. 2 is a side view showing a second drilling unit constructing a first embodiment of a borehole boring machine according to the present invention, in which certain parts are shown in cross-section and fixing means is omitted;

FIG. 3 is a side view of the boring machine shown in FIG. 2, in which the inherently-equipped fixing means is drawn but advancing means is omitted;

FIG. 4 is a plan view of the boring machine shown in FIG. 2, in which the fixing means are drawn;

FIG. 5 is a side cross-sectional view of a guide rod along which the second drilling unit depicted in FIG. 2 is guided;

FIG. 6 is a side view illustrating a relationship between a derrick and the second drilling unit, which in combination construct the first embodiment of the borehole boring machine according to the present invention;

FIG. 7 is a plan view illustrating a positional relationship between the second drilling unit and reaction-force-supporting plates arranged on the derrick, said second drilling unit and reaction-force-supporting plates constituting the first embodiment of the borehole boring machine according to the present invention;

FIG. 8 is a side view depicting the relative arrangement among the guide rod, a pin inserted in the guide rod and a load sensor for detecting force transmitted to the pin, said guide rod, pin and load sensor constituting the first embodiment of the borehole boring machine according to the present invention;

FIG. 9 is a side view showing the relative arrangement among the pin inserted in the guide rod, the load sensor for detecting force transmitted to the pin and a hydraulic cylinder for positioning the pin, said pin, load sensor and hydraulic cylinder constituting the first embodiment of the borehole boring machine according to the present invention;

FIG. 10 is a side view showing the state of borehole boring work performed by the first embodiment of the borehole boring machine according to the present invention;

FIG. 11 is a plan view depicting the relationship among the derrick, a control room and a hydraulic power unit in the state shown in FIG. 10;

FIG. 12 is a side view depicting the state of earth-discharging work performed by the first embodiment of the borehole boring machine according to the present invention;

FIG. 13 is a side view showing a state in which the second drilling unit has been moved sideward from the state depicted in FIG. 12;

FIG. 14 is a side view illustrating a state in which to remove boulders present in a drilled borehole, the second drilling unit 2 has been moved sideward as in FIG. 13;

FIG. 15 is a block diagram depicting the relationship between various switches and control devices arranged in the control room shown in FIG. 11 and various sensors and various actuators arranged on the second drilling unit or the derrick;

FIG. 16 is a plan view of the guide rod and the second drilling unit for illustrating the directions and magnitudes of biased loads acting on the guide rod in the first embodiment of the borehole boring machine according to the present invention;

FIG. 17 is a side view corresponding to FIG. 16;

FIG. 18 is a side view depicting the relative arrangement between the derrick and the second drilling unit for illustrating the directions and magnitudes of biased loads acting on the guide rod in the first embodiment of the borehole boring machine according to the present invention;

FIG. 19 schematically illustrates a biased load acting on the guide rod in the first embodiment of the borehole boring machine according to the present invention;

FIG. 20 is a schematic illustration showing the direction and magnitude of the biased load acting on the guide rod, said biased load having been depicted in FIG. 19, in a form converted into the magnitude of force for driving the fixing means;

FIG. 21 is a side view illustrating a second embodiment of the borehole boring machine according to the present invention;

FIG. 22 is a plan view of the second embodiment depicted in FIG. 21;

FIG. 23 is a side view showing a third embodiment of the borehole boring machine according to the present invention;

FIG. 24 is a schematic illustration of a first example of conventional borehole boring machines;

FIG. 25 is a schematic illustration of a second example of conventional borehole boring machines;

FIG. 26 is a schematic illustration of a third example of conventional borehole boring machines;

FIG. 27 is a side view showing a still further example of conventional bore-hole boring methods and machines; and

FIG. 28 is a side view showing on an enlarged scale

the boring machine illustrated in FIG. 27.

**[0050]** The embodiments of the borehole boring method and machine according to the present invention will hereinafter be described based on the drawings.

**[0051]** FIGS. 1A through 1F are schematic illustrations of the borehole boring method according to the first embodiment corresponding to claims 1, 2, 3, 4, 5, 6, 8 and 9 of the present application.

**[0052]** In this embodiment, as is shown in FIG. 1A, the first drilling unit for boring a guide hole smaller in diameter than a target borehole, that is, a pilot hole is arranged on a ground 1. This first drilling unit includes a down-the-hole drill 2 for boring the pilot hole, a rotary table 3 for rotating the down-the-hole drill 2, a hydraulic power unit 4 as a drive source for these down-the-hole drill 2 and the rotary table 3, and an unillustrated compressor as a drive force for the down-the-hole drill 2. Incidentally, the first drilling unit equipped with the down-the-hole drill 2 is publicly known as disclosed in Japanese Patent Application Laid-Open Nos. HEI 3-119284 and SHO 63-312497.

**[0053]** When the hydraulic power unit 4 is actuated in the state of FIG. 1A to rotate the rotary table 3, drilling by the down-the-hole drill 2 is performed by air from a compressor as illustrated in FIG. 1B. Crushed soil and rock, which has occurred by the drilling, is discharged to an outside of the ground 1, for example, by blowing air, which is fed from the compressor, against the drilled area. When the down-the-hole drill 2 is upwardly lifted in the above state, a pilot hole 6 is formed in the ground 1.

**[0054]** In this embodiment, a derrick 62 is built upright above the pilot hole 6 as shown especially in FIG. 1C. This derrick 62 is provided with a winch 63. In this state, a guide rod 7 is inserted into the pilot hole 6, and a second drilling unit 8 for forming a target borehole greater in diameter than the pilot hole 6 is mounted on the guide rod 7. This results in the state that the guide rod 7 extends through a cylindrical opening centrally formed in the second drilling unit 8. Although the guide rod 7 was inserted into the pilot hole 6 formed by the down-the-hole drill 2 in this embodiment, the down-the-hole drill 2 can also be used as the guide rod 7. Here, pulleys 66 are arranged on an upper part of the second drilling unit 8, and the derrick 62 is also provided with a pulley 64. A wire 65 which has been wound out from the winch 63 on the derrick 62 is wrapped around the pulleys 66 on the second drilling unit 8 and the pulley 64 on the derrick 62. An end portion of the wire 65 is anchored on the derrick 62. The wire 65 is therefore wound out or in by driving the winch 63, so that the second drilling unit 8 can be lowered or lifted in a suspended state along the extension of the guide rod 7.

**[0055]** The second drilling unit 8 includes a drilling tool for drilling the ground 1, means for rotating the drilling tool in a horizontal plane, means for advancing the drilling tool, and means for fixing a main body of the drilling

unit relative to the ground 1. Incidentally, a drive source for the above-mentioned rotating means, advancing means and fixing means is the above-described hydraulic power unit 4. Actuation of the hydraulic power unit 4 can therefore selectively drive the rotating means, advancing means and fixing means of the second drilling unit 8. When the fixing means is driven to fix the upper part composing the main body of the drilling unit 8 and the rotating means and advancing means are then driven with the upper part maintained in the fixed position, the drilling tool mounted on a lower part which composes the main body is caused to downwardly advance along the guide rod 7 while being rotated, thereby making it possible to bore a vertical borehole as the desired target borehole in the ground 1.

**[0056]** In this case, the main body of the second drilling unit 8 is constructed, for example, in such a way that the main body carries the above-described fixing means mounted thereon and also has a stationary unit 10 fixable on a wall of a target borehole 7a formed in the ground 1 and a movable unit 12 holding a drilling tool 19a. The above-described fixing means is constructed of extendible plates 61, which can be pressed against the wall of the target borehole 7a, and hydraulic cylinders 60 for extending or contracting the corresponding extendible plates 61. The above-mentioned rotating means is composed, for example, of hydraulic motors 20 and causes the movable unit 12 to rotate in a horizontal plane. The above-mentioned advancing means is composed, for example, of a hydraulic cylinder 21 and causes the movable unit 12 to advance downwardly.

**[0057]** Upon initiation of boring work by the second drilling unit 8, the fixing means of the second drilling unit 8 is first driven, that is, the hydraulic cylinders 60 are caused to extend so that the stationary unit 10 of the second drilling unit 8 is fixed on structural members of the derrick 62. In this state, the hydraulic power unit 4 is actuated to drive the hydraulic motors 20 as the rotating means for the second drilling unit 8 and the hydraulic cylinder 21 as advancing means. Then, the movable unit 12 including the earth drilling bucket 19a as the drilling tool advances downwardly while rotating, whereby boring is performed over a predetermined distance corresponding to the stroke of the hydraulic cylinder 21 as the advancing means. Here, the second drilling unit 8 is once stopped. In this state, the hydraulic cylinders 60 are caused to contract to cancel the fixing of the stationary unit 10 relative to the derrick 62 and the winch 63 is driven. The stationary unit 10 is then allowed to descend by its own weight over the predetermined distance corresponding to the stroke of the hydraulic cylinder 21.

**[0058]** When the hydraulic cylinders 60 are caused to extend again, the extendible plates 61 are brought into contact with the wall of the thus-formed borehole 7a so that the stationary unit 10 is fixed. FIG. 1D illustrates a state in which boring has been performed several times, each, over the predetermined distance subsequent to the completion of the first boring over the predetermined

distance with the stationary unit 10 fixed on the derrick 62. After boring has been performed several times, each, over the predetermined distance as described above, the stationary unit 10 is in such a position that it is fixed on the wall of the borehole 7a in the ground 1. A description will hereinafter be made, starting from the state shown in FIG. 1D.

**[0059]** Now, the hydraulic motors 20 and the hydraulic cylinder 21 are driven again. As is illustrated in FIG. 1E, the movable unit 12 including the earth drilling bucket 19a as the drilling tool then advances downwardly while rotating, so that boring is performed over the predetermined distance corresponding to the stroke of the hydraulic cylinder 21.

**[0060]** Here, the drilling unit 8 is once stopped, and the hydraulic cylinders 60 are caused to contact to separate the extendible plates 61 from the wall of the borehole 7a. This cancellation of the fixing of the stationary unit 10 relative to the wall of the borehole 7a in the ground 1. By driving the winch 63, the stationary unit 10 is caused descend by its own weight over the predetermined distance corresponding to the stroke of the hydraulic cylinder 21 as shown in FIG. 1F.

**[0061]** A similar operation is then repeated to alternately move the stationary unit 10 and the movable unit 12. This makes it possible to successively proceed with boring, each time, over the predetermined distance corresponding to the stroke of the hydraulic cylinder 21, so that the desired target borehole 7a can be formed over its entire length in the ground.

**[0062]** During such boring work, crushed soil and rock occurred by the boring of the target borehole 7a is, for example, deposited on the rear wall of the earth drilling bucket 19a by making use of the shape of the earth drilling bucket 19a. Accordingly, the crushed soil and rock so drilled can be taken out of the borehole 7a by driving the winch 63 and lifting the drilling unit 8.

**[0063]** After the formation of the target borehole 7a, the second drilling unit 8, for example, is detached from the guide rod 7 and is taken out of the target borehole 7a. After the second drilling unit 8 has been taken out of the target borehole 7a as described above, the guide rod 7 is also taken out of the target borehole 7a, for example. The boring work is hence finished.

**[0064]** According to the borehole boring method of this embodiment, reaction force occurring during boring can be supported via the fixing means by the wall of the target borehole 7a bored in the ground 1. Further, the reaction force occurring during the boring can also be supported by the guide rod 7 which has sufficient rigidity. Accordingly, it is possible to limit such reaction force so that swinging of the second drilling unit 8 can be minimized during the boring. This makes it possible to bore the ground straight along the direction of extension of the guide rod 7, so that off-centering of the central axis of the drilling unit 8 relative to the central axis of the target borehole 7a and occurrence of tilting of the drilling unit 8 can be prevented, thereby allowing to bore the

borehole 7a with highly-accurate verticality. Further, it is basically unnecessary to adjust the spatial orientation of the drilling unit 8 during boring work. This can improve the efficiency of the boring work. Since the borehole 7a can be formed with highly-accurate verticality, it is no longer required to make the diameter of the borehole 7a unnecessarily large. When concrete is placed in the borehole 7a subsequent to the boring, the concrete placing can be performed with a minimized loss.

**[0065]** It is also designed to discharge crushed soil and rock by means of the earth drilling bucket 19a. In other words, the earth drilling bucket 19a also serves as earth discharging means. The earth drilling bucket 19a is generally known to permit deposit of drilled earth in an amount as much as the capacity of the earth drilling bucket 19a irrespective of the condition of the ground and the depth of boring. It is therefore possible to efficiently discharge crushed soil and rock without the need for arranging any special earth discharging means.

**[0066]** As has been described above, reaction force occurring during boring is supported by the wall of the target borehole 7a and the guide rod 7. It is therefore unnecessary to consider supporting such large reaction force by the second drilling unit 8 itself. This makes it possible to construct the second drilling unit 8 small in shape and light in weight. Further, the guide rod 7 can be designed to have such a relatively small diametrical dimension that it can be inserted into the pilot hole 6 smaller in diameter than the target borehole 7a. Owing to these features, the borehole boring machine which includes the first drilling unit with the down-the-hole drill 2 carried thereon, the guide rod 7 and the second drilling unit 8 can be designed smaller in its overall shape and moreover, lighter in weight. Accordingly, the work required to transport the borehole boring machine, which includes the first drilling unit with the down-the-hole drill 2 carried thereon, the guide rod 7 and the second drilling unit 8, can be made relatively easy. Coupled with this, the number of steps required for boring can be reduced, thereby making it possible to reduce the boring cost.

**[0067]** When it is desired to form the target borehole 7a with a larger diameter, it is only necessary to set the size of the earth drilling bucket 19a or the like of the second drilling unit 8 in correspondence to the diameter of the target borehole 7a. This makes it possible to bore a target borehole 7a of a desired diameter without the need for substantially increasing the guide rod 7 and the second drilling unit 8 in size and weight. As a consequence, formation of a target borehole 7a of a large diameter of 3 to 4 meters or so can be easily achieved although the formation of such a large target borehole has heretofore been considered to be rather difficult.

**[0068]** According to the present embodiment, the work for transporting the borehole boring machine to a boring site is relatively easy and the formation of a target borehole of a large diameter of 3 to 4 meters or so is easily feasible. Accordingly this embodiment can also be applied to the formation of foundation boreholes for



power transmission towers or the like in a mountainous region although the formation of such foundation boreholes has heretofore been performed by hand boring. When the present embodiment is applied, instead of hand boring, to the formation of foundation boreholes for power transmission towers or the like in a mountainous region, the efficiency of boring work can be improved significantly.

**[0069]** In the above-described embodiment, crushed soil and rock which had occurred by drilling was taken out by means of the earth drilling bucket 19a as the drilling tool. Such crushed soil and rock can however be discharged to an outside of the ground 1 by using air or by feeding water in combination with air.

**[0070]** Upon taking the guide rod 7 out of the target borehole 7a subsequent to the formation of the target borehole 7a in the above-described embodiment, the guide rod 7a can be taken out of the target borehole 7a after dividing the same.

**[0071]** In the above-described embodiment, the second drilling unit 8 and the guide rod 7 were removed from the target borehole 7a to the outside of the ground 1 after the formation of the target borehole 7a. Unless insertion of a structure such as a tower into the target borehole 1 would be hampered, these second drilling unit 8 and guide rod 7 may be buried together with the structure, such as the tower inserted in the target borehole 7a, in the ground 1 without their removal to the outside of the ground 1.

**[0072]** Further, in the embodiment described above, a vertical borehole extending was bored as the target borehole 7a. The present invention is however not limited to the boring of such a vertical borehole. It is possible to bore a borehole extending in a horizontal direction or a borehole extending in a direction inclined at a predetermined angle relative to a vertical direction.

**[0073]** In the embodiment described above, upon boring the borehole 7a, the earth drilling bucket 19a was caused to advance while simultaneously rotating it in a horizontal plane, so that boring was performed. It is however possible to perform the rotation of the drilling tool in the horizontal plane and the advancing of the drilling tool independently from each other.

**[0074]** For example, the movable unit 12 which composes the main body of the second drilling unit 8 may be provided as a drilling tool with a bucket rotatable in a vertical plane instead of the above-mentioned earth drilling bucket 19a. With the stationary unit 10 of the drilling unit 8 fixed via the fixing means on the wall of the borehole 7a formed in the ground 1, the bucket is then rotated within the vertical plane while extending the hydraulic cylinder 21 as the advancing means. As a consequence, boring can be performed along the direction of extension of the guide rod 7 over the predetermined straight distance corresponding to the stroke of the hydraulic cylinder 21. Then, the bucket is once caused to retreat over the above-mentioned, predetermined straight distance. In this state, the swivel motors 20 as

the rotating means are driven so that the movable unit 12, namely, the bucket as the drilling tool is turned over a predetermined angle. In this state, as has been described above, the hydraulic cylinder 21 is driven again to lower the drilling tool so that the bucket is caused to bore the ground over the predetermined straight distance. In a similar manner, the borehole 7a is then bored to a depth corresponding to the predetermined distance. The fixing of the stationary unit 10 by the stationary means is next canceled so that the stationary unit 10 is allowed to descend, for example, by its own weight. Here again, the borehole 7a is again bored over the predetermined straight distance as described above. By repeating the boring which involves the advance and retreat of the bucket over the predetermined straight distance and its turning over the predetermined angle as described above, the desired target borehole 7a can be formed over the entire length thereof. Such a borehole boring method corresponds to the present invention as defined in claim 2.

**[0075]** FIGS. 2 through 20 are schematic illustrations showing the first embodiment of the borehole boring machine corresponding to claims 11-17, 19-21 and 23-35 of the present application.

**[0076]** The first embodiment of the boring machine is provided, as essential elements, with the first drilling unit for boring the pilot hole 6 smaller in diameter than the target borehole 7a in the ground 1, the guide rod 7 inserted in the pilot hole 6 formed by the first drilling unit, the second drilling unit including the drilling tool for drilling the ground 1 and boring the target borehole 7a under the guidance of the above-mentioned guide rod 7, and the fixing means for fixing the main body of the second drilling unit.

**[0077]** Of these elements, the first drilling unit for boring the pilot hole 6 includes, as shown in FIG. 1A for example, the down-the-hole drill 2 for boring the pilot hole 6 smaller than the target borehole 7a, the hydraulic power unit 4 as a drive source for driving the down-the-hole drill 2 and the rotary table 3, and a compressor for feeding compressed air to the down-the-hole drill 2. As has been described above, the first drilling unit equipped with the down-the-hole drill 2 is known from Japanese Patent Application Laid-Open No. HEI 3-119284 and the like.

**[0078]** The remaining elements will hereinafter be described with reference to FIG. 2 through FIG. 15 in particular.

**[0079]** The basic structure of the guide rod 7, which is introduced into the pilot hole 6 formed by the first drilling unit, is composed of a cylindrical pipe arranged extending, for example, in a vertical direction as shown in FIG. 5. The guide rod 7 can be divided into plural sections. These divided sections are threadably engaged together at threadably connected portions 7b into an integral element.

**[0080]** As is shown in FIGS. 2 to 4, the second drilling unit 8 mounted on the guide rod 7 is provided with the

main body, which is composed of the stationary unit 10 arranged at an upper position and the movable unit 12 connected to a lower part of the stationary unit 10 and movable along the length of the guide rod 7.

**[0081]** The stationary unit 10 is provided with the fixing means for fixing the stationary unit 10 on the wall of the target borehole 7a in the ground 1. Each fixing means comprises, as depicted in FIGS. 3 and 4, the extendible plate 61 and the hydraulic cylinder 60. The extendible plate 61 can be pressed against the wall of the target borehole 7a, while the hydraulic cylinder 60 can be caused to extend or contract so that the extendible plate 61 can be moved. The fixing means composed in combination of these extendible plates 61 and hydraulic cylinders 60 are arranged, as shown by way of example in FIG. 4, at four positions, that is, at front, rear, left and right positions in a horizontal plane.

**[0082]** As is illustrated in FIG. 2 etc., the above-described movable unit 12 is provided with a main frame 16, a sub-frame 18, a swivel bearing 17, the earth drilling bucket 19a, a fixed drilling bit 19d, a movable drilling bit 19e, and the hydraulic motors 20. The main frame 16 defines at a central position thereof the central opening 23 and, when connected to the fixed stationary unit 10, forms a non-rotating unit whose rotation about the guide rod 7 and along the wall of the target borehole 7 is limited. The sub-frame 18 forms a rotating unit which is freely rotatable about the guide rod 7 and along the wall of the target borehole 7a. The swivel bearing 17 is interposed between the main frame 16 and the sub-frame 18. The earth drilling bucket 19a, fixed drilling bit 19d and movable drilling bit 19e are fixed on the sub-frame 18 and are drilling tools for boring the target borehole 7a in the ground. The hydraulic motors 20 are fixed on the main frame 16 and constitute means for rotating the sub-frame 18, namely, the earth drilling bucket 19a.

**[0083]** The above-mentioned earth drilling bucket 19a is arranged at a lowest position of the movable unit 12 and on the rear wall thereof, has a temporary storage portion 19c capable of holding drilled soil and rock there as shown in FIG. 2 etc. Such an earth drilling bucket is publicly known. By lifting the second drilling unit 8, the crushed soil and rock held in the temporary storage portion 19c of the earth drilling bucket 19a can be taken out of the target borehole 7a. Namely, this earth drilling bucket 19a serves not only as a drilling tool but also as earth discharging means. Further, the fixed drilling bit 19a is arranged above a side portion of the earth drilling bucket 19a and is attached immovably by itself to the movable unit 12. Further, the movable drilling bit 19e is also arranged above the side portion of the earth drilling bucket 19a but is movable in the radial direction of the drilling unit 8, in other words, can increase the diameter of the drilling unit 8 by a hydraulic cylinder 19f mounted on the movable unit 12.

**[0084]** Between the stationary unit 10 and the movable unit 12, the advancing means for causing the earth drilling bucket 19a is arranged as shown in FIG. 2. For

example, this advancing means is connected at an upper end thereof to the frame forming the stationary unit 10 and at a lower end thereof to the main frame 16 forming the non-rotating unit of the movable unit 12, and is composed of the hydraulic cylinder 21 which can be extended and contracted. As is illustrated by way of example in FIG. 4, four hydraulic cylinders 21 are arranged at equal angular intervals so that they surround the guide rod 7.

**[0085]** In the first embodiment, the derrick 62 which can lift and lower the second drilling unit 8 in a suspended state is arranged on the ground 1 at the boring site of the target borehole 7a as shown in FIG. 6 etc. This derrick 62 includes masts 71 which are arranged upright at four positions, that is, front, rear, left and right positions in a horizontal plane. On inner sides of these masts 71, reaction-force-receiving plates 76 with which the extendible plates 61 making up the above-described fixing means can be brought into contact are arranged, respectively, as also illustrated in FIG. 7.

**[0086]** Further, a frame 72 as a support member is arranged on upper parts of the mast 71, and a support 73 is arranged on the frame 72. The winch 63 and the pulley 64 are disposed on the support 73. Further, as is illustrated in FIG. 6 etc., the pulleys 66 are arranged on the upper part of the stationary unit 10 of the second drilling unit 8 so that the wire 65 would out from the winch 63 is wrapped around the pulleys 66 on the stationary unit 10 and the pulley 64 on the support 73 and is anchored at the end portion thereof on the support 73. Driving of the winch 63 winds up or out the wire 65 so that the second drilling unit 8 can be lifted or lowered in the suspended state. The above-mentioned winch 63 and wire 65 constitute means for removing the second drilling unit 8 from the inside of the target borehole 7a to an outside.

**[0087]** In addition, the derrick 62 is, as shown in FIGS. 8 and 9, provided with a pin 78 for positioning the guide rod 7 upon its insertion into the pilot hole 6. This pin 78 is provided with a load sensor 77 for detecting forces which the guide rod 7 would receive during boring work by the second drilling unit 8. As is illustrated in FIG. 9, this load sensor 77 is mounted on the support 73, and is held by hydraulic cylinders 79 which are arranged at four positions in a horizontal plane and can extend and contract in four directions, that is, forward, rearward, leftward and rightward, respectively.

**[0088]** As is illustrated in FIG. 13, rails 14 are arranged on the frame 72 of the derrick 62 and rollers 75 maintained in engagement with the rails 74 are arranged on a lower part of the support 73. By causing the rollers 75 to roll on the rails 74, the support 73 can be moved sideward, namely, in a horizontal plane. As is shown in FIG. 13, the above-described rails 74 and rollers 75 constitute means for moving the support 73 so that the second drilling unit 8 is moved sideward from a position above the target borehole 7a.

**[0089]** Further, as is shown in FIGS. 12 and 13, a discharged earth stage 82 for depositing thereon drilled

earth released from the earth drilling bucket 19a is arranged so that the discharged earth stage 82 can be positioned in a lower part of a space surrounded by the four masts 71 of the derrick 62. This discharged earth stage 82 is arranged movably.

**[0090]** Incidentally, the hydraulic power unit 4 for driving the rotary table 3, the down-the-hole drill 2 and the like of the above-described first drilling unit also constitutes a drive source for driving the hydraulic cylinders 60 forming the fixing means for the second drilling unit 8, the hydraulic motors 20 forming the rotating means, the hydraulic cylinders 21 forming the advancing means, the hydraulic cylinder 19f for driving the moving drilling bit 19e, the hydraulic cylinders 79 for holding the load sensor 77 arranged on the derrick 62, and the like.

**[0091]** In addition, as is depicted in FIG. 10 etc., a control room 80 is arranged in adjacent to the hydraulic power unit 4 to perform operation, control and the like of the second drilling unit 8. Arranged inside the control room 80 are, as shown in FIG. 15, a drilling unit lowering switch 86 for outputting a command signal to drive the winch 63 so that the second drilling unit 8 is caused to descend, a drilling unit lifting switch 87 for outputting a command signal to drive the winch 63 so that the second drilling unit 8 is caused to ascend, a drilling start switch 88 for outputting a command signal to start drilling by the second drilling unit 8, a drilling stop signal 89 for outputting a command signal to stop drilling by the second drilling unit 8, an earth discharge start switch 90 for outputting a command signal to start discharging crushed soil and rock, which has deposited in the earth drilling bucket 19a by drilling, to an outside of the target borehole 7a, an earth discharge stop switch 91 for outputting a command signal to stop discharge of crushed soil and rock, a support moving switch 110 for outputting a command signal to move the support 73 arranged on the derrick 62, and a stage moving switch 111 for outputting a command signal to move the discharged earth stage arranged on the derrick 62.

**[0092]** Also arranged inside the control room 80 is a controller 99 for inputting command signals outputted from these switches 86, 87, 88, 89, 90, 91, 110 and 111. This controller 99 is composed, for example, of a micro-computer and has an input/output unit, a memory unit and a processor unit. The processor unit is provided with a boring control unit 100 for controlling boring and earth-discharging work by the second drilling unit 8 and an off-centering control unit 101 for controlling the spatial orientation of the second drilling unit 8 during boring.

**[0093]** The command signals from the above-mentioned individual switches 86, 87, 88, 89, 90, 91, 110 and 111 are inputted to the boring control unit 100 of the controller 99. Each detection signal from the load sensor 77 arranged on the derrick 62 is inputted to the off-centering control unit 101 of the controller 99.

**[0094]** The second drilling unit 8 is also provided with an angle sensor 93 for detecting any dislocation of the drilling unit 8 as mounted on the guide rod 7 about the

guide rod 7 relative to a reference position located right underneath the load sensor 77. Each detection signal from the angle sensor 93 is also inputted to an off-centering control unit 101 of the controller 99. In this embodiment, a distance sensor 94 is also provided for the detection of a distance L1 (shown in FIG. 18) between the mounted position of the load sensor 77 and the second drilling unit 8. Each detection signal from this distance sensor 94 is also inputted to the off-centering control unit 101 of the controller 99. Incidentally, as the distance sensor 94, it is possible to arrange, for example, a sensor which detects each change in length of the wire 65 wound out from the winch 63.

**[0095]** Drive signals outputted from the boring control unit 100 of the controller 99 are fed - as are, namely, as electrical signals or after being converted to hydraulic signals at the hydraulic power unit 4 - to a winch driving unit 95 for driving the winch 63, a support moving unit 96 for moving the support 73, the hydraulic motors 20 for rotating the movable unit 12 of the drilling unit 8, the hydraulic cylinders 21 for causing the movable unit 12 of the drilling unit 8 to advance, the hydraulic cylinder 19f for moving the movable drilling bit 19e mounted on the movable unit 12 of the drilling unit 8, an open/close cylinder 97 for opening or closing the earth drilling bucket 19a mounted on the movable unit 12 of the drilling unit 8, a discharged-earth-stage moving unit 98 for moving the discharged earth stage 82 arranged on the derrick 62, and the hydraulic cylinders 60 for fixing the stationary unit 10 of the drilling unit 8 on the wall of the target borehole 7a, respectively. Further, each drive signal outputted from the off-centering control unit 101 of the controller 99 is converted to a hydraulic signal at the hydraulic power unit 4 and is then fed to the relevant one of the hydraulic cylinders 60 for fixing the stationary unit 10 against the wall of the target borehole 7a.

**[0096]** Referring again to FIGS. 1A through 1F described above, a description will hereinafter be made of a drilling operation performed by the first embodiment of the borehole boring machine of the present invention constructed as described above.

**[0097]** The first drilling unit including the down-the-hole drill 2, the guide rod 7, the second drilling unit 8 and the like are transported to a boring site. Upon performing boring work, the first drilling unit which is equipped with the down-the-hole drill 2 and the rotary table 3 is first arranged on the ground 1 to bore the pilot hole 6 smaller in diameter than the target borehole 7a as depicted in FIG. 1A. In the state shown in FIG. 1A, the hydraulic power unit 4 is actuated to rotate the rotary table 3, and air is fed into the down-the-hole drill 2 from the compressor. Boring is thus performed by the down-the-hole drill 2 as shown in FIG. 1B. Crushed soil and rock occurred by the drilling is discharged to an outside of the ground 1 by blowing the air, which has been fed from the compressor, against the drilled area. The down-the-hole drill 2 is then lifted, whereby the pilot hole 6 is formed in the ground 1. The guide rod 7 shown in FIG. 5 is inserted

into the pilot hole 6.

**[0098]** For example, with the guide rod 7 inserted in the pilot hole 6, the derrick 62 is built as shown in FIG. 6 etc., and the stage moving switch 111 arranged in the control room 80 is operated. As a result, a drive signal is outputted from the drilling control unit 100 of the controller 99 to the discharged-earth-stage moving unit 98. The discharge earth stage 82 shown in FIGS. 12 and 13 is moved out of the derrick 62, thereby forming a space large enough to place the second drilling unit 8 therein.

**[0099]** With the drilling unit 8 suspended via the wire 65, the drilling unit lowering switch 86 or the drilling unit lifting switch 87 arranged in the control room 80 is operated. As a result, the winch driving unit 95 is driven to drive the winch 63 on the support 73 of the derrick 62 so that, as is illustrated in FIG. 6 etc., the second drilling unit 8 is lowered or lifted in a suspended state and is mounted on the guide rod 7. FIG. 6 illustrates the second drilling unit 8 in a state after it has been mounted on the guide rod 7. Next, as is shown by way of example in FIG. 9, desired one or more of the hydraulic cylinders 79 (four cylinders, that is, the front, rear, left and right cylinders) are selectively caused to extend or contract to move the load sensor 77 and the pin 78, so that the pin 78 is fitted in the guide rod 7. As a consequence, the guide rod 7 has been positioned in such a way that it will not undergo swinging.

**[0100]** Upon starting boring work by the second drilling unit 8, the drilling start switch 88 shown in FIG. 15 and arranged in the control room 80 is first operated. As a result, hydraulic fluid is fed to the four hydraulic cylinders 60 which construct the fixing means, so that these hydraulic cylinders 60 are caused to extend. As a consequence, the extendible plates 61 are caused to press the corresponding reaction-force-supporting plates 76 of the derrick 62, whereby the stationary unit 10 of the drilling unit 8 is fixed on these reaction-force-supporting plates 76. Further, hydraulic fluid is also fed to the hydraulic cylinder 19f so that the hydraulic cylinder 19f is caused to extend to maintain the movable drilling bit 19e in a bore-diameter-increasing position. The state shown in FIGS. 6, 7, 8 and 9 indicates the state achieved at this point.

**[0101]** In this state, the hydraulic motors 20 as the rotating means and the hydraulic cylinders 21 as the advancing means are actuated responsive to drive signals outputted from the drilling control unit 100 of the controller 99 shown in FIG. 15. Accordingly, the movable unit 12 downwardly advances while rotating, so that boring is performed over the predetermined distance corresponding to the stroke of the hydraulic cylinders 21 by the drilling tools, that is, the earth drilling bucket 19a, the fixed drilling bit 19d and the movable drilling bit 19e.

**[0102]** When the drilling stop switch 89 in the control room 80 is operated here, signals are outputted from the drilling control unit 100 of the controller 99, so that the hydraulic motors 20 and the hydraulic cylinders 21 are stopped, the hydraulic cylinders 60 forming the fixing

means are caused to contract to separate the extendible plates 61 from the corresponding reaction-force-supporting plates 76 of the derrick 62, and the hydraulic cylinder 19f for the movable drilling bit 19e is caused to contract.

**[0103]** When the drilling unit lowering switch 86 in the control room 80 is operated in this state, the winch driving unit 95 is actuated responsive to a drive signal outputted from the drilling control unit 100 of the controller 99. By the own weight of the stationary unit 10 of the drilling unit 8, the hydraulic cylinders 21 are caused to contract, whereby the stationary unit 10 is allowed to descend toward the movable unit 12. When the stationary unit 10 has descended over a predetermined distance, the winch driving unit 95 is stopped.

**[0104]** After such operation is repeated several times, the drilling start switch 88 in the control room 80 is operated again. The hydraulic cylinders 60 of the fixing means are hence caused to extend to press the individual extendible plates 61 against the wall of the bored borehole 7a so that the stationary unit 10 is fixed. In addition, the hydraulic motors 20 and the hydraulic cylinders 21 as the advancing means are also actuated. This causes the movable unit 12 to downwardly advance under rotation, whereby boring is performed over the predetermined distance corresponding to the stroke of the hydraulic cylinders 21 by the earth drilling bucket 19a, the fixed drilling bit 19d and the movable drilling bit 19e.

**[0105]** Similar operation is then repeated until crushed soil and rock is deposited in a sufficient amount on the earth drilling bucket 19a. FIG. 1D and FIG. 10 illustrate, in the above-described boring operation, a state immediately before the stationary unit 10 is fixed in the target borehole 7a by the fixing means and the boring is started. On the other hand, FIG. 1E shows a state in which the boring over the predetermined distance corresponding to the stroke of the hydraulic cylinders has been completed. Further, FIG. 1F depicts a state in which the stationary unit 10 has been fixed in the target borehole 7a by the fixing means in order to perform boring over the next predetermined distance.

**[0106]** When a substantial amount of crushed soil and rock has been placed in the temporary storage portion 19c of the earth drilling bucket 19a subsequent to repetition of the boring operation over the predetermined distance, the drilling unit lifting switch 87 in the control room 80 is operated. As a result, responsive to a drive signal outputted from the boring control unit 100 of the controller 99, the winch driving unit 95 is actuated so that the drilling unit 8 is lifted in a suspended state into the derrick 62 located above the target borehole 7a. Here, the stage moving switch 111 in the control room 80 is operated. As a result, the discharged earth stage 82 is moved to a position right underneath the drilling unit 8. In this state, the earth discharge start switch 90 in the control room 80 is operated. Responsive to a drive signal outputted from the boring control unit 100 of the controller 99, hydraulic fluid is fed to the earth drilling

bucket open/close cylinder 97 so that the earth drilling bucket 19a is opened at the lower part thereof. Hence, the drilled soil and rock is released from the earth drill bucket 19a onto the discharge earth stage 82 as depicted in FIG. 12. Subsequence to completion of the release of the drilled soil and rock, the earth discharge stop switch 91 in the control room 80 is operated. As a consequence, the earth drilling bucket open/close cylinder 97 is actuated responsive to a drive signal outputted from the drilling control unit 100 of the controller 99, whereby the lower part of the earth drilling bucket 19a is closed. When the stage moving switch 111 is next operated, the discharged earth stage moving unit 98 is actuated responsive to a drive signal outputted from the boring control unit 100 of the controller 99, whereby the discharged earth stage 82 with drilled earth 83 loaded thereon is moved to an outside of the derrick 62. The drilled earth 83 on the discharged earth stage 82 is removed from the discharged earth stage 82 by unillustrated means.

[0107] When the target borehole 7a has been formed over the entire length thereof and the boring work has been completed or, as illustrated in FIG. 14, when boulders 85 or the like which interfere with the work have been found to exist in the target borehole 7a in the course of the boring work, the guide rod 7 is divided in the vicinity of the drilling unit 8 and the support moving switch 110 arranged in the control room 80 is operated. As a result, an unillustrated support moving unit is actuated responsive to a drive signal outputted from the boring control unit 100 of the controller 99 and, as is illustrated in FIGS. 13 and 14, the support 73 moves sideward from a position above the target borehole 7a so that the drilling unit 8 can be moved sideward. Accordingly, the drilling unit 8 which has been suspended via the wire 65 can be detached from the wire 65 and then moved away. Where the boulders 85 exist inside the target borehole 7a as shown in FIG. 14, the boulders 85 are removed and the guide rod 7 and the drilling unit 8 are then placed back so that the boring can be resumed.

[0108] When the second drilling unit 8 is removed at the end of the work, the remaining divided portion of the guide rod 7, said portion being still received in the target borehole 7a, is also taken out of the target borehole 7a.

[0109] In the manner as described above, the target borehole 7a can be bored straight along the extension of the guide rod 7.

[0110] Further, to form a more accurate target borehole 7a, control of the drilling unit 8 is performed by processing detection signals outputted from the load sensor 77, the angle sensor 93 and the distance sensor 94, respectively. This control will hereinafter be described based on FIGS. 16 through 20.

[0111] The guide rod 7 is also provided with a load sensor 77 as described above. This load sensor 77 is however composed, for example, of a load cell of the two-axis detection type or the like, so that forces crossing at a right angle in two directions of X-Y in FIG. 16

can be detected. Two axes X'-Y' in FIG. 16 represent two axes which connect mutually-opposing ones of the advancing means to be fixed upon fixing of the stationary unit 10 of the drilling unit 8 on the wall of the target borehole 7a, namely, of the four hydraulic cylinders 21 and which extend at a right angle with respect to each other. If the guide rod 7 and the drilling unit 8 are provided with means for preventing the drilling unit 8 from moving about the guide rod 7, the X-Y axes which are the directions of forces detectable by the load sensor 77 in advance can be registered with the X'-Y' axes which are imaginarily set on the drilling unit 8. In such a case, the above-described angle sensor 93 arranged on the drilling unit 8 is not required. Since the above-mentioned preventing means is not arranged in the first embodiment, any attempt to register the X-Y axes of the load sensor 77 with the X'-Y' axes set on the drilling unit 8 can hardly be succeeded due to twisting of the wire 65 via which the drilling unit 8 is suspended. Accordingly, the angle sensor 93 of the drilling unit 8 is used as means for converting forces in the directions of the two axes X-Y, which have been detected by the load sensor 77, into forces in the directions of the imaginary two axes X'-Y' set on the drilling unit 8.

[0112] Further, as is depicted in FIG. 18, the following formulae can be established:

$$F = P + N \quad (1)$$

$$P \times L2 = N \times L1 \quad (2)$$

where,

N: Force obtained by combining two forces in the two directions X-Y as detected by the load sensor 77.

F: Biased load applied to the drilling unit 8 in the course of drilling by the earth drilling bucket 19a.

P: Reaction force applied to the guide rod 7.

L2: Distance between the lower extremity of the earth drilling bucket 19a, where reaction force P is produced, and an approximately central point of the earth drilling bucket 19a as viewed in the direction of the height thereof, under the assumption that the biased load F occurs at the approximately central point of the earth drilling bucket 19a.

L1: Distance from the approximately central point of the earth drilling bucket 19a as viewed in the direction of the height thereof to the load sensor 77.

[0113] Here, the distance L2 can be taken as a constant which can be determined from the shape of the earth drilling bucket 19a. The force N, as described above, can be obtained as composition of forces, i.e., detection values in the directions of the two axes X-Y as detected by the load sensor 77. Further, the distance L1

is determined in accordance with a signal outputted from the above-described distance sensor 94. Accordingly, the reaction force P applied to the guide rod 7 can be computed in accordance with the formula (2). In addition, based on the reaction force P determined as described above and the composition of force N obtained from the load sensor 77 as mentioned above, the magnitude of the biased load F applied to the drilling unit 8 can be determined in accordance with the formula (1). The biased load F is opposite in direction to the reaction force P and the composition of force N.

**[0114]** Upon performing boring work, individual detection signals of the load sensor 77, the angle sensor 93 and the distance sensor 94 are inputted to the off-centering control unit 101 of the controller 99 arranged in the control room 8. At this time, the off-centering control unit 101 performs, for example, determination of the composition of force N from forces in the directions of the two axes X-Y as detected by the load sensor 77. Further, from a change in the length of the wire 65 as detected by the distance sensor 94, determination of the distance L1 shown in FIG. 18 is also conducted. Computation is then performed in accordance with the formula (1) to determine the reaction force P, which is applied to the guide rod 7, from the reaction force P and composition of force N determined as described.

**[0115]** Between the composition of force N and the reaction force P and biased load F, all determined as described above, there is a relationship as depicted in FIG. 19. Here, as shown in FIG. 19, computation is performed based on a detection signal of the angle sensor 93 to convert the biased load F on the X-Y axes into force F' on the X'-Y' axes and components of the force F' in the directions of the X' and Y' axes are also determined. Computation is then performed to determine a target distance of operation over which the relevant one of the hydraulic cylinders 60 of the fixing means shown in FIG. 16 should be caused to extend or contract to reduce these components to 0. A drive signal corresponding to this target distance of operation is outputted from the off-centering control unit 101 of the controller 99, and the relevant hydraulic cylinder 60 is actuated responsive to this drive signal.

**[0116]** In the manner as described above, it is possible to control the spatial orientation of the drilling unit 8 during boring work so that the drilling unit 8 receives substantially equal force along the entire periphery thereof. This makes it possible to perform boring while always maintaining the central axis of the drilling unit 8 in substantial coincidence with the central axis of the guide rod 7, i.e., the central axis of the target borehole 7a.

**[0117]** The first embodiment of the borehole boring machine, which is constructed as described above, can also support, as described above in connection with the embodiment of the borehole boring method shown in FIGS. 1A through 1F, reaction force by the wall of the target borehole 7a via the fixing means and also by the

guide rod 7 so that swinging of the drilling unit 8 during boring can be limited and reduced. This makes it possible to perform boring along the extension of the guide rod 7 while minimizing off-centering of the central axis of the drilling unit 8 relative to that of the target borehole 7a and occurrence of tilting of the drilling unit 8, so that the borehole 7a of highly accurate verticality can be bored. Basically, adjustment of the spatial orientation of the drilling unit 8 is not required during boring work, thereby making it possible to improve the efficiency of the boring work. Further, the borehole 7a can be formed with highly accurate verticality so that it is no longer needed to make the diameter of the borehole 7a unnecessarily large. When concrete is placed in the borehole 7a after the boring, concrete can be placed with a minimized loss.

**[0118]** Further, the earth drilling bucket 19a also serves as the earth discharging means. Irrespective of the condition of the ground and the depth of boring, the earth drilling bucket 19a allows to deposit drilled soil and rock therein to an amount corresponding to the capacity of the earth drilling bucket 19a. It is therefore possible to efficiently conduct the discharge of such drilled soil and rock without the need for any special earth discharging means.

**[0119]** In the above-described embodiment, reaction force is supported by the reaction-force-supporting plates 76 arranged on the respective masts 71 of the derrick 62 upon initiation of boring by the second drilling unit 8. No other large structure is therefore needed to support boring reaction force, thereby bringing about an economical advantage.

**[0120]** Further, reaction force is supported during boring by the wall of the target borehole 7a and the guide rod 7 as described above. It is therefore unnecessary for the second drilling unit 8 itself to consider supporting large reaction force, so that the second drilling unit 8 can be constructed small and light. Further, the guide rod 7 can be designed to have such a relatively small diameter that it can be inserted in the pilot hole 6 smaller in diameter than the target borehole 7a. Owing to these features, the borehole boring machine, which includes the first drilling unit with the down-the-hole drill 2 carried thereon, the guide rod 7 and the second drilling unit 8, can be formed small in its overall shape and light in weight. Accordingly, the work for transporting the borehole boring machine, which includes the first drilling unit with the down-the-hole drill 2 carried thereon, the guide rod 7 and the second drilling unit 8, to a boring site is relatively easy. The number of steps required for boring can hence be decreased, thereby making it possible to reduce the boring cost.

**[0121]** To form a target borehole 7a with a greater diameter, it is only necessary to set the size of the drilling tool, such as the earth drilling bucket 19a, on the second drilling unit 8 in correspondence with the diameter of the target borehole 7a. Without causing substantial increases in the sizes and weights of the guide rod 7 and second

drilling machine 8, target boreholes of a large diameter around 3 to 4 meters can therefore be easily formed although the formation of such large boreholes has heretofore been considered relatively difficult.

**[0122]** Because, as has been mentioned above, the work for transporting the borehole boring machine to a boring site is relatively easy and target boreholes of a large diameter around 3 to 4 m can be readily formed, the borehole boring machine according to this embodiment can also be applied to the formation of foundation boreholes for power transmission towers or the like in a mountainous region although the formation of such foundation boreholes has heretofore been performed by hand boring. When the borehole boring machine of this embodiment is applied, instead of hand boring, to the formation of foundation boreholes for power transmission towers or the like in a mountainous region as mentioned above, the efficiency of boring work can be improved significantly.

**[0123]** The second embodiment of the borehole boring machine according to the present invention will next be described with reference to FIGS. 21 and 22.

**[0124]** This second embodiment is provided, as earth discharging means, with means for discharging crushed soil and rock, which has been deposited in the temporary storage portion 19c of the earth drilling bucket 19a, by vacuum suction, in other words, by using an air pressure.

**[0125]** According to this second embodiment, a vacuum unit 102 is arranged on the ground and a hopper 104 for storing crushed soil and rock is arranged on the derrick 62. In a pipe line between the hopper 104 and the vacuum unit 102, a filter unit 103 is arranged. An earth discharge pipe 105 which is connected at one end thereof to the hopper 104 is located facing the temporary storage portion 19c of the earth drilling bucket 19a at a lower end thereof. The remaining structure is similar to the corresponding structure of the first embodiment described above.

**[0126]** In this second embodiment, the vacuum unit 102 is operated when it is desired to discharge crushed soil and rock deposited in the temporary storage portion 19c of the earth drilling bucket 19a as a result of boring work. Upon operation of the vacuum unit 102, the crushed soil and rock in the temporary storage portion 19c is sucked into the earth discharge pipe 105 and is then stored in the hopper 104. Incidentally, the air sucked by the vacuum unit 102 is cleaned at the filter unit 103. In this manner, the crushed soil and rock, which has been removed from the temporary storage portion 19c of the earth drilling bucket 19a and has then been stored in the hopper 104, can be taken out of the derrick 62 by suitable means by opening a lower part of the hopper 104. Other advantageous effects are similar to those available from the above-described first embodiment of the borehole boring machine according to the present invention.

**[0127]** The third embodiment of the borehole boring

machine according to the present invention will hereinafter be described with reference to FIG. 23.

**[0128]** In the third embodiment, as a drilling tool mounted on the lower extremity of the movable unit 21 of the second drilling unit 8, a roller bit 106 which bores the ground 1 by rotating rollers is arranged in place of the above-described earth drilling bucket 19a in the second embodiment shown in FIG. 22. The remaining structure is similar to the corresponding structure of the above-described second embodiment shown in FIG. 22. The borehole boring machine constructed as described above can also bore a target borehole 7a accurately in the ground.

**[0129]** In the first to third embodiments described above, the guide rod 7 is constructed so that it can be divided into plural portions. Where the boring distance of the target borehole 7a is relatively short, a guide rod 7 free of such divided portions can be arranged.

**[0130]** Further, the above-described first to third embodiments are each provided with the hydraulic cylinders 60 as means for driving the extendible plates 61 of the fixing means. It is however possible to adopt such a construction that an electric motor is arranged in place of the hydraulic cylinders 60, conversion means, such as a rack or the like, is arranged to convert rotation of the electric motor into linear motion and the extendible plates 61 is then caused to advance or retreat via the conversion means. Incidentally, four fixing means are arranged at front, rear, left and right positions in a horizontal plane. Only two fixing means can however be arranged in a mutually-opposing relationship, or only three fixing means can be arranged at equal intervals. Five or more fixing means can also be arranged if necessary.

**[0131]** In the first to third embodiments described above, the load sensor 77, the angle sensor 93 and the distance sensor 94 are arranged. It is however possible to design them without these sensors 77, 93, 94 because the target borehole 7a can be bored fundamentally with highly accurate verticality without relying upon such detection signals.

**[0132]** Further, the hydraulic motors 20 are arranged as fixing means in each of the first to third embodiments described above. Electric motors can be arranged in place of these hydraulic motors 20.

**[0133]** In the first to third embodiments described above, the earth drilling bucket 19a, a drilling tool, or the vacuum unit 102 is arranged as earth discharging means. It is however possible to arrange means for blowing compressed air against crushed soil and rock in a drilling area and to remove the crushed soil and rock while blowing compressed air against it. As a further alternative, means for discharging earth by using a water pressure may also be arranged.

**[0134]** As the borehole boring methods and machines according to claims 1-35 of the present application are designed to support boring reaction force by both the wall of the target borehole and the guide rod as described above, the drilling unit for boring the target bore-

hole can be formed into a small-size and lightweight structure which by itself is not required to support large boring reaction force. The borehole boring machine can therefore be formed small in overall shape and light in weight. The work required to transport the boring machine to a boring site is relative easy, so that the number of steps required for boring can be decreased, thereby making it possible to reduce the boring cost compared with the conventional boring machines.

[0135] Further, to form a target borewall with a greater diameter, it is only necessary to set the size of a drilling tool, which is mounted on the boring machine, in correspondence to the diameter of the target borehole. This makes it possible to easily bore a target borehole of a desired size without requiring substantial dimensional enlargement of the guide rod and boring machine. Accordingly, target boreholes having a large diameter around 3 to 4 meters can be formed in the ground although the formation of such large target boreholes has heretofore been difficult.

[0136] As has been described above, the transportation work to the boring site has become relatively easy and the formation of target boreholes of a large diameter around 3 to 4 meters is feasible. Therefore, the borehole boring method and machine according to the present invention can also be applied to the formation of foundation boreholes for power transmission towers or the like in a mountainous region although such foundation boreholes have heretofore been performed by hand boring. When the borehole boring method and machine according to the present invention are applied to the formation of foundation boreholes for power transmission towers or the like in a mountainous region, the efficiency of the boring work can be significantly improved.

[0137] In addition, boring reaction force can be supported by both the wall of the target borehole and the guide rod as described above. This makes it possible to limit and reduce swinging of the boring machine during boring work. It is therefore possible to limit off-centering of the central axis of the boring machine relative to that of the target borehole and also occurrence of tilting of the boring machine, so that the target borehole can be formed straight along the extension of the guide rod. As a consequence, no adjustment of spatial orientation of the boring machine is basically needed in a horizontal plane, thereby making control easier upon performing boring work. Compared with the conventional art, the borehole boring method and machine according to the present invention can therefore efficiently form boreholes with more accurate verticality.

[0138] In the borehole boring machine according to claim 21, especially, the drilling tool is the earth drilling bucket which also serves as earth discharging means. The earth discharging work can hence be efficiently achieve by lifting and lowering the earth drilling bucket in a suspended state. Basically speaking, it is unnecessary to arrange any other earth discharging means. The borehole boring machine can therefore improve the ef-

ficiency of discharging work for drilled soil and rock and moreover, is economical because the number of members required for the construction of the machine can be kept smaller.

## Claims

### 1. A method for boring a borehole by:

drilling in a ground (1) a pilot hole (6) having a diameter smaller than a target borehole (7a) and inserting a guide rod (7) into said pilot hole, mounting a drilling unit (8) on said guide rod, said drilling unit having a drilling tool (19, 19e) for drilling said ground, means (20) for rotating said drilling tool, means (21) for driving said drilling tool and means (62) for fixing a main body of said drilling unit relative to said ground, and causing said drilling tool to advance along said guide rod to bore said target borehole, **characterized in that** said method comprises the following steps:

- 1) inserting said guide rod on a side of an end thereof into said pilot hole;
- 2) inserting said drilling unit into said pilot hole from a side of an opposite end of said guide rod, and positioning and fixing said guide rod on the side of said opposite end thereof on a positioning pin provided on a derrick (62) arranged upright above an opening of said pilot hole;
- 3) causing said fixing means, which is arranged on said main body of said drilling unit, to extend such that said main body of said drilling unit is fixed on said derrick;
- 4) causing said drilling tool to advance while rotating the same;
- 5) after said target hole has been bored over a first predetermined distance, stopping said drilling unit and then causing said fixing means to contract such that said main body of said drilling unit is separated from said derrick;
- 6) moving said main body of said drilling unit over a distance, which corresponds to said first predetermined distance, toward said target borehole;
- 7) causing said fixing means, which is arranged on said main body of said drilling unit, to extend such that said main body of said drilling unit is fixed on a wall of said target borehole bored by said drilling tool;
- 8) causing said drilling tool to advance while rotating the same;
- 9) after said target borehole has been



- bored over a second predetermined distance, stopping said drilling unit and then causing said fixing means to contract such that said main body of said drilling unit is separated from said wall of said target borehole; 5
- 10) moving said main body of said drilling unit over a distance, which corresponds to said second predetermined distance, toward said target borehole; and 10
- 11) repeating said seventh to tenth steps until said target borehole is formed over an entire length thereof.
2. A method according to claim 1, wherein crushed soil and rock occurred by the drilling of the ground is taken out of said ground. 15
  3. A method according to claim 1, wherein said target borehole is a vertical borehole formed extending in a vertical direction. 20
  4. A method according to claim 1, wherein said target borehole is a horizontal bore hole formed extending in a horizontal direction. 25
  5. A method according to claim 1, wherein after formation of said target borehole over the entire length thereof, said drilling unit is taken out of said target borehole. 30
  6. A method according to claim 5, wherein after said drilling unit has been taken out, said guide rod is also taken out of said target borehole. 35
  7. A method according to claim 6, wherein said guide rod is taken out after said guide rod has been divided in advance. 40
  8. A borehole boring machine provided with: 45
    - a first drilling unit (3) for drilling in a ground (1) a pilot hole (6) smaller than a target borehole (7a),
    - a guide rod (7) for being inserted on a side of an end thereof into said pilot hole formed by said first drilling unit, and
    - a second drilling unit (8) having means (62) for fixing a main body of said second drilling unit relative to said ground and a drilling tool for drilling said ground, said second drilling unit being guided by said guide rod to bore said target borehole, 50
    - said second drilling unit further comprising a main body having a stationary unit (10) fixable against a wall of said target borehole via said guide rod and a movable unit (12) movable along a length of said guide rod, said movable unit being connected to said stationary unit and being provided with a non-rotating portion (16) limited in rotation about a wall of said guide rod and said wall of said target borehole, and a rotating portion (18) rotatable about said walls of said guide rod and target borehole, means (60,61) for fixing said stationary unit against said wall of said target borehole, said drilling tool mounted on a rotating portion of said movable unit for boring said target borehole in said ground, means for rotating said drilling tool, and means for causing said movable unit to advance, said advance-causing means being connected at an end thereof to a non-rotating portion of said movable unit and at an opposite end thereof to said stationary unit, 55
- characterized in that:**
- said machine further comprises:
- a derrick (62) for holding said second drilling unit, and
  - a positioning pin arranged on said derrick for positioning and fixing said guide rod on a side of an opposite end thereof.
9. A borehole boring machine according to claim 8, wherein said fixing means comprises a hydraulic cylinder (60) and an extendible plate (61) arranged for being pressed against a wall of said target borehole upon actuation of said hydraulic cylinder.
  10. A borehole boring machine according to claim 8, wherein said rotating means comprises one of a hydraulic motor (20) and an electric motor.
  11. A borehole boring machine according to claim 8, wherein said advancing means comprises a hydraulic cylinder.
  12. A borehole boring machine according to claim 8, wherein said drilling tool is an earth drill bucket (19a).
  13. A borehole boring machine according to claim 8, wherein said drilling tool is a roller bit (106).
  14. A borehole boring machine according to claim 8, wherein said first drilling unit has a down-the-hole drill (2) for drilling said pilot hole.
  15. A borehole boring machine according to claim 8, wherein said machine is additionally provided with means (82; 102-105) for discharging, to an outside of the ground, drilled earth (83) occurred by drilling said ground with said drilling tool of said second

drilling unit.

16. A borehole boring machine according to claim 15, wherein said tool of said second drilling unit is an earth drill bucket (19a) and said earth drill bucket also serves as said drilled-earth discharging means. 5
17. A borehole boring machine according to claim 15, wherein said drilled-earth discharging means is at least one of means (102-103) for discharging the drilled earth by using pneumatic pressure and means for discharging the drilled earth by using hydraulic pressure. 10
18. A borehole boring machine according to claim 8, wherein said guide rod is dividable. 15
19. A borehole boring machine according to claim 8, wherein said machine is additionally provided with means for taking said second drilling unit out of said ground. 20
20. A borehole boring machine according to claim 19, wherein said taking-out means has a wire (65). 25
21. A borehole boring machine according to claim 8, wherein said drilling tool comprises an earth drill bucket (19a), a fixed drilling bit (19d) and a movable drilling bit (19e). 30
22. A borehole boring machine according to claim 21, wherein said machine is additionally provided with a hydraulic cylinder (19f) for actuating said movable drilling bit. 35
23. A borehole boring machine according to claim 8, wherein said derrick has a winch (63) which can lift or lower said second drilling unit in a suspended state. 40
24. A borehole boring machine according to claim 23, wherein said derrick is additionally provided with a support (73) for holding said winch and means for moving said support. 45
25. A borehole boring machine according to claim 24, wherein said moving means comprises rails (74) arranged on said derrick and rollers mounted on said support (73) for rolling movement on said rails. 50
26. A borehole boring machine according to claim 8, wherein said positioning pin (78) is provided with a load sensor (77) for detecting a load which said guide rod receives. 55
27. A borehole boring machine according to claim 8 or 26, wherein said derrick is additionally provided with

a hydraulic cylinder (79) for positioning said pin (78).

28. A borehole boring machine according to claim 8, wherein said derrick is additionally provided with a reaction-force-receiving plate (76) with which said fixing means is engageable.

## 10 Patentansprüche

1. Verfahren zum Bohren eines Bohrloches durch:

Bohren eines Führungsloches (6) in einen Untergrund (1), das einen Durchmesser hat, der kleiner als ein Sollbohrloch (7a) ist, und Einsetzen einer Führungsstange (7) in das Führungsloch,

Montieren einer Bohreinheit (8) an die Führungsstange, wobei die Bohreinheit ein Bohrgerät (19, 19e) zum Bohren des Untergrundes, eine Einrichtung (20) zum Drehen des Bohrgerätes, eine Einrichtung (21) zum Antreiben des Bohrgerätes und eine Einrichtung (62) zum Befestigen eines Hauptkörpers der Bohreinheit relativ zu dem Untergrund aufweist, und Bewirken des Vorschiebens des Bohrgerätes entlang der Führungsstange, um das Sollbohrloch zu bohren, **dadurch gekennzeichnet, dass** das Verfahren die folgenden Schritte aufweist:

1) Einsetzen der Führungsstange an einer Seite ihres einen Endes in das Führungsloch;

2) Einsetzen der Bohreinheit in das Führungsloch von einer Seite eines entgegengesetzten Endes der Führungsstange, und Positionieren und Befestigen der Führungsstange an der Seite ihres entgegengesetzten Endes an einem Positionierstift, der an einem Bohrturm (62) vorgesehen ist, der oberhalb einer Öffnung des Führungsloches aufrecht angeordnet ist;

3) Bewirken, dass sich die Befestigungseinrichtung, welche an dem Hauptkörper der Bohreinheit angeordnet ist, derart erstreckt, dass der Hauptkörper der Bohreinheit an dem Bohrturm befestigt ist;

4) Bewirken, dass sich das Bohrgerät vorschiebt, während dasselbe gedreht wird;

5) nachdem das Sollloch über eine erste vorbestimmte Entfernung gebohrt worden ist, Stoppen der Bohreinheit und dann Bewirken, dass sich die Befestigungseinrichtung derart zusammenzieht, dass der Hauptkörper der Bohreinheit von dem Bohrturm getrennt wird;

- 6) Bewegen des Hauptkörpers der Bohreinheit über eine Entfernung, welche der ersten vorbestimmten Entfernung entspricht, zu dem Sollbohrloch;
- 7) Bewirken, dass sich die Befestigungseinrichtung, welche an dem Hauptkörper der Bohreinheit angeordnet ist, derart erstreckt, dass der Hauptkörper der Bohreinheit an einer Wand des Sollbohrloches befestigt ist, das durch das Bohrgerät gebohrt wird; 5
- 8) Bewirken des Vorschiebens des Bohrgerätes, während dasselbe gedreht wird; 10
- 9) nachdem das Sollbohrloch über eine zweite vorbestimmte Entfernung gebohrt worden ist, Stoppen der Bohreinheit und dann Bewirken, dass sich die Befestigungseinrichtung derart zusammenzieht, dass der Hauptkörper der Bohreinheit von der Wand des Sollbohrloches getrennt wird; 20
- 10) Bewegen des Hauptkörpers der Bohreinheit über eine Entfernung, welche der zweiten vorbestimmten Entfernung entspricht, zu dem Sollbohrloch; und
- 11) Wiederholen des siebten bis zehnten Schrittes, bis das Sollbohrloch über seine gesamte Länge ausgebildet ist. 25
2. Verfahren gemäß Anspruch 1, wobei vorkommendes gebrochenes Erdreich und Gestein durch das Bohren des Untergrundes aus dem Untergrund entfernt wird. 30
3. Verfahren gemäß Anspruch 1, wobei das Sollbohrloch ein vertikales Bohrloch ist, das in einer vertikalen Richtung erstreckt ausgebildet wird. 35
4. Verfahren gemäß Anspruch 1, wobei das Sollbohrloch ein horizontales Bohrloch ist, das in einer horizontalen Richtung erstreckt ausgebildet wird. 40
5. Verfahren gemäß Anspruch 1, wobei nach der Ausbildung des Sollbohrloches über seine gesamte Länge die Bohreinheit aus dem Sollbohrloch entfernt wird. 45
6. Verfahren gemäß Anspruch 5, wobei, nachdem die Bohreinheit entfernt worden ist, die Führungsstange ebenfalls aus dem Sollbohrloch entfernt wird. 50
7. Verfahren gemäß Anspruch 6, wobei die Führungsstange entfernt wird, nachdem die Führungsstange vorher zerlegt worden ist.
8. Bohrlochbohrmaschine, die mit Folgendem versehen ist: 55

einer ersten Bohreinheit (3) zum Bohren eines

Führungsloches (6) in einen Untergrund (1), das kleiner als ein Sollbohrloch (7a) ist, einer Führungsstange (7) zum Einsetzen werden an einer Seite ihres einen Endes in das Führungsloch, das durch die erste Bohreinheit ausgebildet ist, und einer zweiten Bohreinheit (8), die eine Einrichtung (62) zum Befestigen eines Hauptkörpers der zweiten Bohreinheit relativ zu dem Untergrund und ein Bohrgerät zum Bohren des Untergrundes hat, wobei die zweite Bohreinheit durch die Führungsstange geführt wird, um das Sollbohrloch zu bohren,

wobei die zweite Bohreinheit ferner aufweist:

einen Hauptkörper mit einer stationären Einheit (10), die gegenüber einer Wand des Sollbohrloches über die Führungsstange befestigbar ist, und einer bewegbaren Einheit (12), die entlang einer Länge der Führungsstange bewegbar ist, wobei die bewegbare Einheit mit der stationären Einheit verbunden ist, und mit einem nichtdrehenden Abschnitt (16), der um eine Wand der Führungsstange und der Wand des Sollbohrloches in der Drehung beschränkt ist, und einem drehenden Abschnitt (18) versehen ist, der um die Wände der Führungsstange und des Sollbohrloches drehbar ist, eine Einrichtung (60, 61) zum Befestigen der stationären Einheit gegenüber der Wand des Sollbohrloches, das Bohrgerät, das an einem sich drehenden Abschnitt der bewegbaren Einheit zum Bohren des Sollbohrloches in den Untergrund montiert ist, eine Einrichtung zum Drehen des Bohrgerätes, und eine Einrichtung zum Bewirken, dass die bewegbare Einheit vorgeschoben wird, wobei die Vorschubbewirkungseinrichtung an ihrem einen Ende mit einem nichtdrehenden Abschnitt der bewegbaren Einheit und an ihrem einen entgegengesetzten Ende mit der stationären Einheit verbunden ist,

**dadurch gekennzeichnet, dass**  
die Maschine ferner aufweist:

einen Bohrturm (62) zum Halten der zweiten Bohreinheit, und einen Positionierstift, der an dem Bohrturm zum Positionieren und Befestigen der Führungsstange an einer Seite ihres einen entgegengesetzten Endes angeordnet ist.

9. Bohrlochbohrmaschine gemäß Anspruch 8, wobei die Befestigungseinrichtung einen Hydraulikzylinder

der (60) und eine ausziehbare Platte (61) aufweist, die angeordnet ist, um gegen eine Wand des Sollbohrloches bei der Betätigung des Hydraulikzylinders gedrückt zu werden.

10. Bohrlochbohrmaschine gemäß Anspruch 8, wobei die Dreheinrichtung einen Hydraulikmotor (20) und einen Elektromotor aufweist. 5
11. Bohrlochbohrmaschine gemäß Anspruch 8, wobei die Vorschubeinrichtung einen Hydraulikzylinder aufweist. 10
12. Bohrlochbohrmaschine gemäß Anspruch 8, wobei das Bohrgerät ein Abraumbohrfördergefäß (19a) ist. 15
13. Bohrlochbohrmaschine gemäß Anspruch 8, wobei das Bohrgerät ein Rollenbohrer bzw. Rollenmeißel (106) ist. 20
14. Bohrlochbohrmaschine gemäß Anspruch 8, wobei die erste Bohreinheit einen Abwärtsbohrer (2) zum Bohren des Führungsloches hat. 25
15. Bohrlochbohrmaschine gemäß Anspruch 8, wobei die Maschine zusätzlich mit Einrichtungen (82; 102-105) zum Absondern des gebohrten Abraumes (83), der durch das Bohren des Untergrundes mit dem Bohrgerät der zweiten Bohreinheit vorkommt, zu einer Außenseite des Untergrundes versehen ist. 30
16. Bohrlochbohrmaschine gemäß Anspruch 15, wobei das Gerät der zweiten Bohreinheit ein Abraumbohrfördergefäß (19a) ist und das Abraumbohrfördergefäß ebenfalls als die Absonderungseinrichtung des gebohrten Abraumes dient. 35
17. Bohrlochbohrmaschine gemäß Anspruch 15, wobei die Absonderungseinrichtung des gebohrten Abraumes zumindest eine der Einrichtungen (102-103) zum Absondern des gebohrten Abraumes durch Verwenden des pneumatischen Druckes und die Einrichtung zum Absondern des gebohrten Abraumes durch Verwenden des hydraulischen Druckes ist. 40 45
18. Bohrlochbohrmaschine gemäß Anspruch 8, wobei die Führungsstange zerlegbar ist. 50
19. Bohrlochbohrmaschine gemäß Anspruch 8, wobei die Maschine zusätzlich mit einer Einrichtung zum Entfernen der zweiten Bohreinheit aus dem des Untergrund versehen ist. 55
20. Bohrlochbohrmaschine gemäß Anspruch 19, wobei die außerhalb aufnehmende Einrichtung ein Seil

(65) hat.

21. Bohrlochbohrmaschine gemäß Anspruch 8, wobei das Bohrgerät ein Abraumbohrfördergefäß (19a), einen befestigten Bohrer (19d) und einen bewegbaren Bohrer (19e) aufweist.
22. Bohrlochbohrmaschine gemäß Anspruch 21, wobei die Maschine zusätzlich mit einem Hydraulikzylinder (19f) zum Betätigen des bewegbaren Bohrers versehen ist.
23. Bohrlochbohrmaschine gemäß Anspruch 8, wobei der Bohrturm ein Hebezeug (63) hat, welches die zweite Bohreinheit in einem hängenden Zustand anheben oder absenken kann.
24. Bohrlochbohrmaschine gemäß Anspruch 23, wobei der Bohrturm zusätzlich mit einer Trageeinrichtung (73) zum Halten des Hebezeuges und einer Einrichtung zum Bewegen der Trageeinrichtung versehen ist.
25. Bohrlochbohrmaschine gemäß Anspruch 24, wobei die Bewegungseinrichtung Schienen (74), die an dem Bohrturm angeordnet sind, und Rollen aufweist, die an der Trageeinrichtung (73) für die Rollbewegung auf den Schienen montiert sind.
26. Bohrlochbohrmaschine gemäß Anspruch 8, wobei der Positionierstift (78) mit einem Belastungssensor (77) zum Erfassen einer Belastung versehen ist, welche die Führungsstange aufnimmt.
27. Bohrlochbohrmaschine gemäß Anspruch 8 oder 26, wobei der Bohrturm zusätzlich mit einem Hydraulikzylinder (79) zum Positionieren des Stiftes (78) versehen ist.
28. Bohrlochbohrmaschine gemäß Anspruch 8, wobei der Bohrturm zusätzlich mit einer Reaktionskraft-Aufnahmeplatte (76) versehen ist, mit welcher die Befestigungseinrichtung in Eingriff bringbar ist.

## Revendications

### 1. Procédé de forage d'un trou en :

forant dans un sol (1) un trou d'implantation (6) présentant un diamètre inférieur à un trou de repère (7a) et en insérant une vis-guide (7) à l'intérieur dudit trou d'implantation, montant une unité de forage (8) sur ladite vis-guide, ladite unité de forage présentant un outil de forage (19, 19e) destiné à forer ledit sol, des moyens (20) destinés à faire pivoter ledit outil de forage, des moyens (21) destinés à entraîner

ner ledit outil de forage et des moyens (62) destinés à fixer un corps principal de ladite unité de forage par rapport au dit sol, et contraignant ledit outil de forage à avancer le long de ladite vis-guide pour forer ledit trou de repère, **caractérisé en ce que** ledit procédé comprend les étapes suivantes consistant à :

- 1) insérer ladite vis-guide sur un côté d'une extrémité de celle-ci à l'intérieur dudit trou d'implantation ;
- 2) insérer ladite unité de forage à l'intérieur dudit trou d'implantation depuis un côté d'une extrémité opposée de ladite vis-guide, et positionner et fixer ladite vis-guide sur le côté de ladite extrémité opposée de celle-ci sur une goupille de serrage proposée sur une tour de forage (62) agencée verticalement au-dessus d'une ouverture dudit trou d'implantation ;
- 3) contraindre lesdits moyens de fixation, qui sont agencés sur ledit corps principal de ladite unité de forage, à s'étendre de telle manière que ledit corps principal de ladite unité de forage est fixé sur ladite tour de forage ;
- 4) contraindre ledit outil de forage à avancer tout en le faisant pivoter ;
- 5) après que ledit trou de repère a été foré sur une première distance prédéterminée, arrêter ladite unité de forage puis contraindre lesdits moyens de fixation à se contracter de telle manière que ledit corps principal de ladite unité de forage soit séparé de ladite tour de forage ;
- 6) déplacer ledit corps principal de ladite unité de forage sur une distance qui correspond à ladite première distance prédéterminée vers ledit trou de repère ;
- 7) contraindre lesdits moyens de fixation qui sont agencés sur ledit corps principal de ladite unité de forage à s'étendre de telle manière que ledit corps principal de ladite unité de forage est fixé sur une paroi dudit trou de repère foré par ledit outil de forage ;
- 8) contraindre ledit outil de forage à avancer tout en le faisant pivoter ;
- 9) après que ledit trou de repère a été foré sur une seconde distance prédéterminée, arrêter ladite unité de forage puis contraindre lesdits moyens de fixation à se contracter de telle manière que ledit corps principal de ladite unité de forage soit séparé de ladite paroi dudit trou de repère ;
- 10) déplacer ledit corps principal de ladite unité de forage sur une distance qui correspond à ladite seconde distance prédé-

terminée vers ledit trou de repère ; et  
11) répéter lesdites septième à dixième étapes jusqu'à ce que ledit trou de repère soit formé sur une longueur totale de celui-ci.

2. Procédé selon la revendication 1, dans lequel le sol et les roches concassés survenus du fait du forage du sol sont sortis dudit sol.
3. Procédé selon la revendication 1, dans lequel ledit trou de repère est un trou vertical formé en s'étendant dans une direction verticale.
4. Procédé selon la revendication 1, dans lequel ledit trou de repère est un trou horizontal formé en s'étendant dans une direction horizontale.
5. Procédé selon la revendication 1, dans lequel après la formation dudit trou de repère sur la totalité de la longueur de celui-ci, ladite unité de forage est sortie dudit trou de repère.
6. Procédé selon la revendication 5, dans lequel après que ladite unité de forage a été sortie, ladite vis-guide est également sortie dudit trou de repère.
7. Procédé selon la revendication 6, dans lequel ladite vis-guide est sortie après que ladite vis-guide a été divisée par avance.
8. Appareil de forage d'un trou proposé avec :

une première unité de forage (3) destinée à forer dans un sol (1) un trou d'implantation (6) inférieur à un trou de repère (7a),  
une vis-guide (7) destinée à être insérée sur un côté d'une extrémité de celle-ci à l'intérieur dudit trou d'implantation formé par ladite première unité de forage, et  
une seconde unité de forage (8) présentant des moyens (62) destinés à fixer un corps principal de ladite seconde unité de forage par rapport au dit sol et un outil de forage destiné à forer ledit sol, ladite seconde unité de forage étant guidée par ladite vis-guide afin de forer ledit trou de repère,  
ladite seconde unité de forage comprenant en outre  
un corps principal présentant une unité stationnaire (10) pouvant être fixée contre une paroi dudit trou de repère par l'intermédiaire de ladite vis-guide et une unité mobile (12) mobile le long de la longueur de ladite vis-guide, ladite unité mobile étant reliée à ladite unité stationnaire et étant proposée avec une partie non rotative (16) limitée en rotation autour d'une paroi de ladite vis-guide et ladite paroi dudit trou de re-

père, et une partie rotative (18) pouvant être pivotée autour desdites parois de ladite vis-guide et dudit trou de repère,

des moyens (60, 61) destinés à fixer ladite unité stationnaire contre ladite paroi dudit trou de repère,

ledit outil de forage monté sur une partie rotative de ladite unité mobile pour forer ledit trou de repère dans ledit sol,

des moyens destinés à faire pivoter ledit outil de forage, et

des moyens destinés à contraindre ladite unité mobile à avancer, lesdits moyens provoquant l'avancée étant reliés au niveau d'une extrémité de ceux-ci à une partie non rotative de ladite unité mobile et au niveau d'une extrémité opposée de ceux-ci à ladite unité stationnaire,

#### **caractérisé en ce que**

ledit appareil comprend en outre :

une tour de forage (62) destinée à maintenir ladite seconde unité de forage, et

une goupille de serrage agencée sur ladite tour de forage pour positionner et fixer ladite vis-guide sur un côté d'une extrémité opposée de celle-ci.

9. Appareil de forage d'un trou selon la revendication 8, dans lequel lesdits moyens de fixation comprennent un cylindre hydraulique (60) et une plaque extensible (61) agencée pour être pressée contre une paroi dudit trou de repère à l'activation dudit cylindre hydraulique.

10. Appareil de forage d'un trou selon la revendication 8, dans lequel lesdits moyens de rotation comprennent un moteur hydraulique (20) et un moteur électrique.

11. Appareil de forage d'un trou selon la revendication 8, dans lequel lesdits moyens d'avancée comprennent un cylindre hydraulique.

12. Appareil de forage d'un trou selon la revendication 8, dans lequel ledit outil de forage est un godet de bêche tarière (19a).

13. Appareil de forage d'un trou selon la revendication 8, dans lequel ledit outil de forage est un taillant à rouleaux (106).

14. Appareil de forage d'un trou selon la revendication 8, dans lequel ladite première unité de forage présente un foret de coup de fond (2) pour forer ledit trou d'implantation.

15. Appareil de forage d'un trou selon la revendication

8, dans lequel ledit appareil est proposé de manière supplémentaire avec des moyens (82, 102 à 105) destinés à décharger vers un extérieur du sol la terre forée (83) survenue du fait du forage dudit sol avec ledit outil de forage de ladite seconde unité de forage.

16. Appareil de forage d'un trou selon la revendication 15, dans lequel ledit outil de ladite seconde unité de forage est un godet de bêche tarière (19a) et ledit godet de bêche tarière sert également en tant que dits moyens de déchargement de terre forée.

17. Appareil de forage d'un trou selon la revendication 15, dans lequel lesdits moyens de déchargement de terre forée sont au moins un des moyens (102-103) destinés à décharger la terre forée utilisant la pression pneumatique et des moyens destinés à décharger la terre forée utilisant la pression hydraulique.

18. Appareil de forage d'un trou selon la revendication 8, dans lequel ladite vis-guide peut être divisée.

19. Appareil de forage d'un trou selon la revendication 8, dans lequel ledit appareil est proposé de manière supplémentaire avec des moyens destinés à sortir ladite seconde unité de forage du sol.

20. Appareil de forage d'un trou selon la revendication 19, dans lequel lesdits moyens de sortie présentent un fil (65).

21. Appareil de forage d'un trou selon la revendication 8, dans lequel ledit outil de forage comprend un godet de bêche tarière (19a), un taillant fixe (19d) et un taillant mobile (19e).

22. Appareil de forage d'un trou selon la revendication 21, dans lequel ledit appareil est proposé de manière supplémentaire avec un cylindre hydraulique (19f) destiné à actionner ledit taillant mobile.

23. Appareil de forage d'un trou selon la revendication 8, dans lequel ladite tour de forage présente un treuil (63) qui peut soulever ou abaisser ladite seconde unité de forage dans un état suspendu.

24. Appareil de forage d'un trou selon la revendication 23, dans lequel ladite tour de forage est proposée de manière supplémentaire avec un support (73) destiné à maintenir ledit treuil et des moyens destinés à déplacer ledit support.

25. Appareil de forage d'un trou selon la revendication 24, dans lequel lesdits moyens mobiles comprennent des rails (74) agencés sur ladite tour de forage et des rouleaux montés sur ledit support (73) pour

un mouvement de roulis sur lesdits rails.

- 26.** Appareil de forage d'un trou selon la revendication 8, dans lequel ladite goupille de serrage (78) est proposée avec un détecteur de charge (77) destiné à détecter une charge que ladite vis-guide reçoit. 5
- 27.** Appareil de forage d'un trou selon la revendication 8 ou 26, dans lequel ladite de forage est proposée de manière supplémentaire avec un cylindre hydraulique (79) destiné à positionner ladite goupille (78). 10
- 28.** Appareil de forage d'un trou selon la revendication 8, dans lequel ladite tour de forage est proposée de manière supplémentaire avec une plaque de réception de force de réaction (76) avec laquelle lesdits moyens de fixation peuvent être mis en prise. 15

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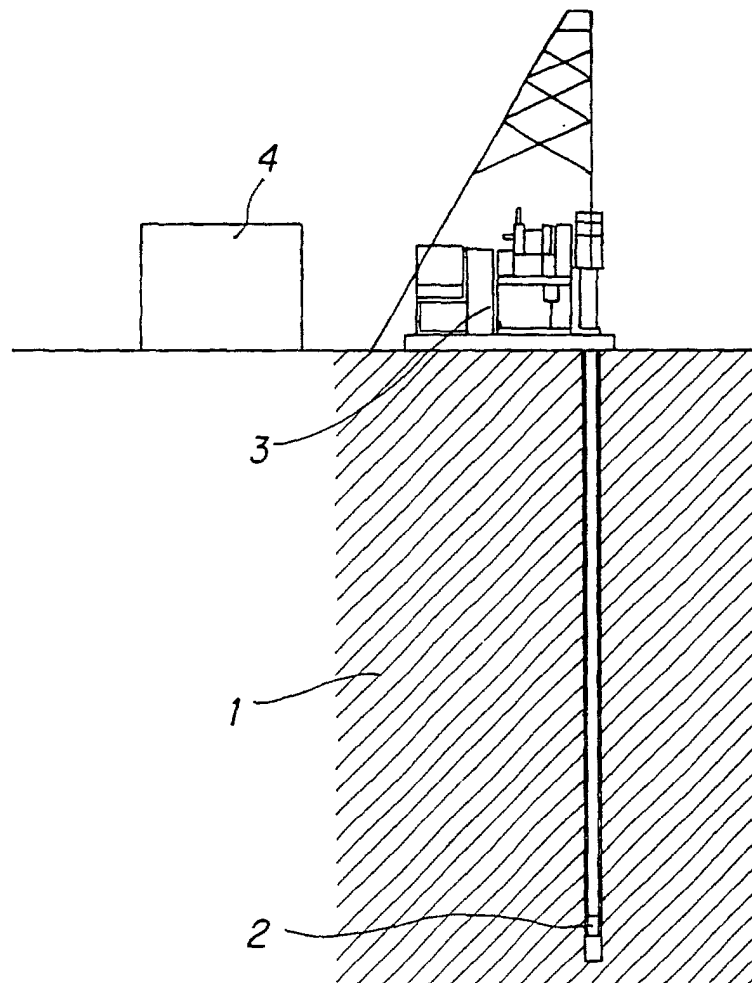
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*FIG. 1A*





**FIG. 1B**

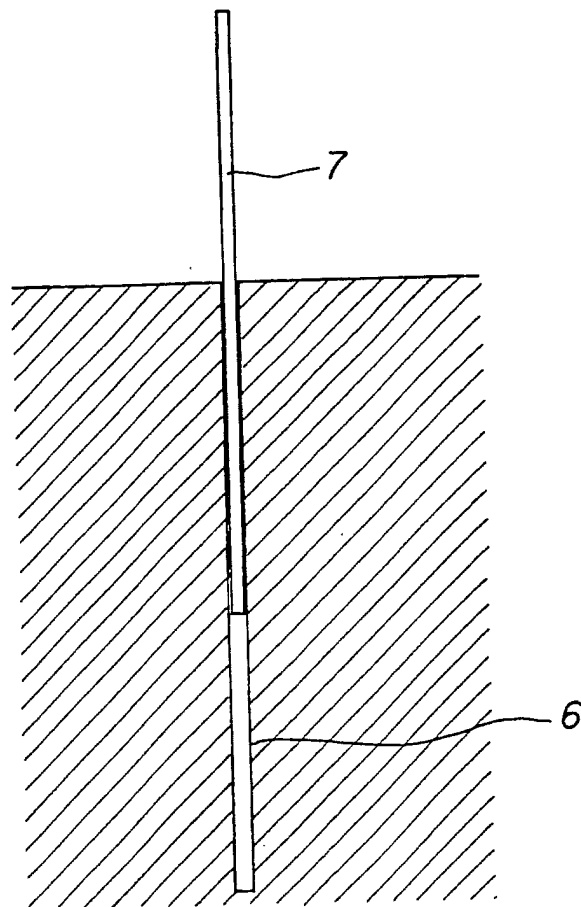


FIG. 1C

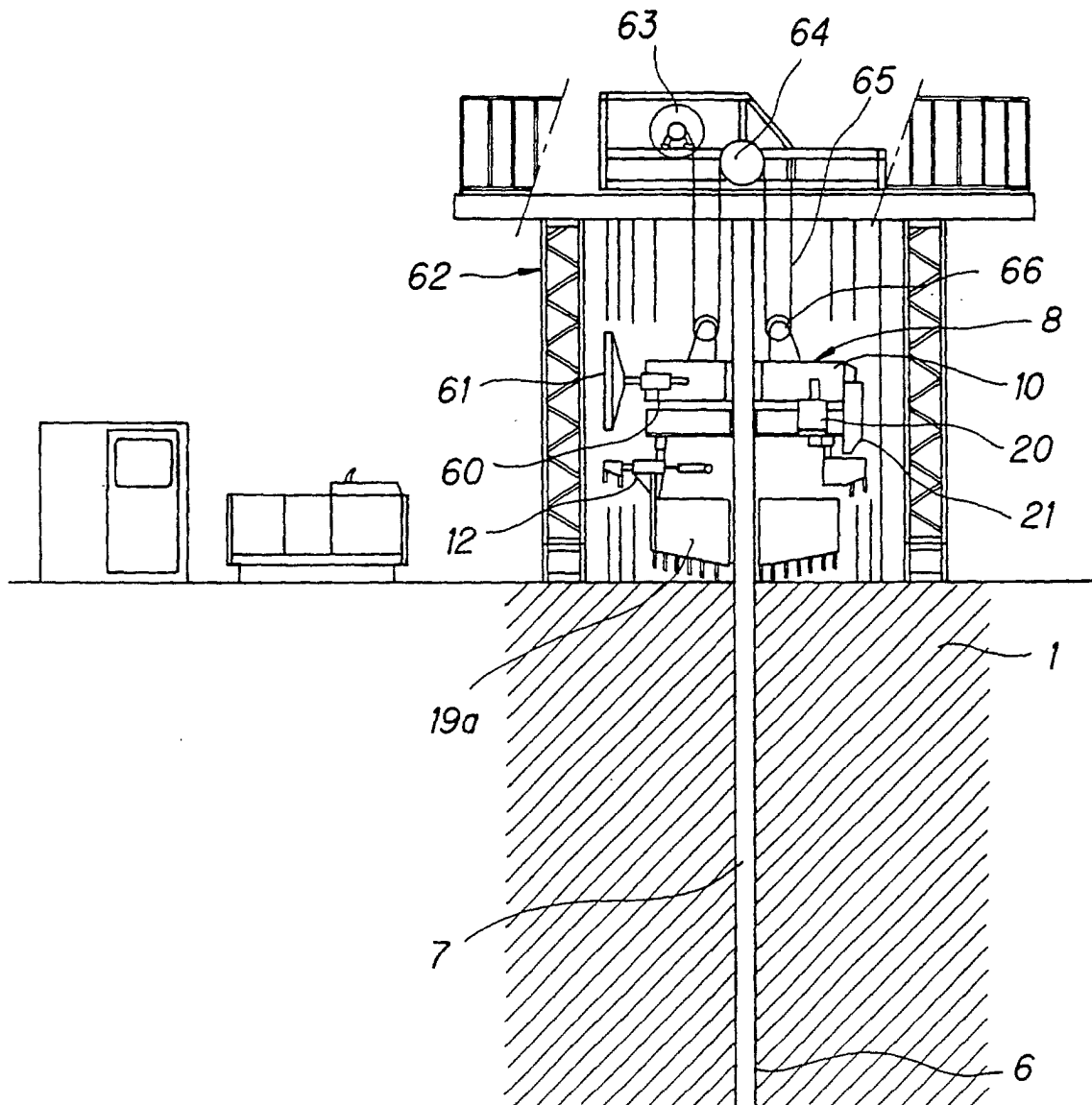


FIG. 1D

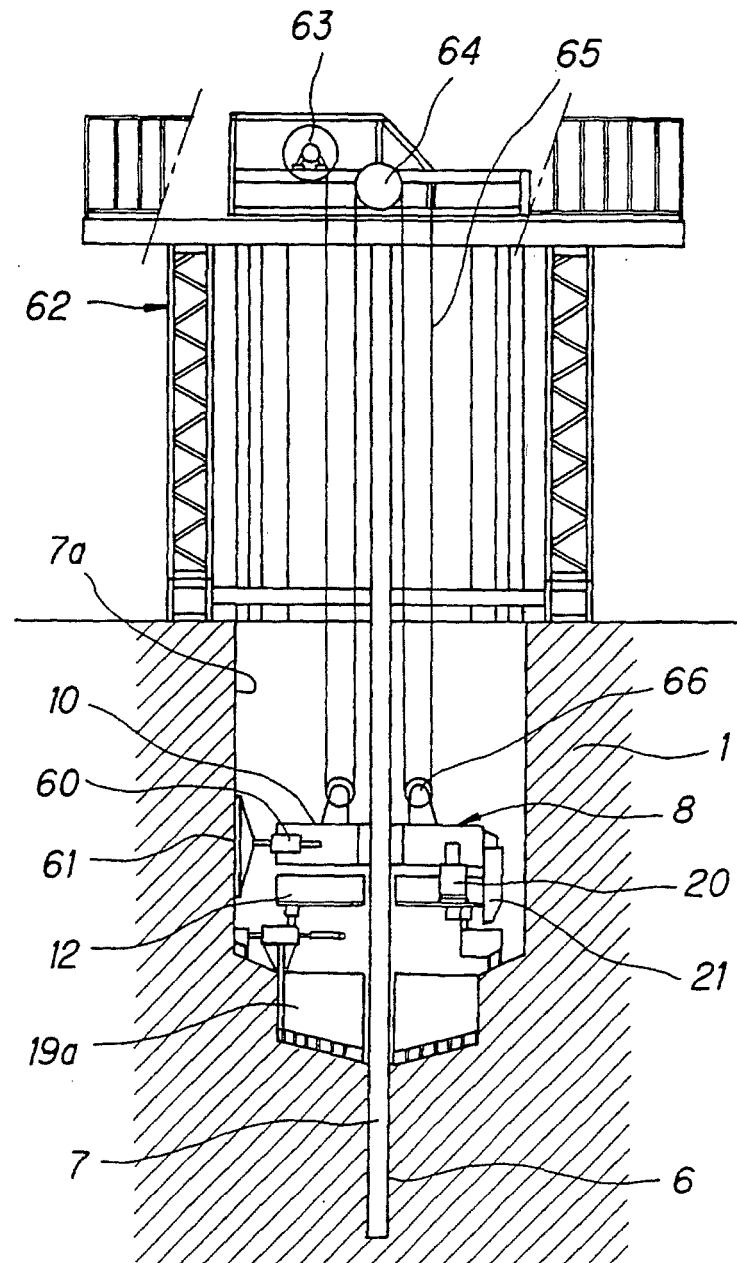


FIG. 1E

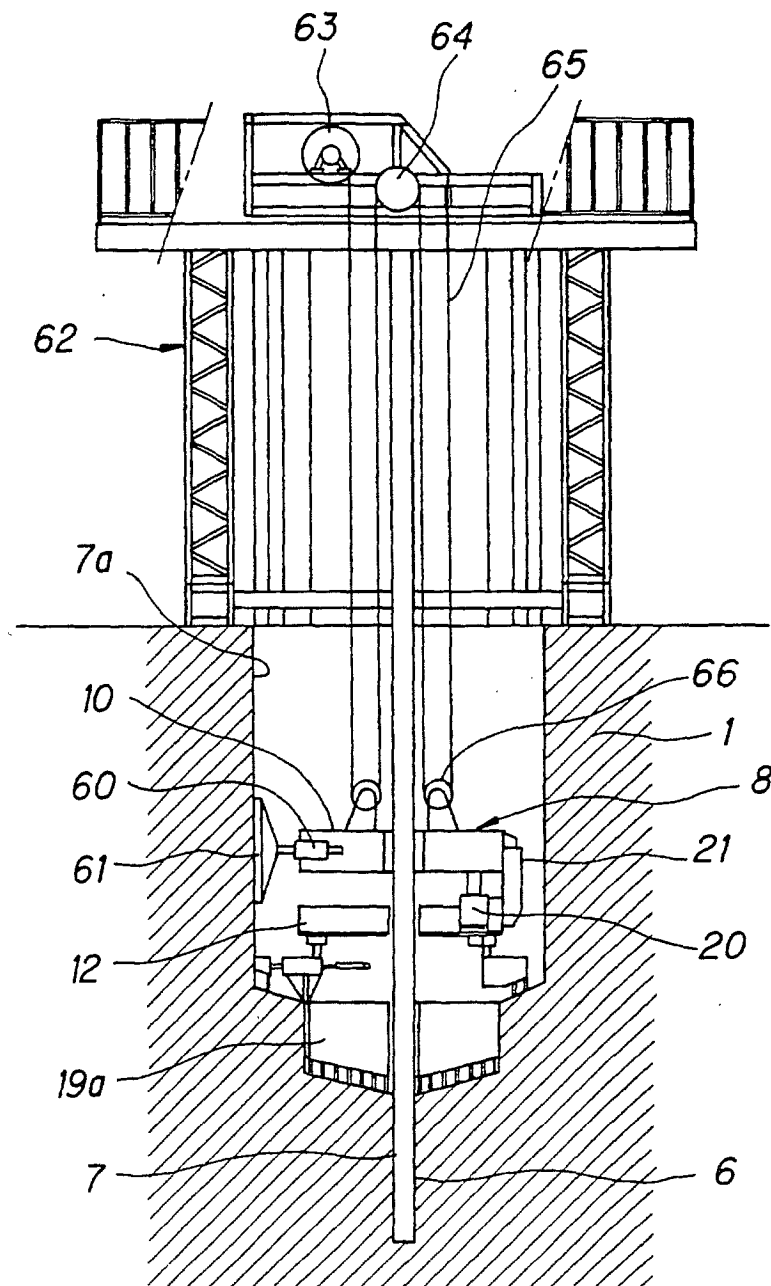


FIG. 1F

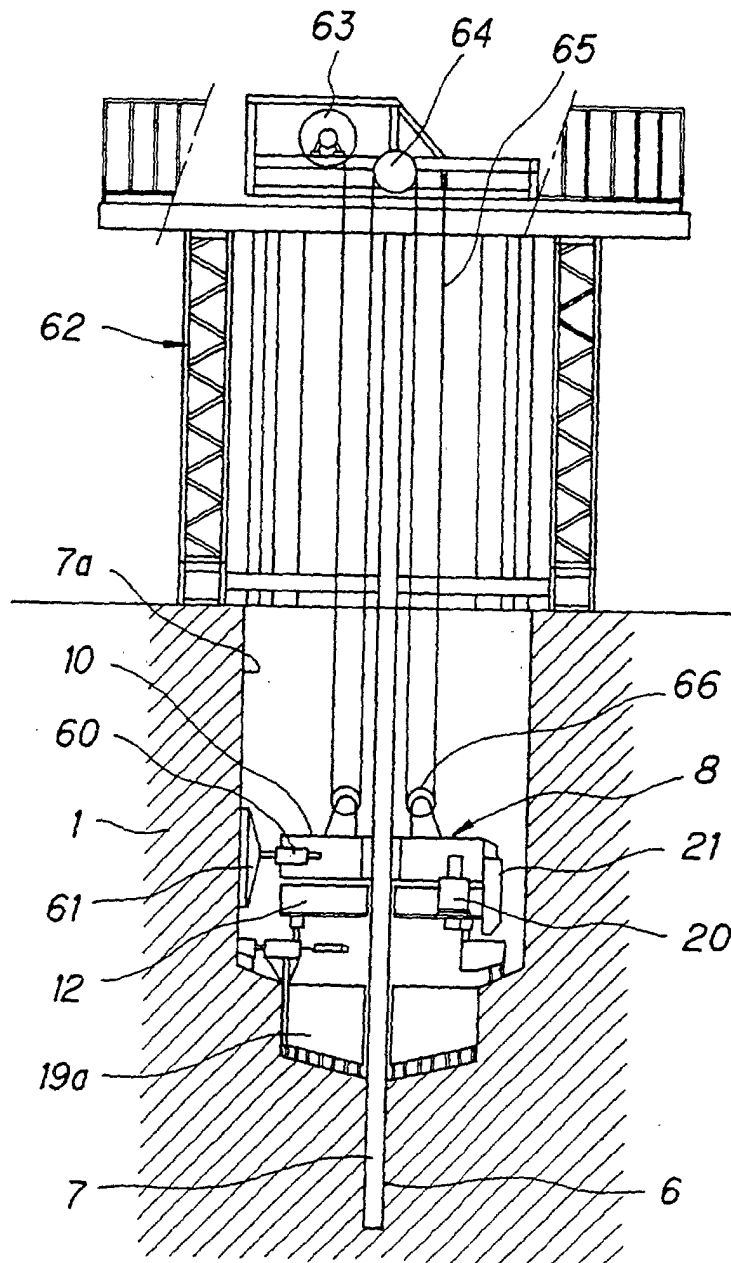


FIG. 2

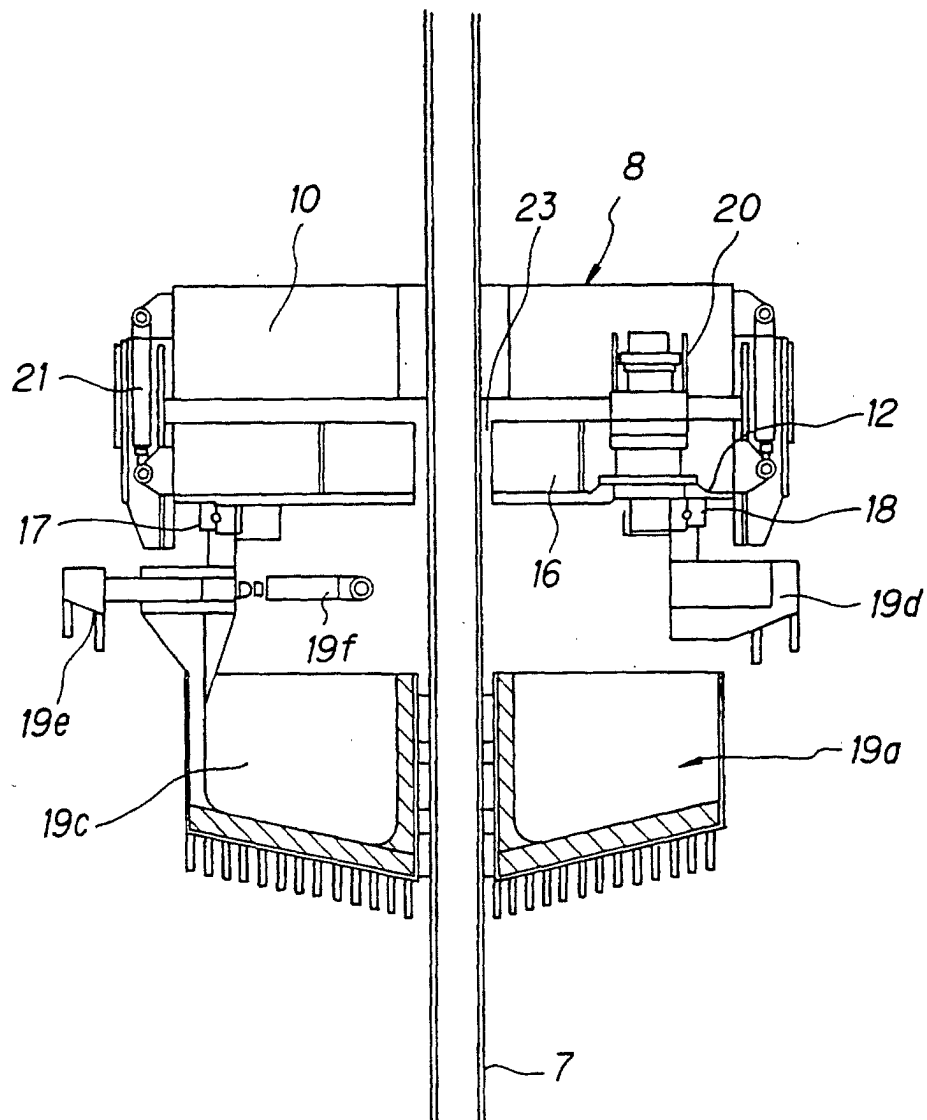


FIG. 3

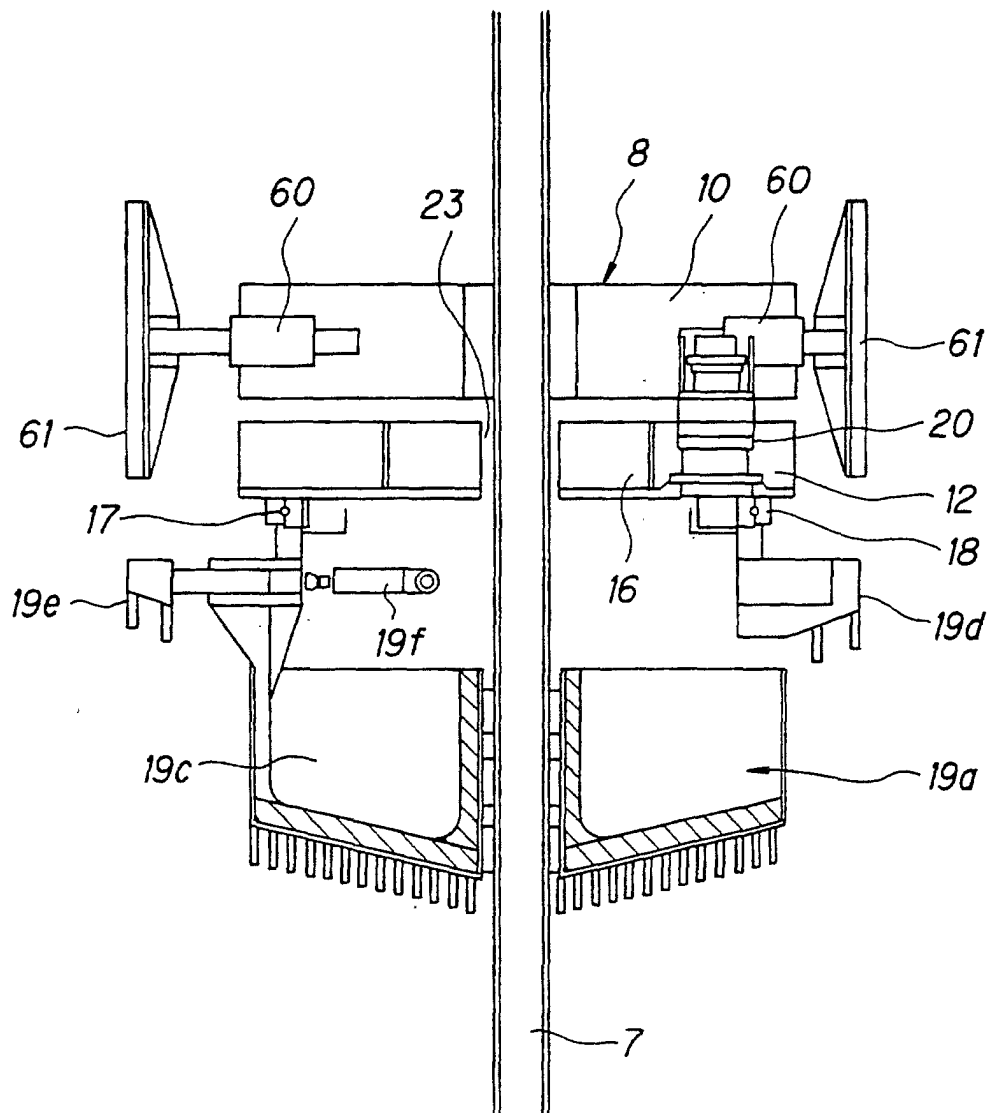
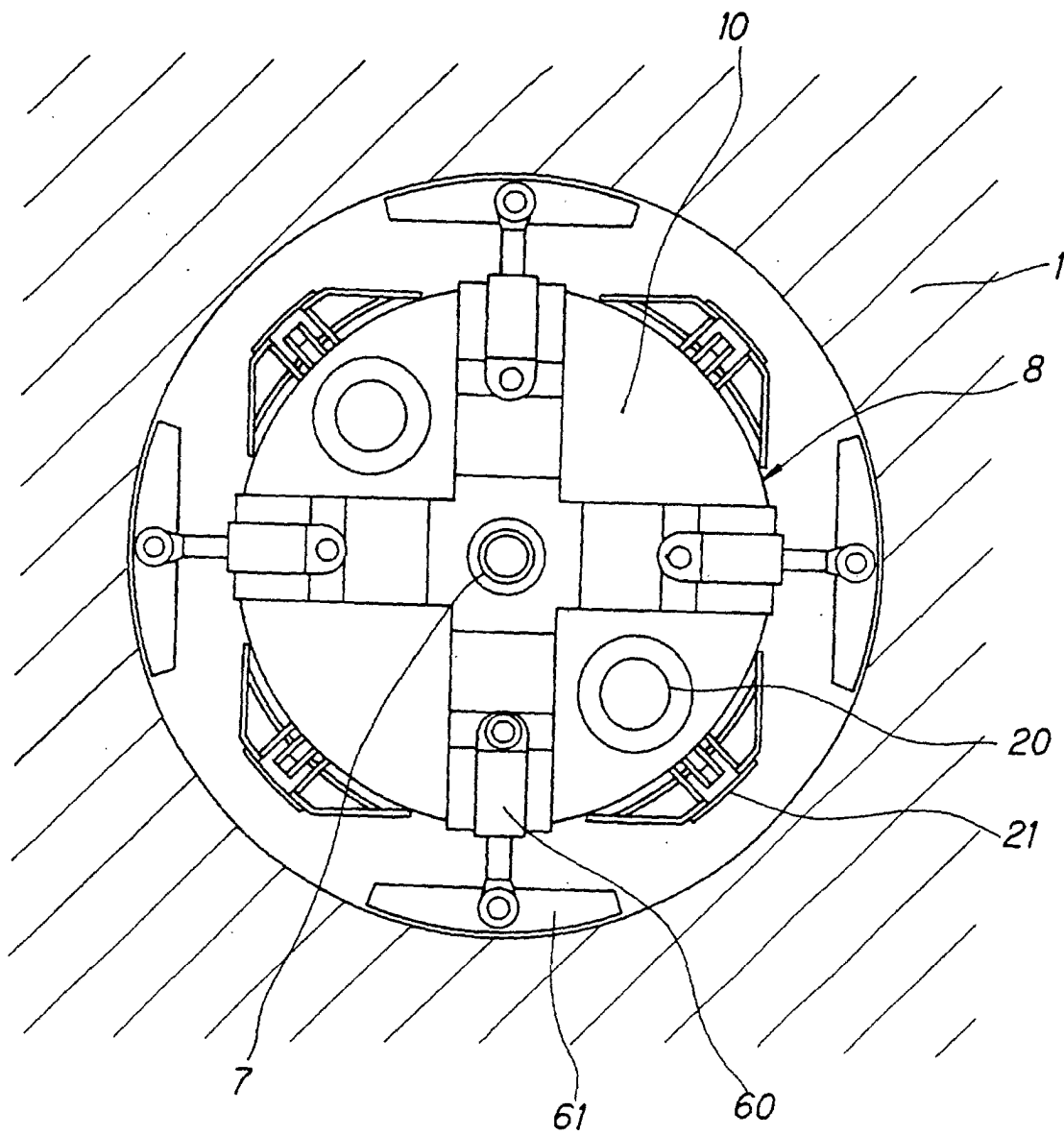


FIG. 4





**FIG. 5**

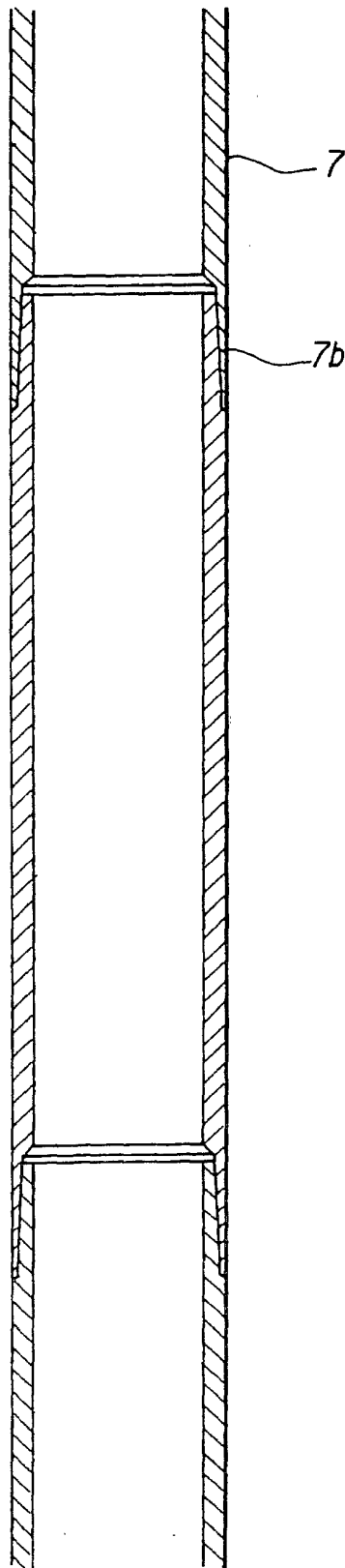
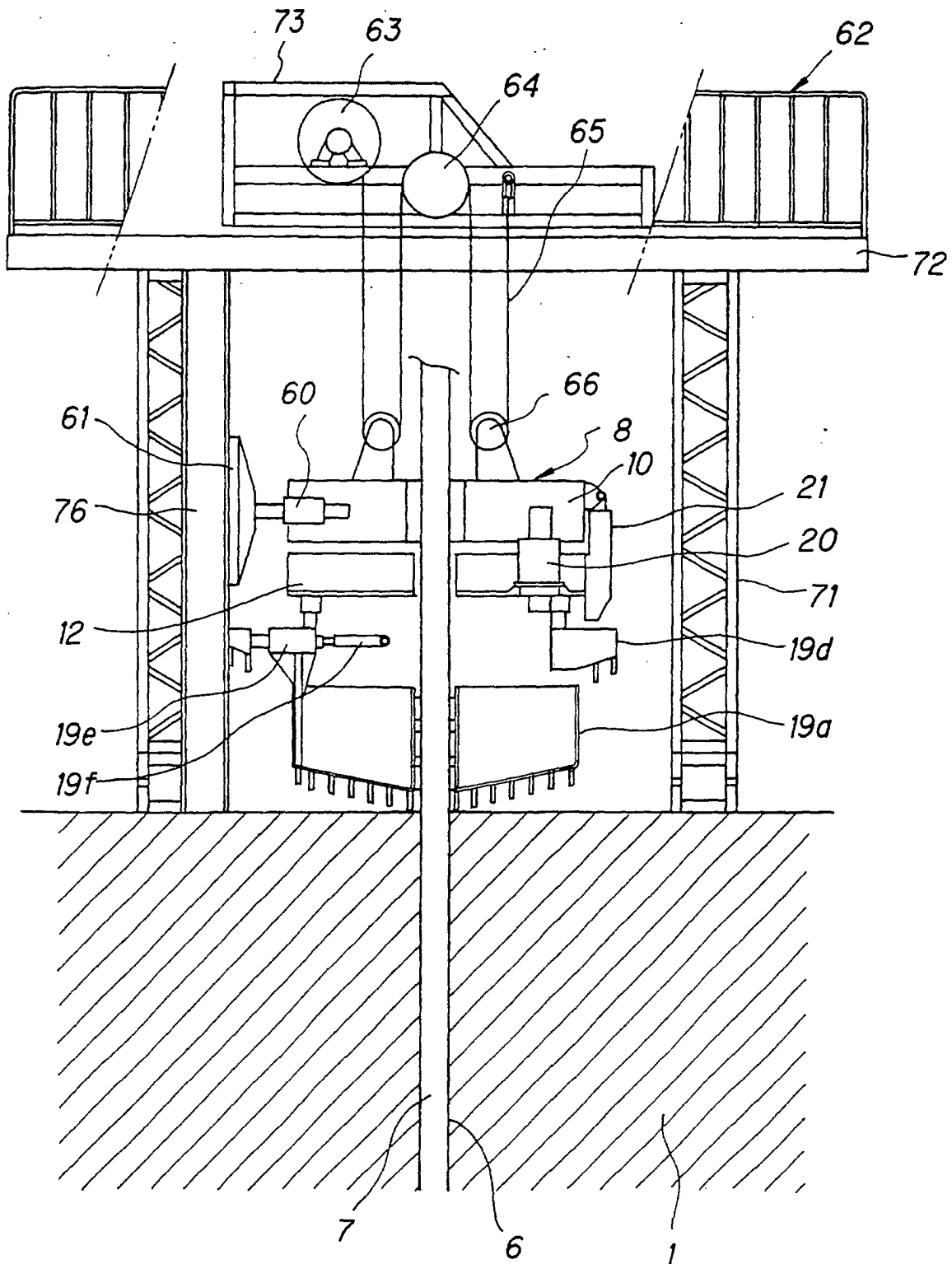


FIG. 6



*FIG. 7*

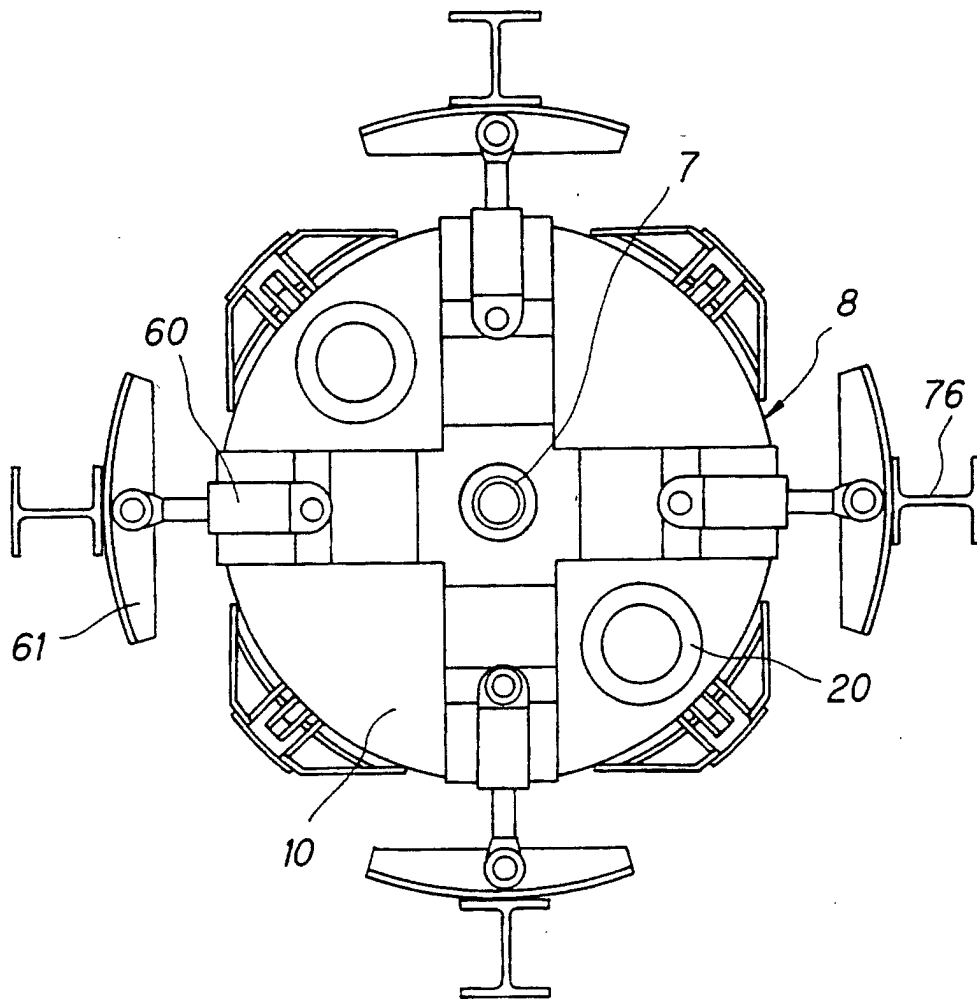


FIG. 8

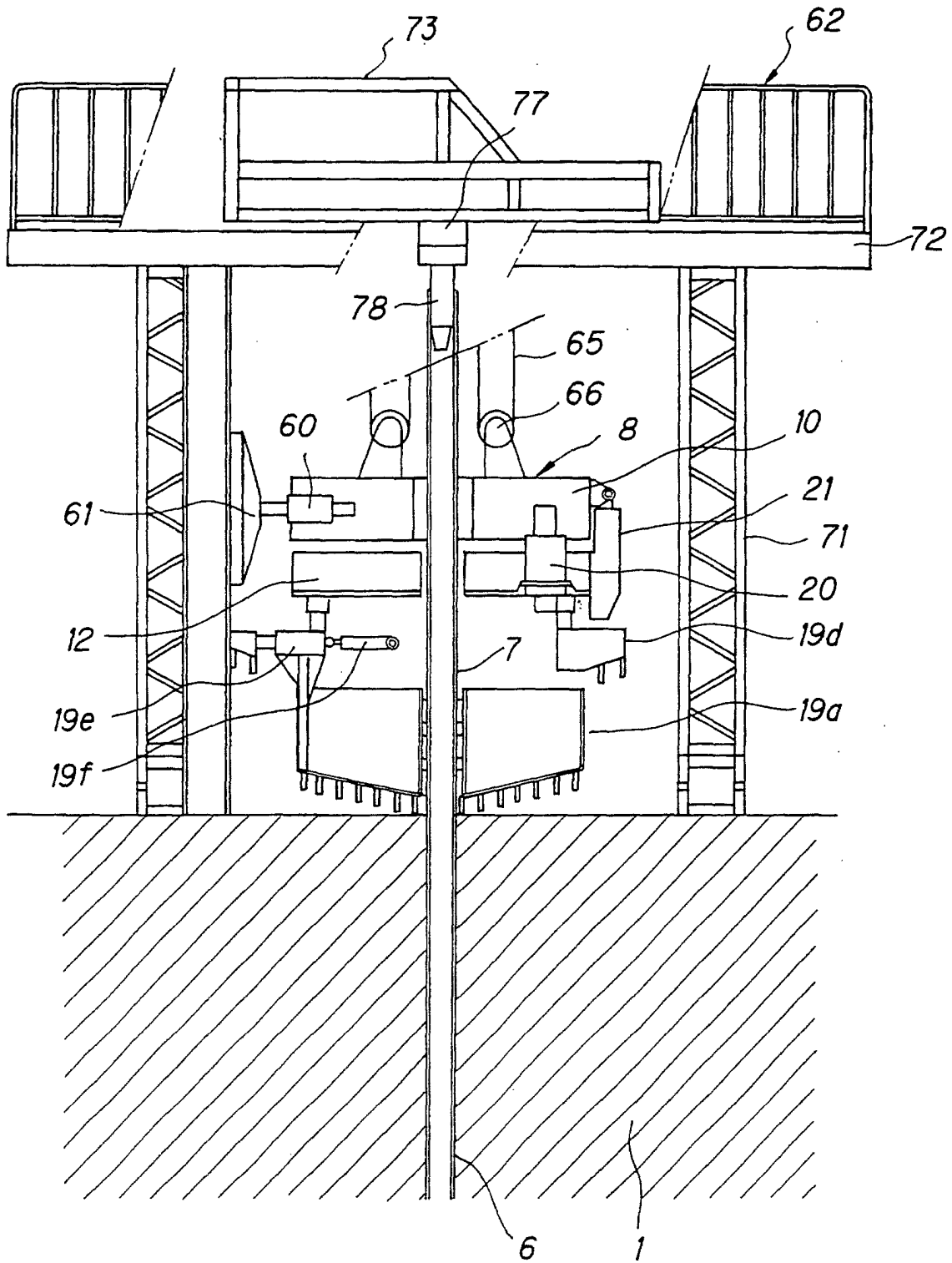
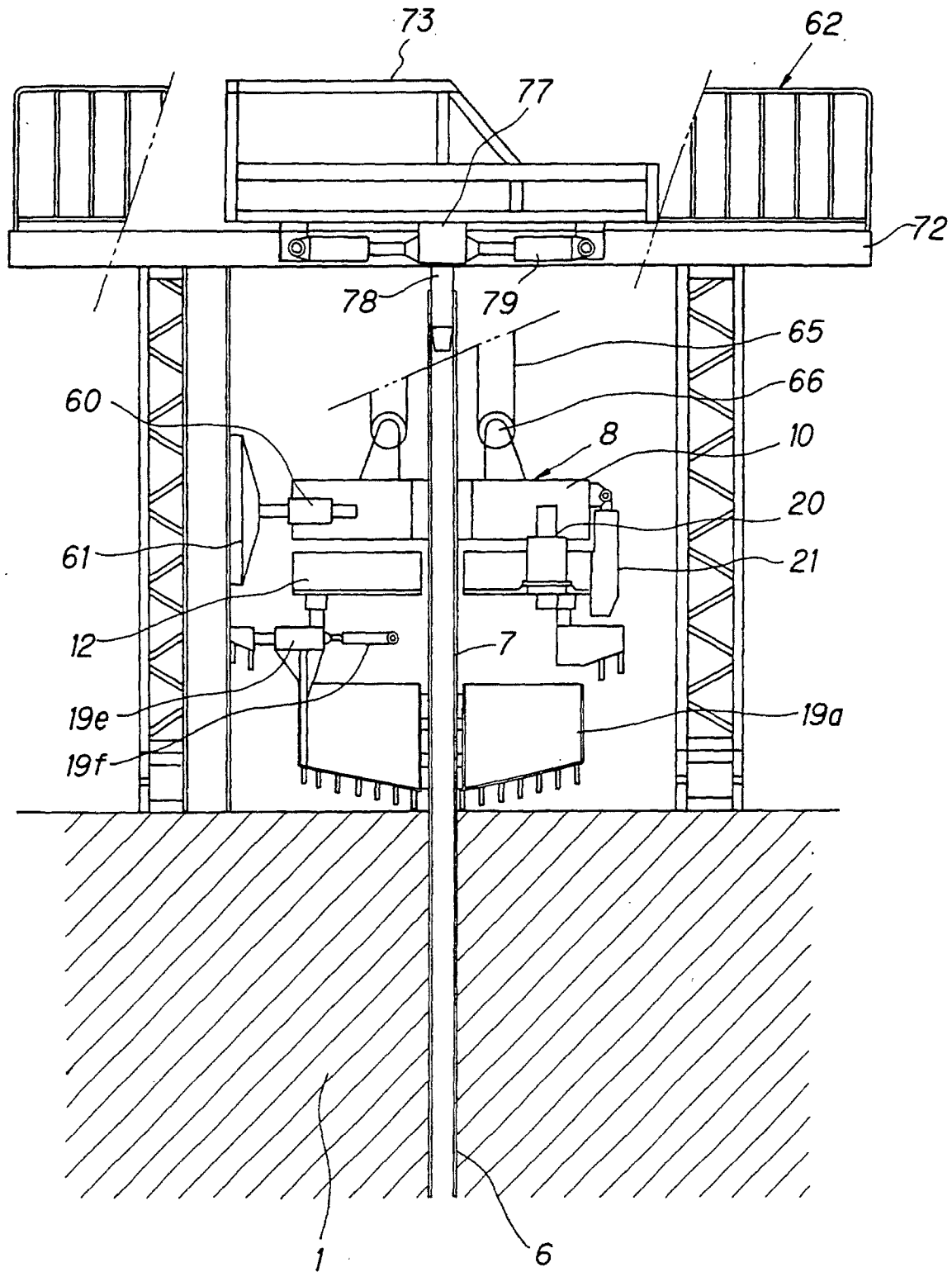
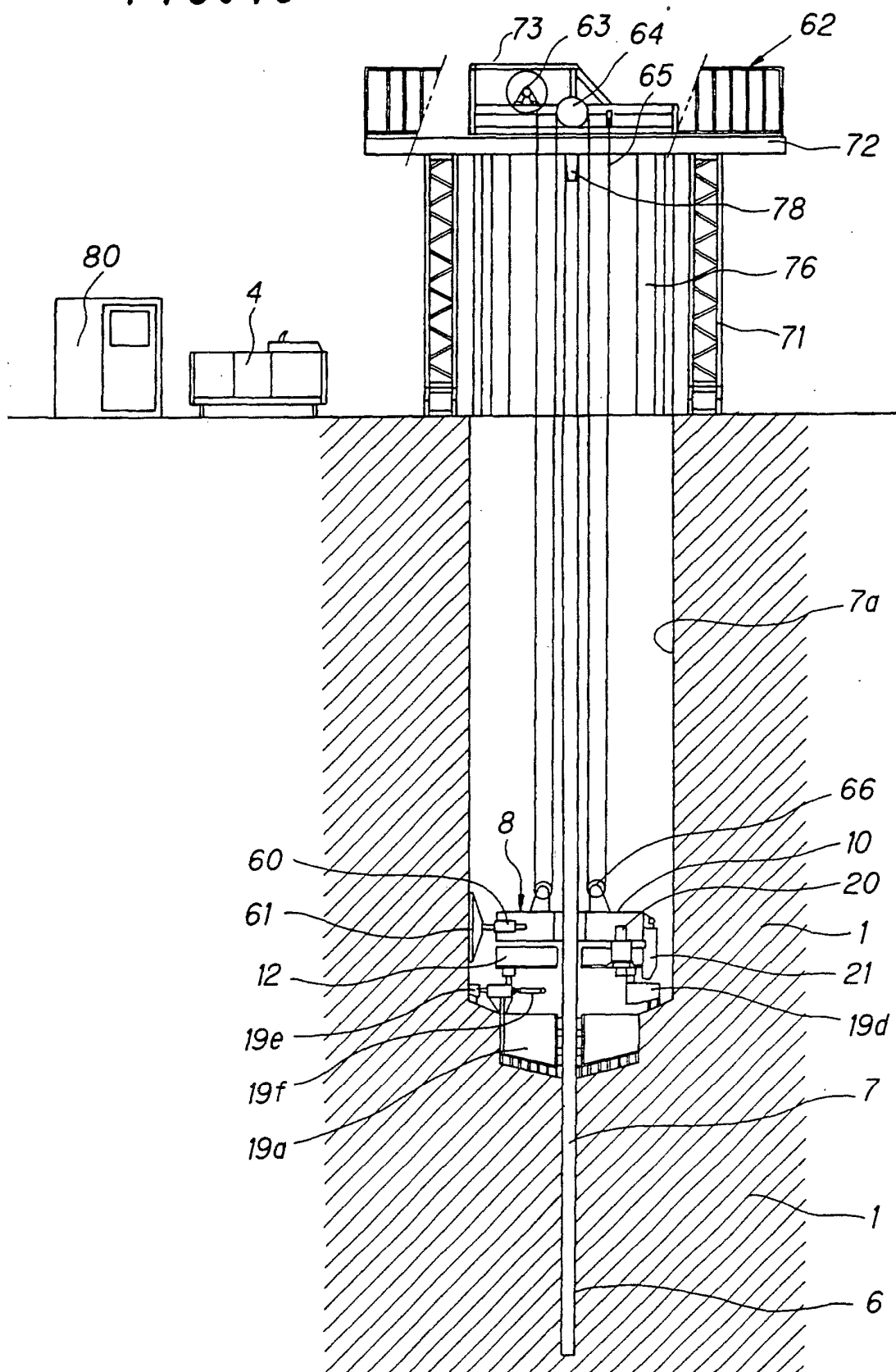


FIG. 9



**FIG. 10**



**FIG. 11**

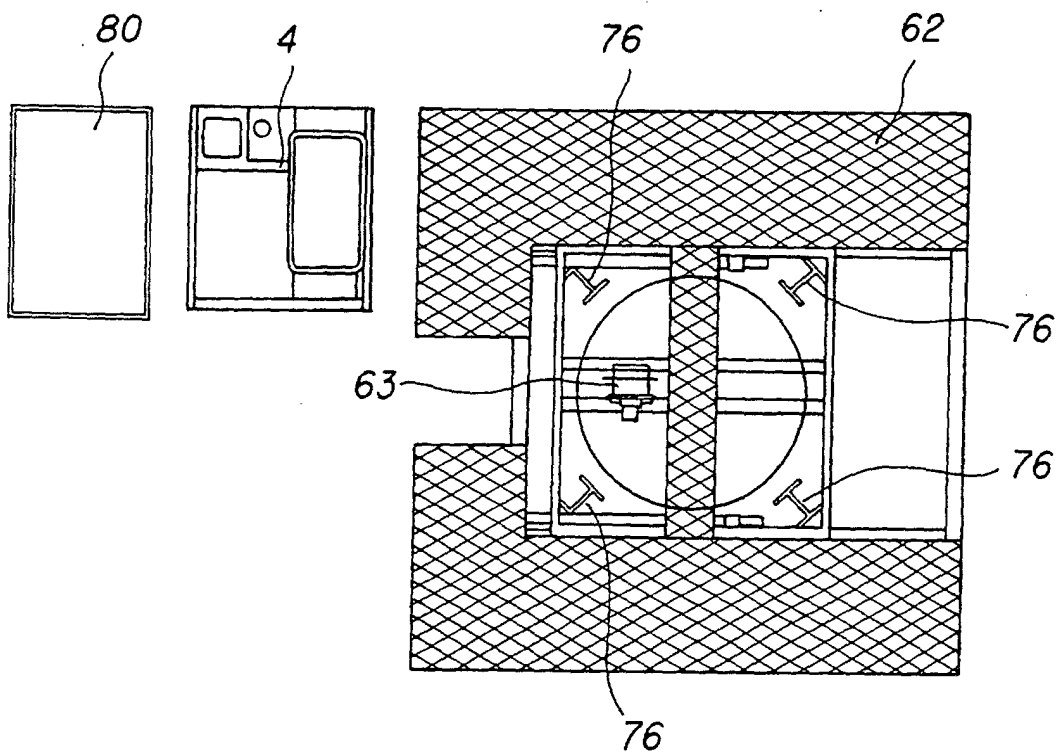


FIG. 12

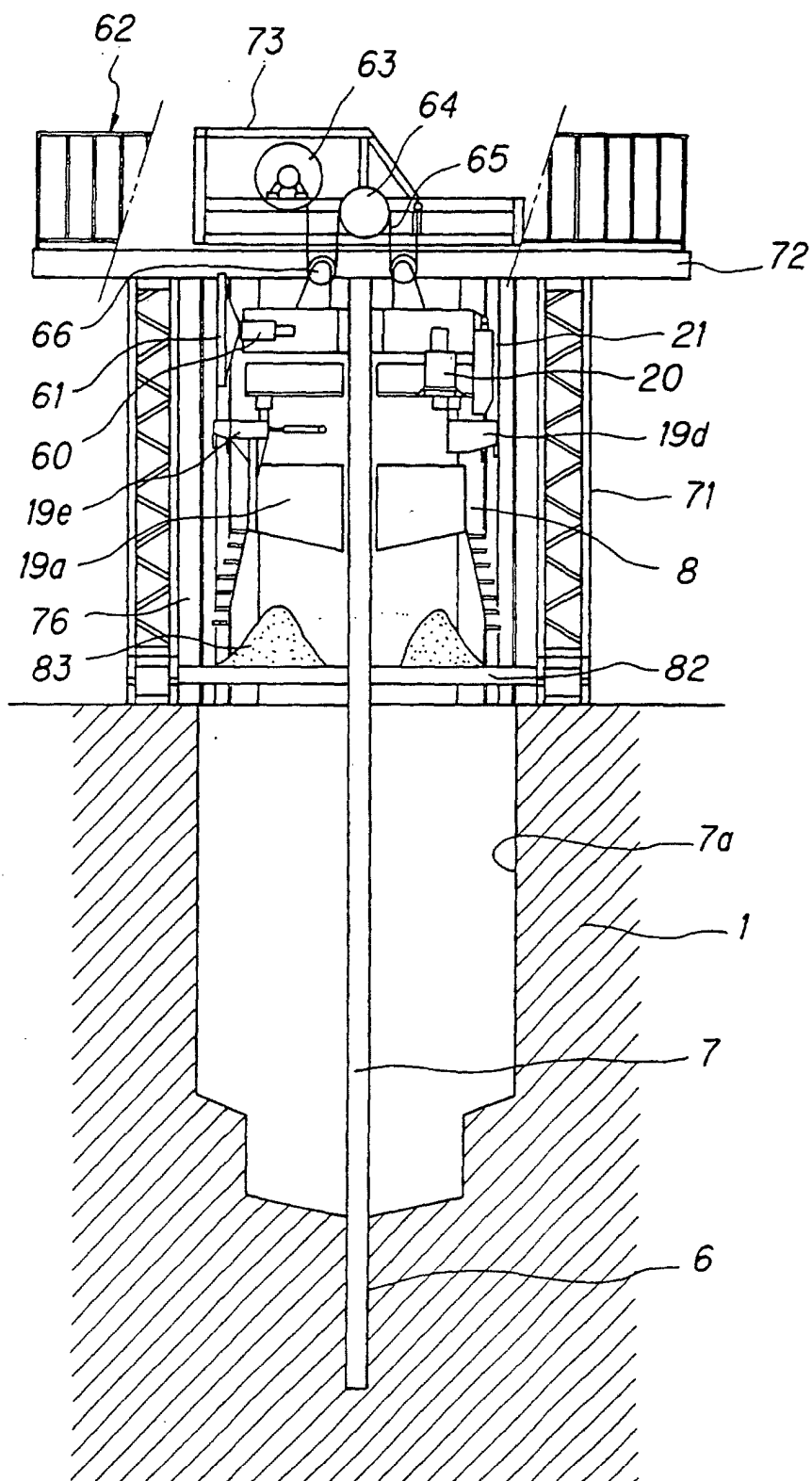




FIG. 13

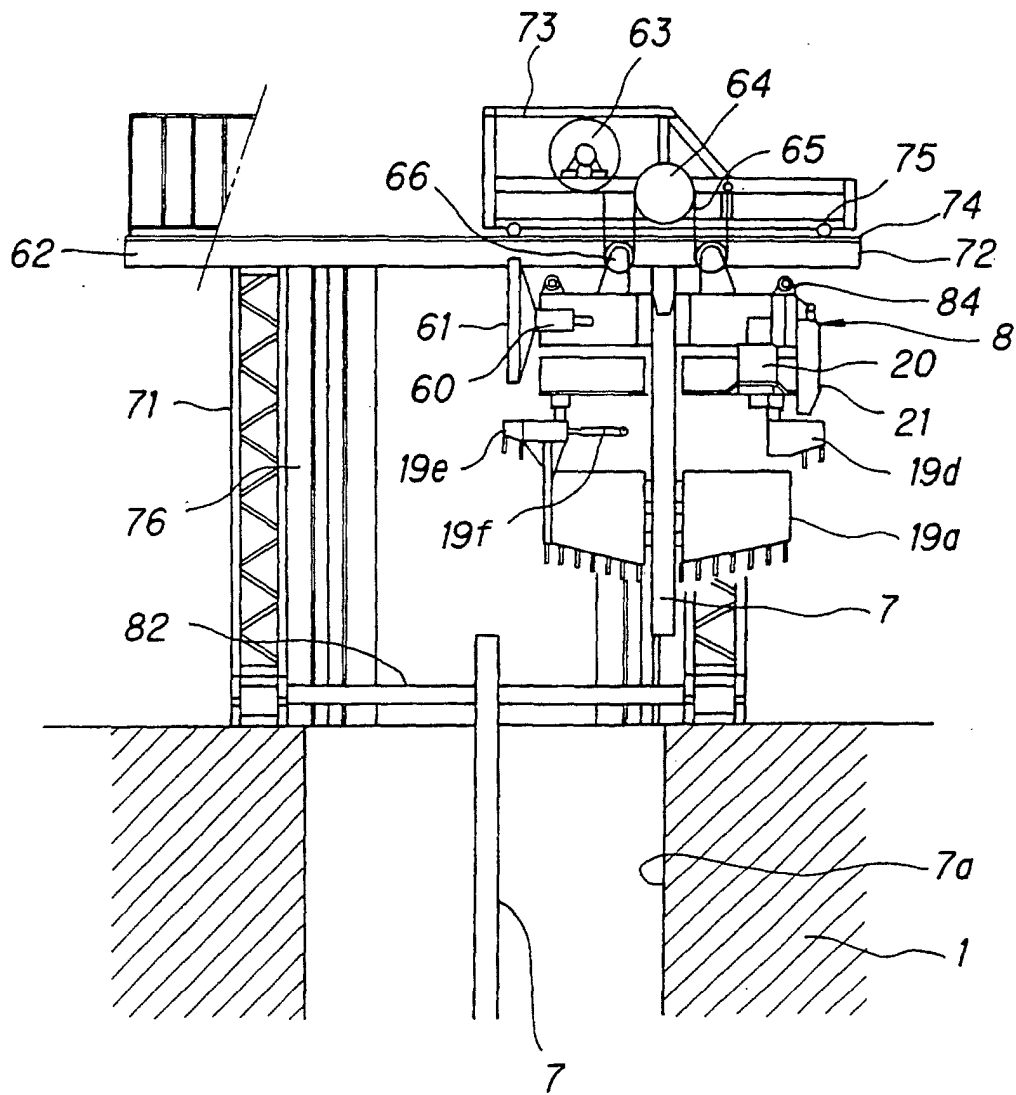


FIG. 14

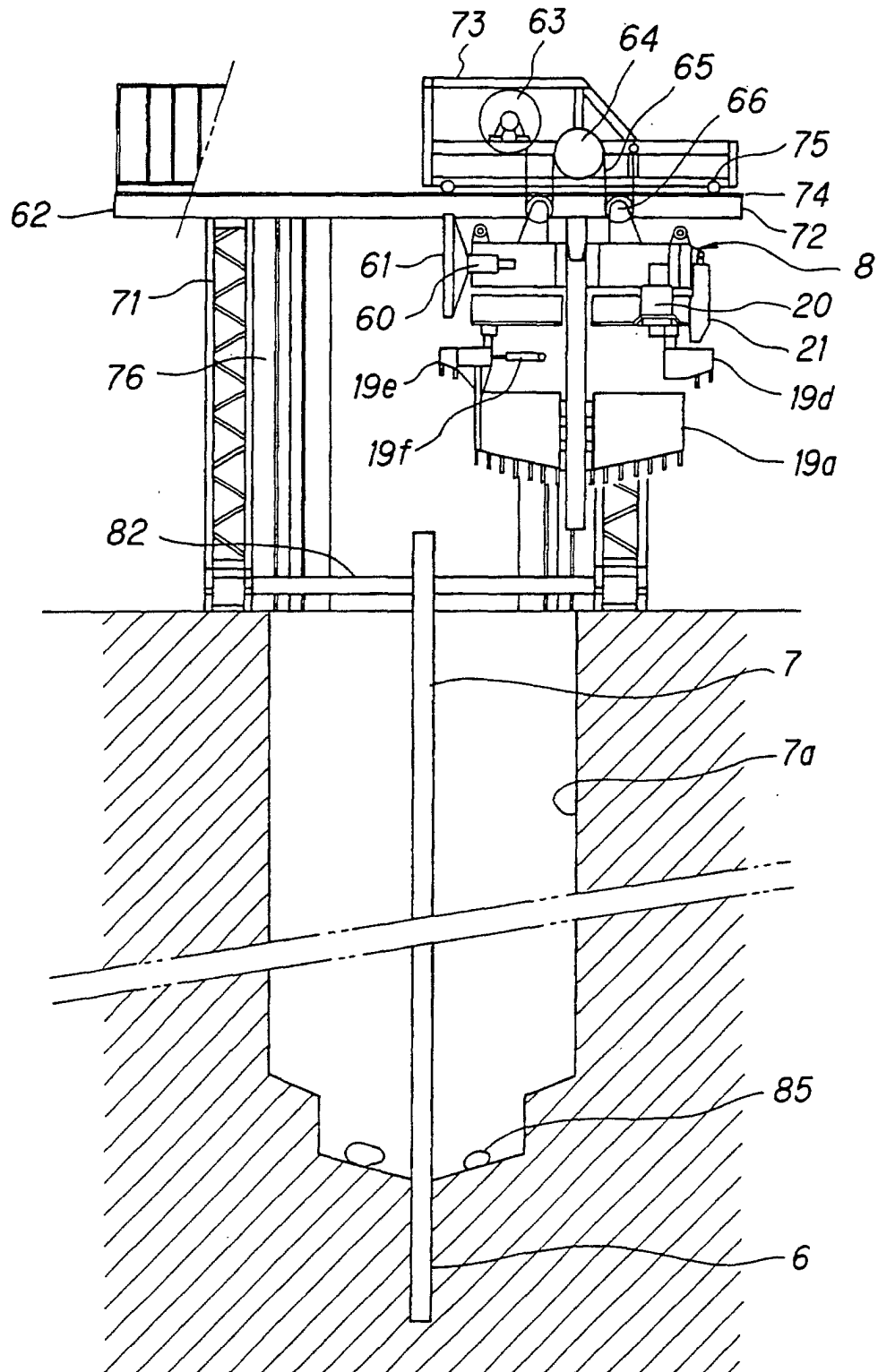
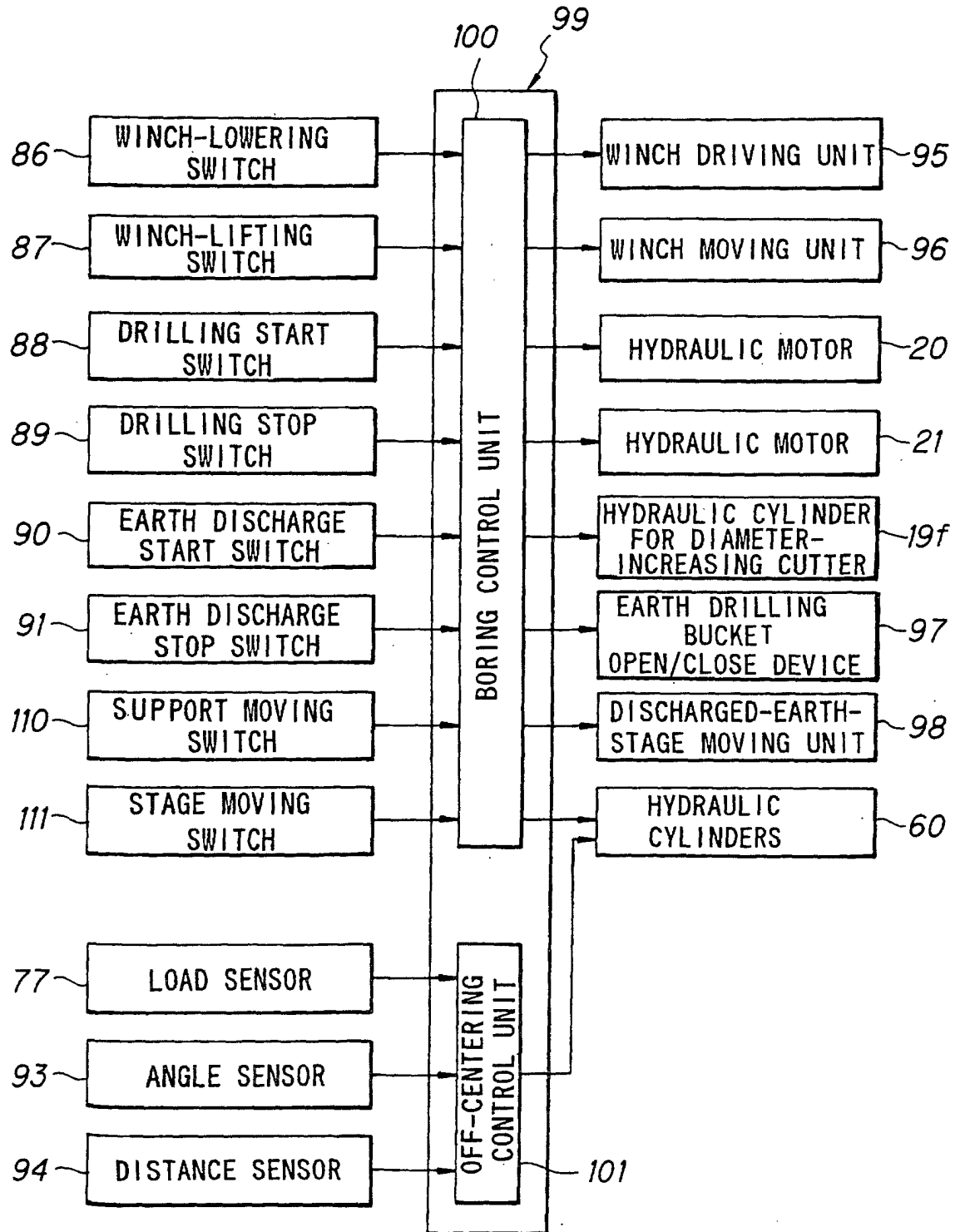


FIG. 15



**FIG. 16**

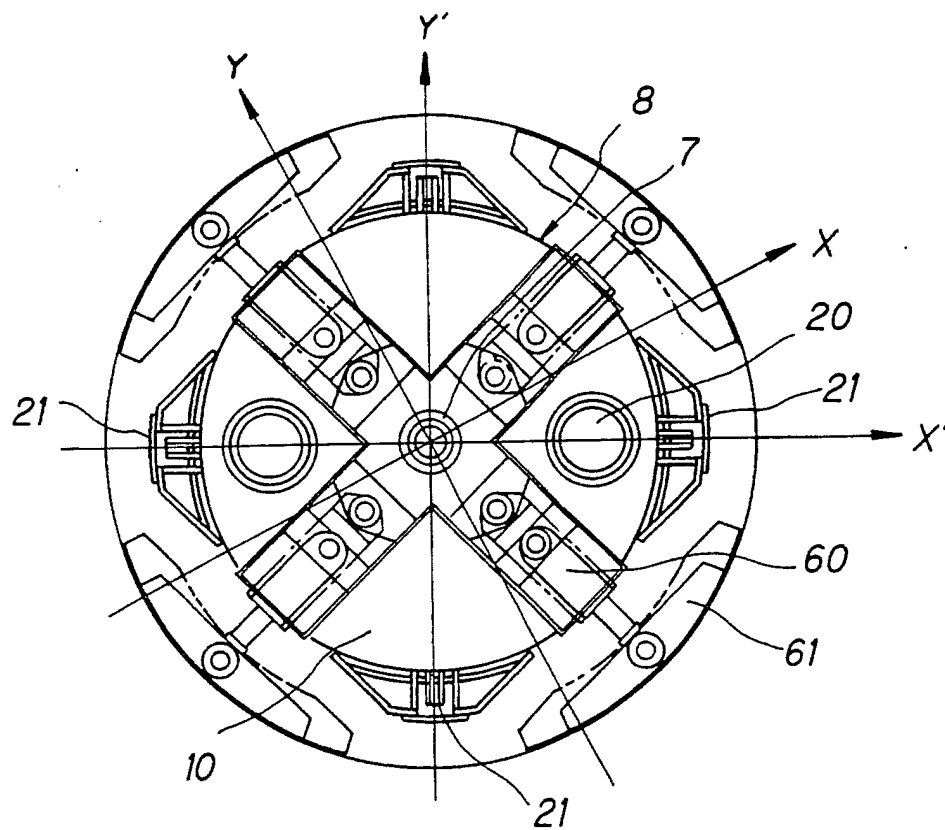


FIG. 17

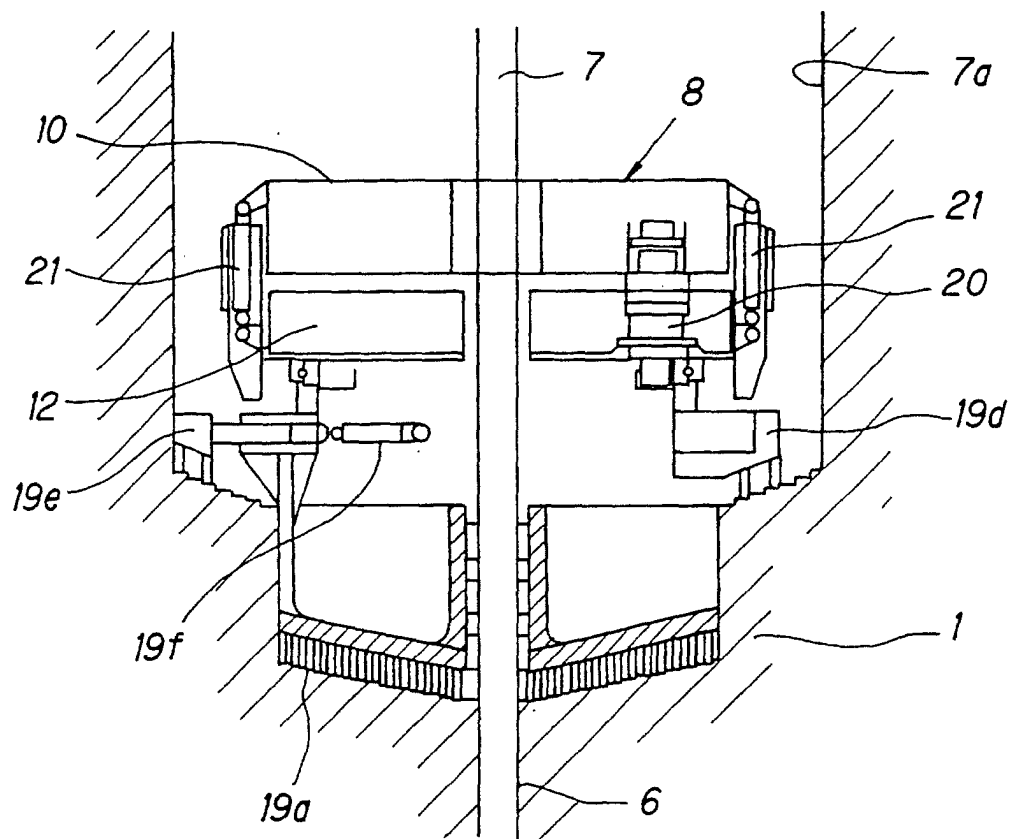
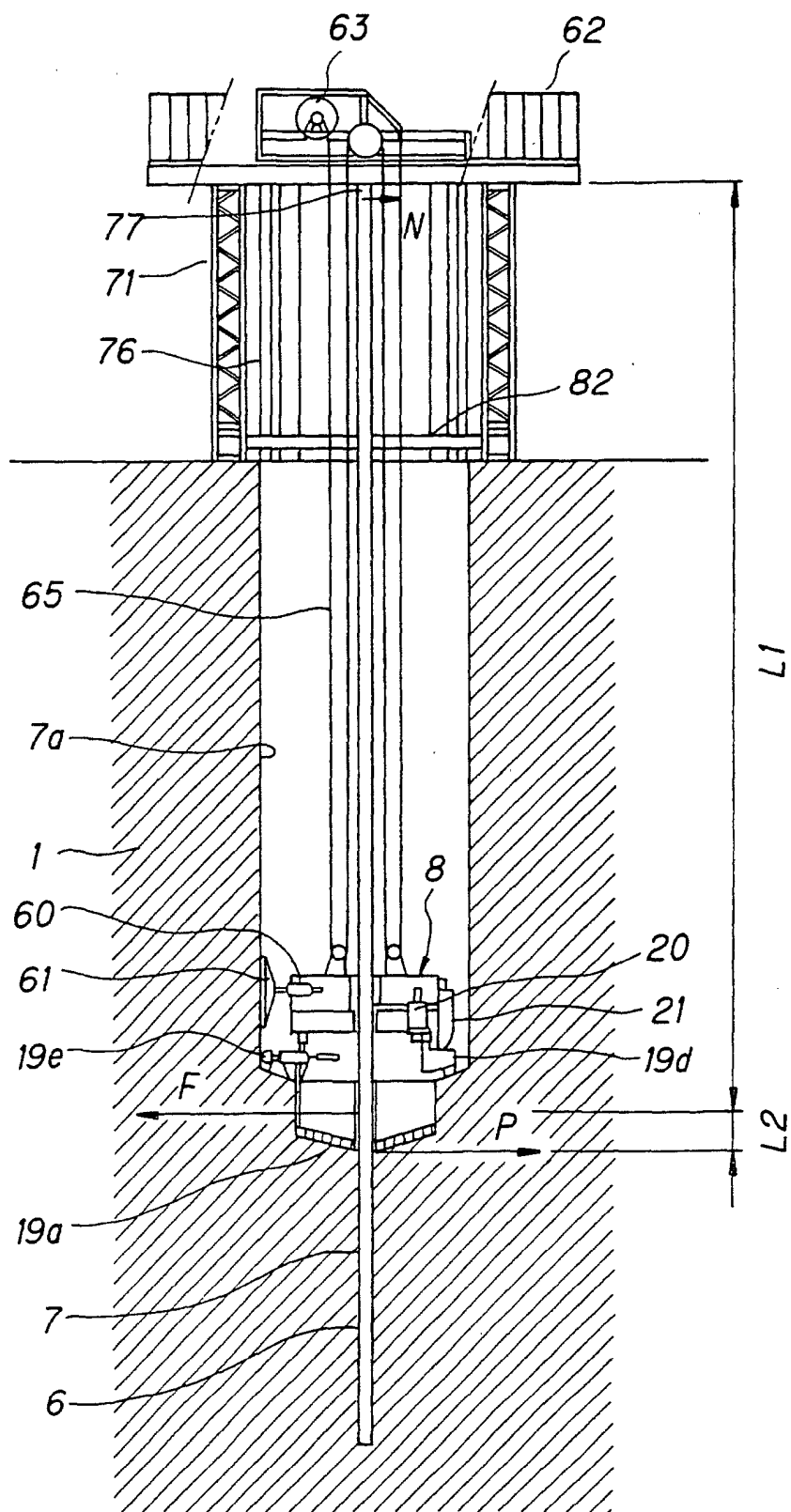
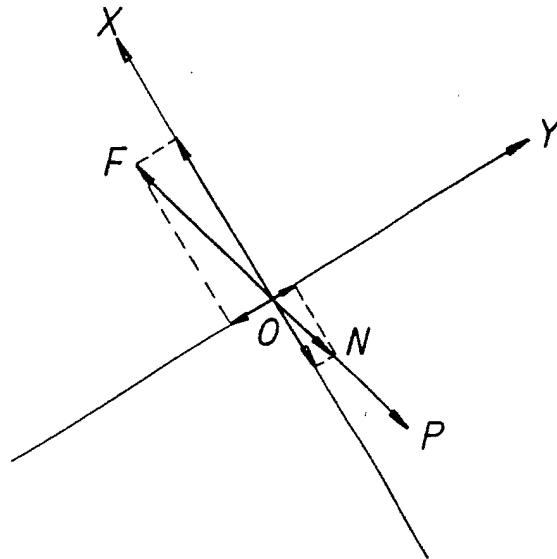


FIG. 18



**FIG. 19**



**FIG. 20**

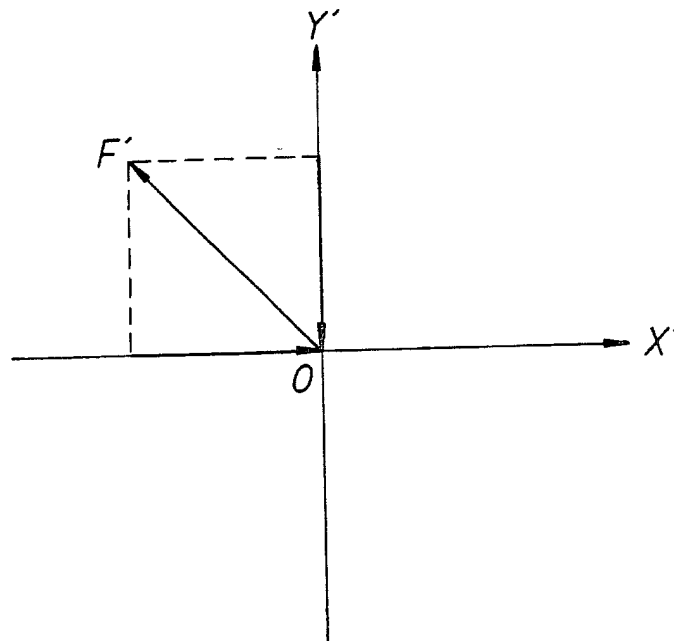


FIG. 21

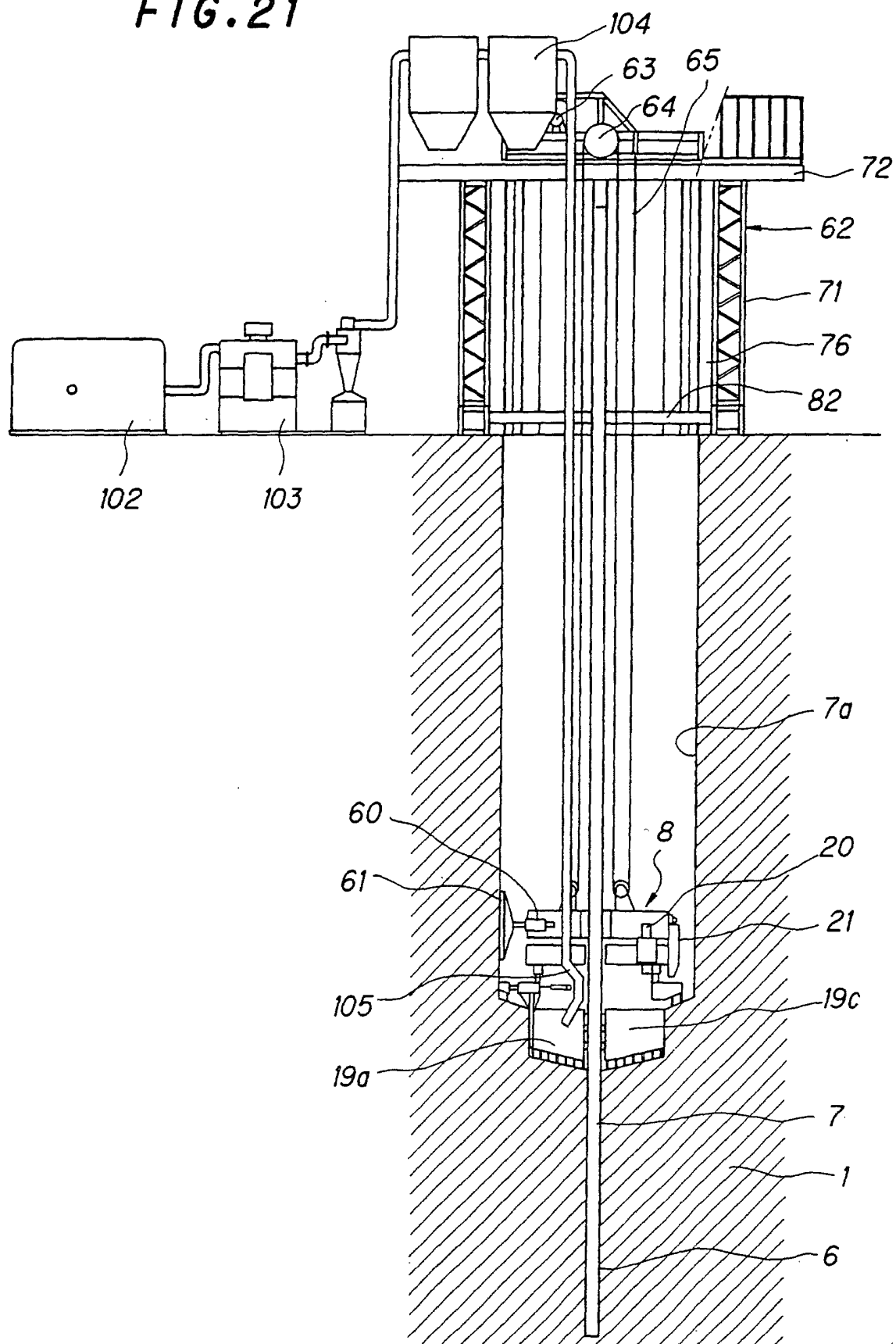




FIG. 22

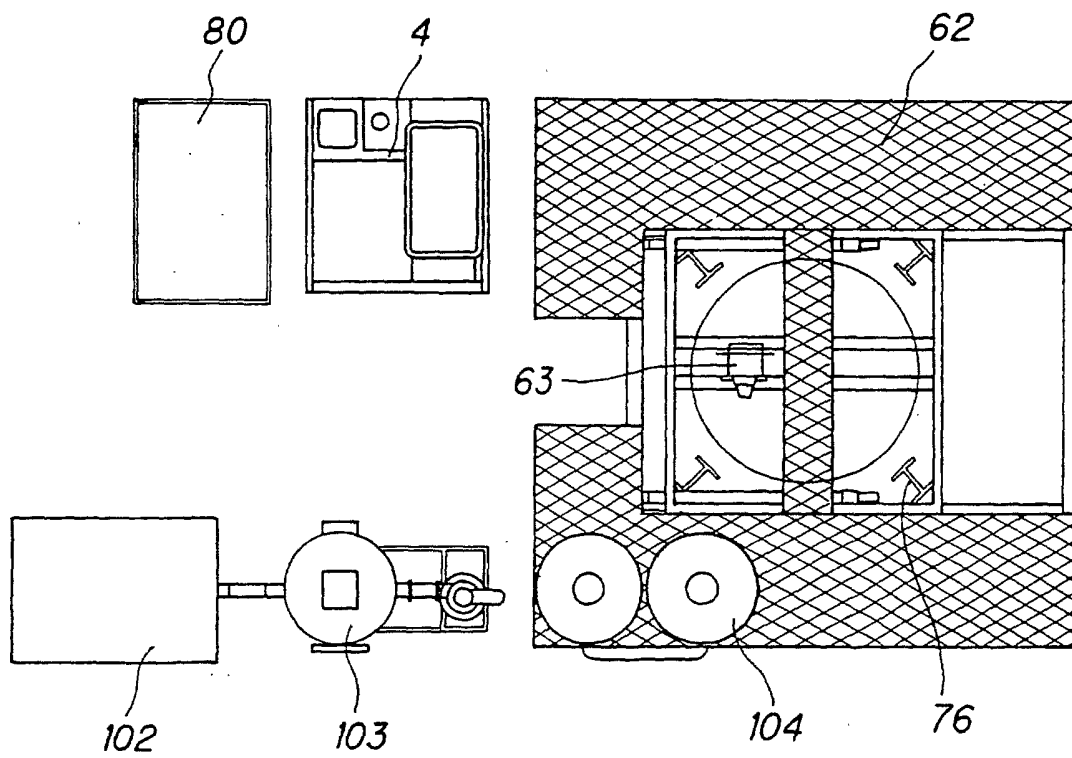


FIG. 23

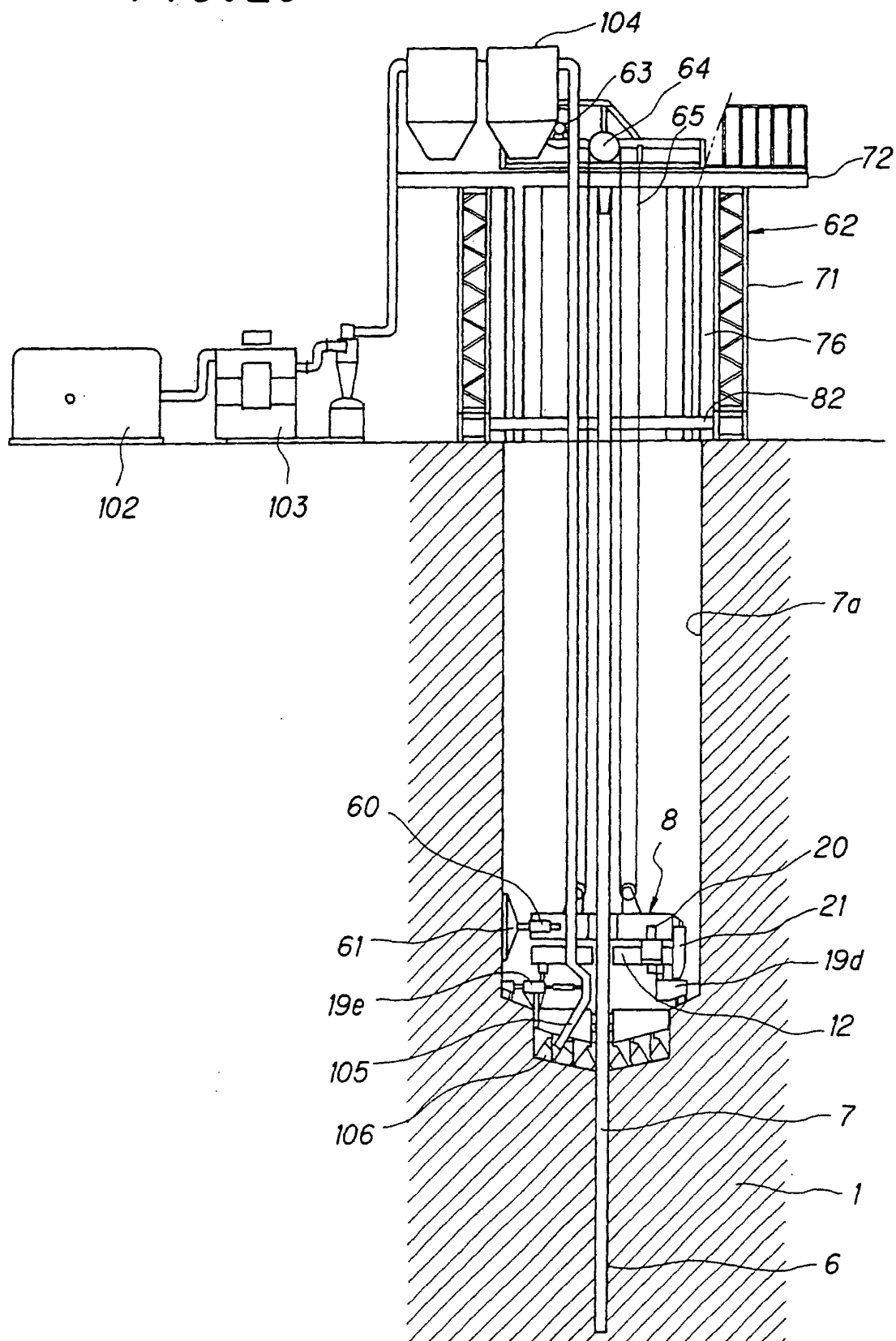


FIG. 24A

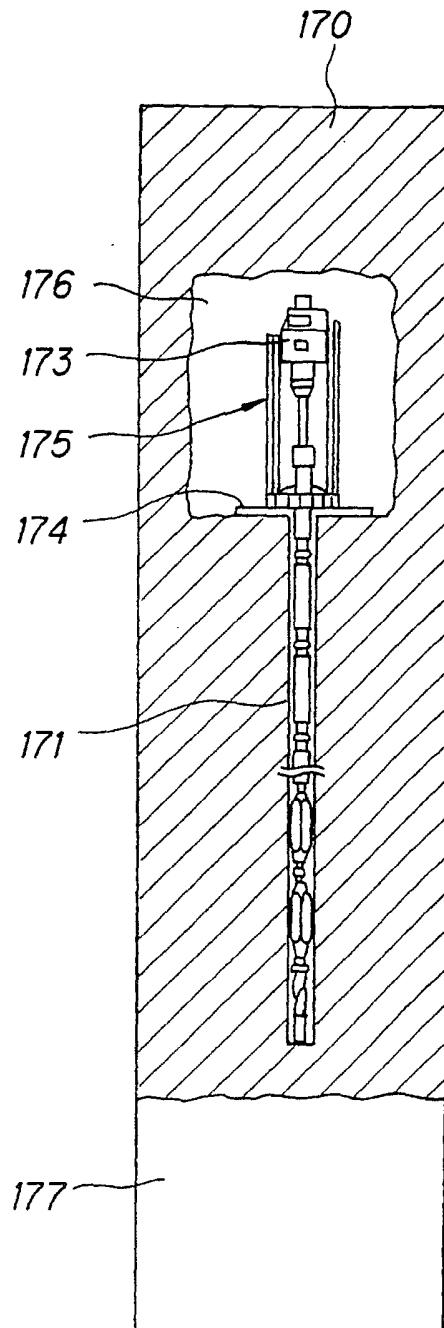
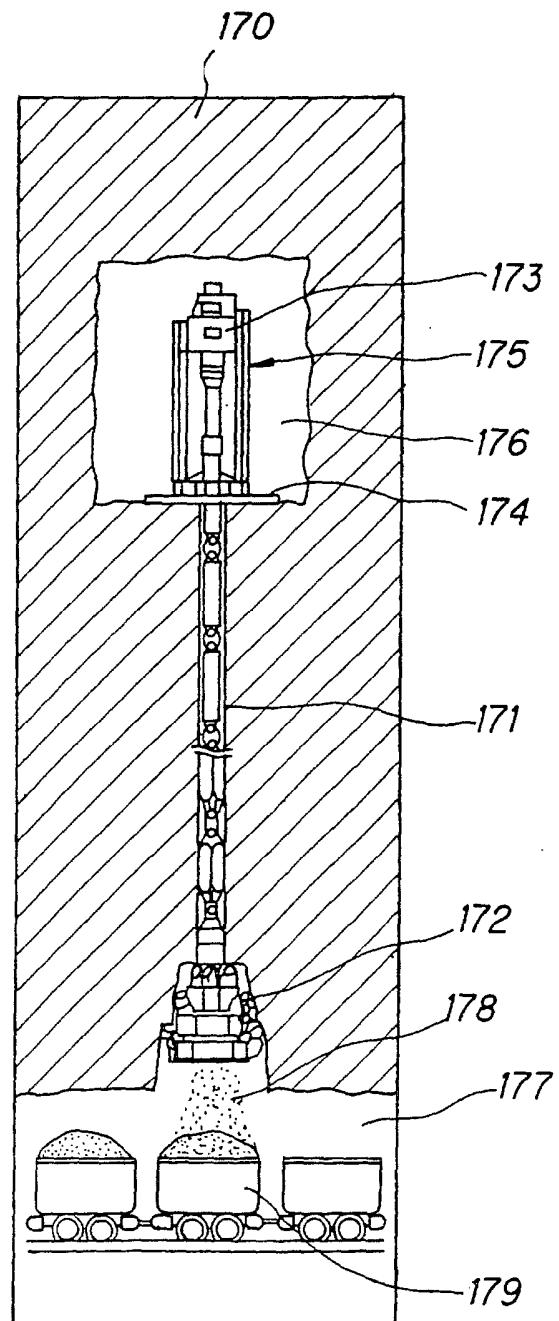
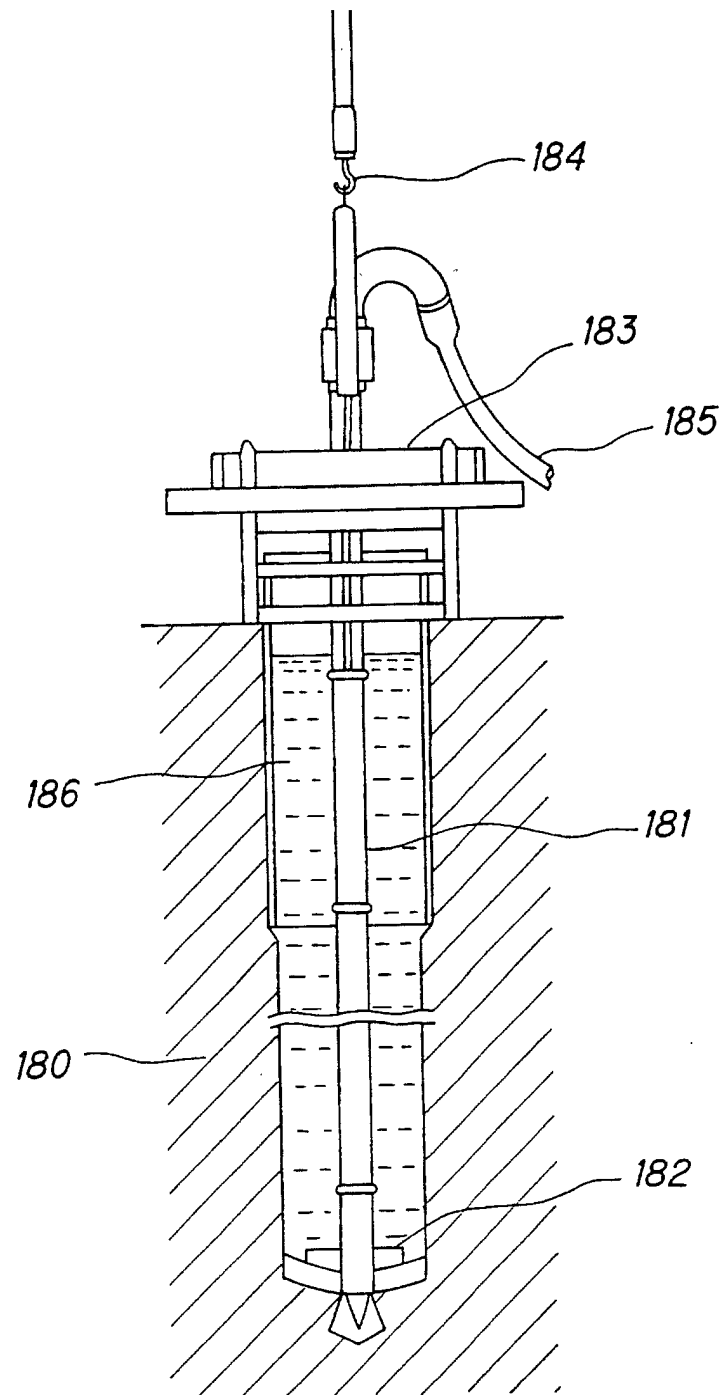


FIG. 24B



*FIG. 25*



**FIG. 26**

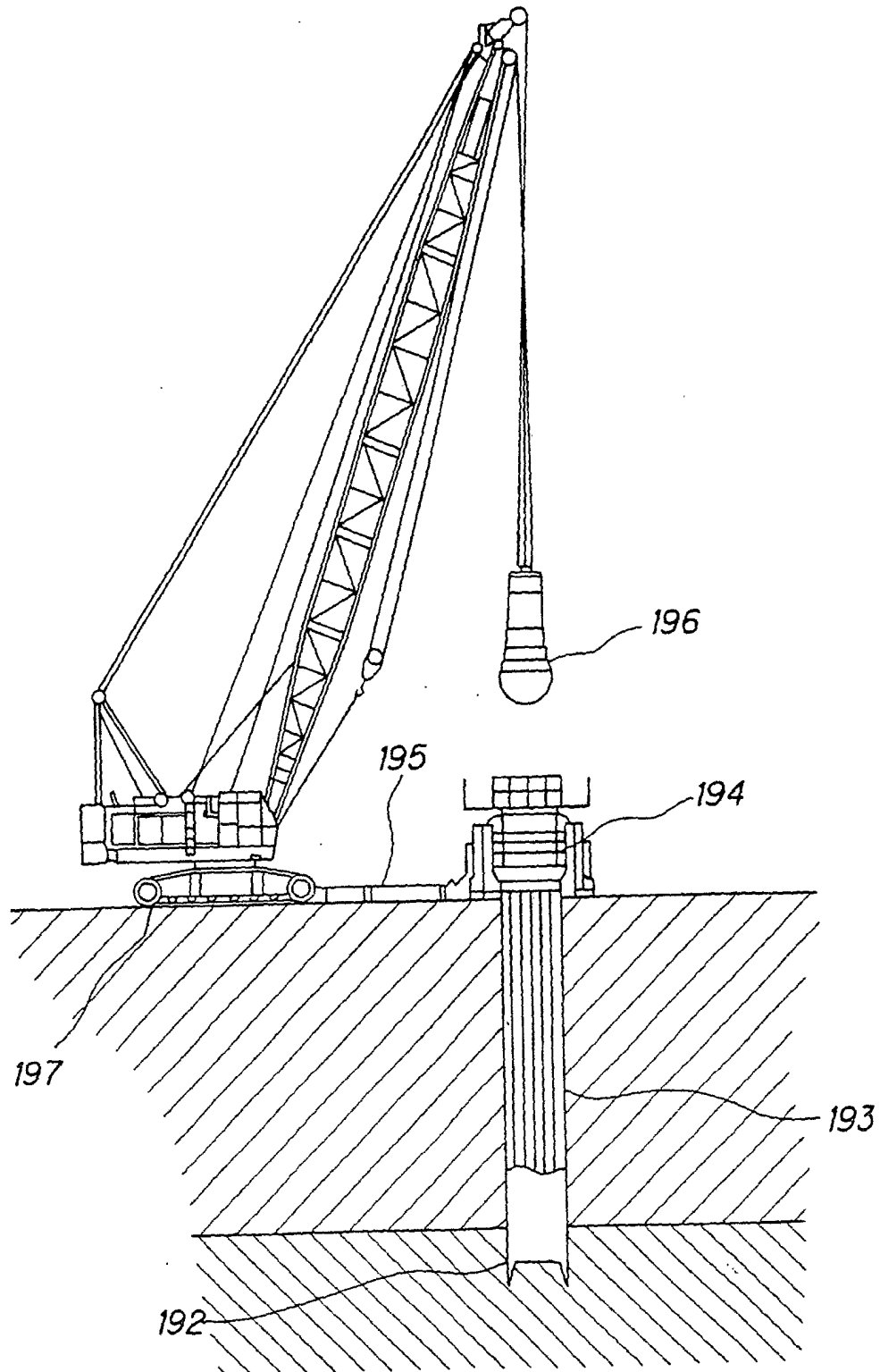


FIG. 27

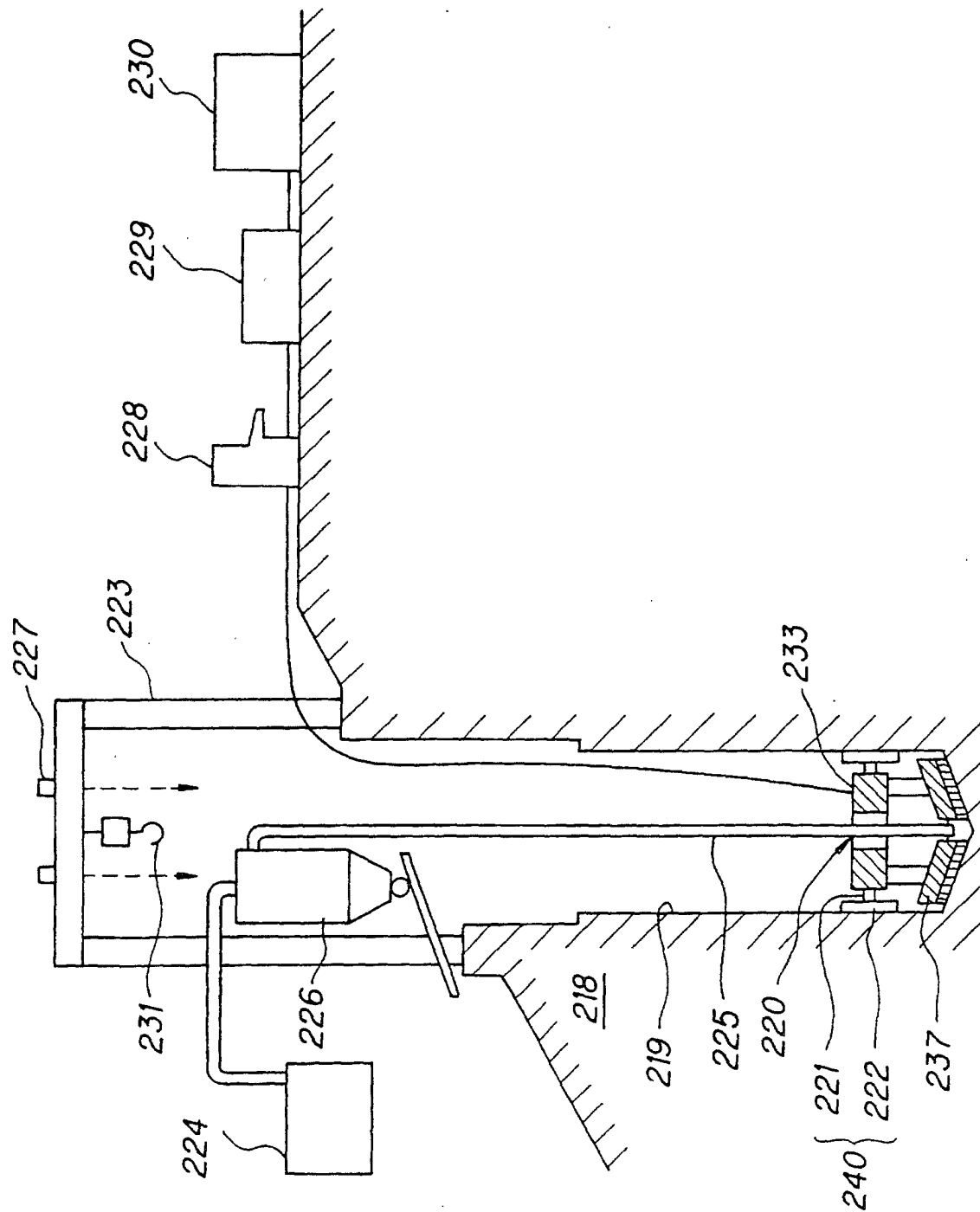


FIG. 28

