

**Construction Method of Pile structure
and
the Special Equipment for Carrying Out the Same**

Field of the Invention

The invention relates to a pile structure used in the fields of civil engineering, irrigation works, municipal works; and particularly to a construction method of piles used in buildings or pile structure with wainscot of foundation pit and the special equipment carrying out the same.

Background of the Invention

Present foundations used in buildings, especially in high-rise buildings, are generally pile foundations, the design of such a foundation is carried out on the basis of the geological exploration reports made with regard to one or more points of the ground. But actually, in most cases, the geological condition of the ground under pile positions constituting the foundation differs significantly from that at the explored point(s), thus causing different load capacities and sedimentation in service life of individual piles constituting the foundation, and further causing a built building to present uneven sedimentation, and this is also why more than 80% of the damage accidents occurred in built buildings are due to foundations. In present design and construction of foundations, there is no desirable method to solve the problem. Another disadvantage of above-mentioned construction method is that the actual load capacity of each pile can not be learnt after construction, and generally the load capacity is determined with a test pile before and after construction, and

the tests on one or two test piles can represent all the piles, so this method prolongs the construction period and increases the construction cost.

Summary of Invention

An object of the invention is to provide a new construction method of pile structure and the equipment carrying out the same, with the method and equipment, the actual load capacity of each pile can be obtained at once after construction; the pressure of the pile hole wall and the pile hole bottom can be determined while constructing, thus the actual load capacity and the sedimentation in a predetermined service life can be obtained upon finish of the construction of each pile; and the load capacity and the sedimentation in service life of each pile in a pile structure can be kept the same.

The object of the invention is achieved through the following method which comprises the steps of:

- a) Carrying out an exploration to the pile ground to generally learn the conditions of the soil layer of the ground and determining the size of the piles and the preliminary size and position of the pile wings ;
- b) drilling a pile hole to a prescribed depth in the ground according to the pile size derived from the exploration;
- c) Obtaining the actual mechanical properties of the soil body in the vicinity of the preliminary position by exploring the soil body of the pile hole wall in the vicinity of the preliminary position of the pile wings by means of pile-wing-hole forming device, thereby determining the final size and final position of the pile wings;
- d) compressing , according to the final size of the pile wings, the soil body of pile hole wall at the final position of the pile wings by means of the pile-wing-hole forming device, thereby forming the pile wing hole;

e) Pouring concrete into the finished pile hole and pile wing hole to form a concrete pile;

f) Constructing other piles in the pile structure according to the above-mentioned steps, thereby forming a pile structure composed of a plurality of concrete piles.

In the step c), in the case that the mechanical properties of the soil body at the preliminary position are poor, moving the pile-wing-hole forming device along the pile hole wall to continue the exploration of the soil body of the hole wall until a required soil layer is found, and using the required position of the soil layer as the final position of a corresponding pile wing.

The pile wings are pile branches.

In the step c), in the case that the mechanical properties of the explored soil body at the preliminary position are poor, still using the position of the soil layer as the final position of a corresponding pile wing; but in the step d), forming a pile wing with a size larger than the corresponding preliminary size at the position.

In the step c), in the case that the mechanical properties of the explored soil body at the preliminary position are poor, still using the position of the soil layer as the final position of a corresponding pile wing; but in step d), forming a plurality of pile wings having the corresponding preliminary size in the area of the soil layer, the number of which is larger than the preliminary determined number of the pile wings at the position.

The pile wings are pile force-bearing plates and/or pile branches.

The mechanical properties of soil body are the compressive mechanical properties of soil body .

The mechanical properties of soil body comprise the friction

resistance coefficient of soil body.

In the step c), the mechanical properties of soil body are determined by means of sensors.

After the pile hole and pile wing holes are formed, a pile-hole-quality detector is inserted into the pile hole to detect the quality of the pile hole and pile wing holes.

For the pile hole and pile wing holes in which there is no water, the quality detection of the holes is carried out by means of a night-vision observation system.

The pile hole and pile wing holes in which there is slurry, the quality detection of the holes is carried out by means of an ultrasonic scanner.

After concrete has been poured into the pile hole and pile wing holes, when the concrete attains a certain strength, the quality of the pile and pile wings is detected by means of an ultrasonic detector.

In the step c), the final size and position of pile wings are calculated by means of a computer system.

During construction, the manipulation of the pile-wing-hole forming device is controlled by a computer system.

During construction, the measured values of mechanical properties of soil body and the signals associated with the quality, size and position of the formed pile and pile wings are converted into digital signals and stored in the computer system.

The actual forming condition of the pipe hole and pile wing holes are displayed through an image display so as to facilitate monitoring.

Reinforcing bars or reinforcing cages are inserted before pouring concrete.

Prestressed reinforcing steels are inserted before pouring concrete,

and the prestressed reinforcing steels are prestressed and anchored after the concrete attains a certain strength.

In the step e), the pouring of concrete is conducted by a tremie method, a series tube method and a pumped concrete method.

In the step b), the pile hole is formed by a positive circulation method, a counter circulation method, an spiral auger drilling method, an jet soil-flushing method, a manual hole-digging method, dipper or grab bucket soil-removing method, sleeve-driven and soil-squeezing method, or a hammering-punching method.

In the step b), the pile hole is formed as such that a pilot hole is formed at the pile position; a guard tube is lowered into the pilot hole; an impact hammer is used to impact the ground along the guard tube to form a hole; thereafter the guard tube is lift out, and then loosened earth bucket is put in.

In the step b), the pile hole is formed by an spiral auger drilling method, and the step d) is accomplished as follows, according to design requirements, the soil layer at the end of the force-bearing plate in an intermediate pile wing is hammered to consolidate in layers; after the loosened soil bucket is put onto the hole bottom, a pile-wing-hole forming device is put in to form pile wing holes through compression at the consolidation positions in layers; and the loosened soil bucket is lift out to form a force-bearing plate at the bottom of the pile.

The step b) includes clearing up the loosened soil at the hole bottom, that is, the drill bit is made to idle at the initial depth until the prescribed requirement is satisfied; and in the step d) the pile wing holes are formed as such: according to the design level, compression and expansion signs for the pile wings are marked in the conspicuous positions on the upper and lower sections of the pile-wing-hole forming device, and the

pile wings are formed through compression and expansion in the order from top to bottom; and after the loosened soil bucket is lift out, the force-bearing plate slot at the hole bottom of the pile wings is formed.

In the step b), the pile hole is formed by a slurry wainscot drilling method, and the step d) is proceeded as such: the pile-wing-hole forming device is slinged, and then slowly lowered into the pile hole after the pile-wing-hole forming device substantially stops sway or rotation; while the device is being putting in, an oil supply pipe and an oil return pipe are locked by special oil pipe clips at 3~5m intervals on a coupling tube of the upper and lower sections of the pile-wing-hole forming device; depth size is marked on the coupling tube of the upper and lower sections of the pile-wing-hole forming device; and according to the required levels, the pile wing holes are formed through compression in a prescribed order.

After the step e) is carried out, slurry is injected under pressure onto the pile hole bottom and the pile wing ends through a preset slurry tube to consolidate the surrounding soil body of the portions.

The angle between the compression direction of the pile wing hole and the direction perpendicular to the pile hole wall is $\pm 90^\circ$.

The pile wing holes are formed by compressing the surrounding soil body of the pile hole wall in the direction parallel to the pile hole axis.

Firstly, a first cavity of a pile wing hole is formed by compressing the soil body in the first prescribed area at the selected position of the pile hole wall upwards in a direction inclined relative to the pile shaft hole axis, and then a second cavity of the pile wing hole is formed by compressing the soil body in the second prescribed area at the selected position of the pile hole wall downwards in a direction inclined relative to the pile hole axis, the first cavity and second cavity jointly constitute

the pile wing hole .

A first cavity of a pile wing hole is formed by compressing the soil body in a first prescribed area at a selected position of the pile hole wall upwards in a direction inclined relative to the pile hole axis, and at the same time, a second cavity of the pile wing hole is formed by compressing the soil body in a second prescribed area at the selected position of the pile hole wall downwards in a direction inclined relative to the pile hole axis, the first cavity and second cavity jointly constitute the pile wing hole.

The pile wing hole is formed by only compressing the soil body in a prescribed area at a selected position of the pile hole wall downwards in a direction inclined relative to the pile hole axis.

First, a horizontal cavity is formed in the surrounding soil body in a prescribed area at a selected position of the pile hole wall, and then the surrounding soil body of the pile hole wall located below the cavity is compressed downwards in a direction parallel to the pile shaft hole axis to form the pile wing hole.

During the forming process of a pile wing hole, reinforcement material for the pile wing is injected.

Part of pile body material is poured during the forming process of the pile wing hole, and the other part is poured after the process; the pile hole wall is protected through a wall-protection fluid.

The wall-protection fluid is cement slurry, the cement slurry is injected into the pile hole as the pile hole forming device is lifted after the pile hole has been formed by means of the pile hole forming device, until a position in the pile hole where no collapse will occur; after the pile wing holes are formed, a slurry-supplementing tube is inserted to the pile hole bottom and, aggregate is put in at the same time; and then

cement slurry is pressed under high pressure into the pile hole through the opening at the bottom of the slurry-supplementing tube via the slurry-supplementing tube until entire pile hole is filled up.

The pile body material is poured into the pile hole and pile wing holes after the pile wing holes are formed.

The pile wing hole is formed by compression into a shape with the size along the axis of the pile hole being larger.

The pile wing hole is formed by compression into an spiral hole extending along the pile hole axis.

The pile wing hole is formed during the process of lifting out the pile hole forming device after the pile hole has been formed.

The finished pile is a neat concrete pile.

The piles are arranged in rows to form a support and guard pile structure.

The tops of the piles in the support and guard pile structure are connected through a connecting beam and the pile wings formed on individual piles.

The equipment for carrying the method comprises a pile-wing-hole forming device, and on the device there is provided a detector for detecting the mechanical properties of soil body of the ground when forming a pile wing hole with the device.

The detector is a sensor.

The sensor comprises a pressure head, the pressure head is connected to an actuating hydraulic cylinder, and the actuating hydraulic cylinder is connected to a pressure display.

The detector is a detecting instrument for friction resistance properties of the soil body.

The equipment further comprises a control system for the pile-wing-

hole forming device, the system comprises a hydraulic unit and a computer monitoring system.

The hydraulic unit comprises a hydraulic pressure display.

The computer monitoring system comprises a data processing unit for converting relevant signals into digital signals and carrying out operations on the relevant signals, a display and a memory for the various digital signals, an operation keyboard, and an image display system for showing the actual forming conditions of a pile hole and pile wing holes.

The computer monitoring system comprises an control panel, and on the control panel there are provided a keyboard, a display, an audio amplifier, an image display showing the actual forming conditions of a pile hole and pile wing holes, a control rod for the pile-wing-hole forming device, and a printer.

The image display system is a night-vision observation system capable of detecting the forming quality of a dry hole, and the system comprises a color videocamera capable of taking pictures, a monitor for showing the pictures taken by the videocamera, a sealed sleeve for receiving the videocamera and a power source, an observation head, a light source for picture-taking, and a video recorder.

The observation head comprises a horizontal observation head for observing the hole wall and a vertical observation head for observing hole bottom.

The image display system comprises an ultrasonic scanner for detecting the forming quality of a wet hole.

The computer monitoring system comprises an unit for controlling the operation of the pile-wing-hole forming device.

The pile-wing-hole forming device is of a hydraulically actuated

type which comprises a bow-type compression mechanism for forming the pile wing holes, the extending portion of the bow-type compression mechanism constitutes the pressure head for the detector.

The detector is a detecting instrument for the friction resistance properties of the soil body.

The pile-wing-hole forming device comprises a pile-wing-hole forming mechanism, the mechanism includes a first bow-type compressing arm and a second bow-type compressing arm, the ends of the first bow-type compressing arm and second bow-type compressing arm are hinged to each other, the other end of the first bow-type compressing arm is hinged to a first connecting member and the other end of the second bow-type compressing arm is hinged to a second connecting member; the first connecting member is rigidly connected to the end of a piston rod of an actuating hydraulic cylinder, and the second connecting member is rigidly connected to the end of the other piston rod of the actuating hydraulic cylinder; the two piston rods are disposed coaxially and move oppositely while working; and the actuating hydraulic cylinder includes two pistons which are disposed coaxially and parallelly and move oppositely while working, the two piston rods are rigidly connected to the two pistons respectively.

The pile-wing-hole forming device comprises a plurality of sets of pile-wing-hole forming mechanism, the sets of pile hole forming mechanism are arranged at intervals along the longitudinal and/or transverse directions of the equipment.

The pile-wing-hole forming device comprises a plurality of sets of pile-wing-hole forming mechanism, the sets of pile-wing-hole forming mechanism are arranged symmetrically relative to the longitudinal axis of the equipment.

The equipment comprises a pile hole forming device, the pile-wing-hole forming device is provided on the pile hole forming device.

The pile-wing-hole forming device comprises a main support member on which there is fixed an driving gear and, and the device further comprise a pile-wing-hole forming mechanism, the mechanism includes a first bow-type compressing arm and a second bow-type compressing arm, one end of the first bow-type compressing arm is hinged to a driving rod driven by the driving gear, and the other end of the first bow-type compressing arm is hinged to one end of the second bow-type compressing arm, the other end of the second bow-type compressing arm is hinged to a first fixed member, the first fixed member is on one side of the hinge point of the first bow-type compressing arm and the driving rod and is on one side of the moving axis of the hinge point of the first and second bow-type compressing arms relative to the hinge point of the driving rod and the first bow-type compressing arm; the second fixed member is hinged to one end of a first branch plate, and the other end of the first branch plate is a free end; the inner side of the first branch plate abuts against the hinge portion of the first and second bow-type compressing arms, and is provided with a guide plate, on the guide plate there is formed a guide groove in the direction parallel to the first branch plate; the first and second bow-type compressing arms are hinged through a transversely movable axle, the guide groove permits the transversely movable axle to slide therein and extends towards the second bow-type compressing arm from the position where the transversely movable axle is located when it has not yet moved outwards transversely.

The equipment comprises a main support member which is provided with an driving gear, and the equipment is further provided with a pile-

wing-hole forming mechanism; the mechanism includes a first bow-type compressing arm and a second bow-type compressing arm; one end of the first bow-type compressing arm is hinged to a driving rod, and the driving rod is driven by the driving gear, the other end of the first bow-type compressing arm is hinged to one end of the second bow-type compressing arm, and the other end of the second bow-type compressing arm is hinged to a fixed member which is fixed to the main support member; and the first bow-type compressing arm has a first branch plate integrally formed thereon, and the second bow-type compressing arm has a second branch plate integrally formed thereon.

The equipment comprises a telescopic power compressing device which can linearly compresses the surrounding soil body of a pile hole wall downwards in a direction inclined relative to the pile hole axis.

The equipment comprises a compressing member which can insert horizontally into the surrounding soil body of a pile hole wall, the member is connected with a driving gear, and thus it can compress the surrounding soil body of the hole wall downwards in a direction parallel to the pile hole axis when inserted into the surrounding soil body of the hole wall.

The equipment comprises a pile hole forming device, the device is an clay digger forming device.

The clay digger forming device is a submersible driller, an jet soil-flushing hole-forming device, a bit driller, an overall casing driller, a positive circulation driller, a counter circulation driller, a grab soil-removing device or a dipper soil-removing device.

The clay digger forming device is an auger driller which includes a drilling rod, the drilling rod is a hollow pipe and is provided with a pile-wing-hole forming device; and at the bottom of the hollow drilling rod

there is formed a nozzle communicated therewith, through the nozzle pile body material or a wall-protection fluid is injected, and the top of the drilling rod is communicated with the supplying fluid of the injected material.

Another special equipment of the invention comprises a caterpillar running gear; a swivel table; and a driver's cab, a control system for the pile-wing-hole forming device on the swivel table; and a boom; the bottom of the boom is connected to the swivel table, and the branch hole and/or force-bearing plate slot forming device is suspended from the top of the boom through a suspension cable, the device is guided and fixed by a gripper block, and the rear end of the gripper block is connected with the swivel table.

The equipment comprises an control system for the pile-wing-hole forming device, which is placed on the ground and is separated from the pile-wing-hole forming device.

With the construction method and equipment of the invention, the actual load capacity and the sedimentation of each foundation pile can be obtained, and all piles can be made to have substantially the same load capacity and sedimentation, thereby the formed foundation will not present an uneven sedimentation to thus significantly reduce a hidden peril during the service life after construction. In addition, with the invention, the work load of foundation exploration before construction can be reduced and the trial piling or pile load testing before and after construction can be reduced or made unnecessary. Thus, the construction cost can be greatly decreased and the construction period shortened. Also, in the present invention, the exploration to geological conditions of ground runs through the pile construction process, thereby the conditions of bottom and surrounding soil of each pile can be learnt clearly to

design the pile foundation more reasonably, thus the waste of materials can be greatly reduced and the cost of pile foundation decreased. Moreover, according to the method of the invention, since a pile branch/pile force-bearing plate is located at the correspondingly required force-sustaining layer, thus the advantages of piles with branches/force-bearing plates can be sufficiently brought into play, and the piles can have the maximum load capacities and minimum sedimentation in service life. Only the advantages of pile foundation, which is used in buildings and subjected to pressure, have been described above, but it is noted that the invention can also apply to pile foundations, which are subjected to tensile forces, and antidumping supporting structures; and can uniformly resist floating-up forces, i.e. buildings only have relative small uniform floating-up amount, or bending moment, i.e. each pile in a supporting structure has a substantially identical, relative small angular displacement.

Brief Description of the Drawings

The invention will be described in detail below in combination with accompanying drawings, in which

Figs. 1A-1C are schematic views of a construction method for pile foundation in accordance with the invention, in which Fig. 1A is a schematic view of the first stage of the construction method for pile foundation of the invention, Fig. 1B is a schematic view of the second stage of the construction method for pile foundation of the invention, and Fig. 1C is a schematic view of the third stage of the construction method for pile foundation of the invention;

Figs. 2A-2C are schematic views of the first embodiment in accordance with the invention, by which a pile hole and a pile branch hole and/or force-bearing plate slot are formed simultaneously, showing

the three different construction stages;

Figs. 3A-3C are schematic views of the second embodiment in accordance with the invention, by which a pile hole and a pile branch hole and/or force-bearing plate slot are formed simultaneously, showing the three different construction stages;

Figs. 4A-4C are schematic views of the third embodiment in accordance with the invention, by which a pile hole and a pile branch hole and/or force-bearing plate slot are formed simultaneously, showing three different construction stages;

Figs. 5A-5C are schematic views of the fourth embodiment in accordance with the invention, by which a pile hole and a pile branch hole and/or force-bearing plate slot are formed simultaneously, showing three different construction stages;

Fig. 6 is a schematic view of the first embodiment of the equipment in accordance with the invention, which has both the pile hole forming device and the pile branch hole and/or force-bearing plate slot forming device;

Fig. 7 is a schematic view of the second embodiment of the equipment in accordance with the invention, which has both the pile hole forming device and a pile branch hole and/or force-bearing plate slot forming device;

Fig. 8 is a schematic view of the first embodiment of the branch hole and/or force-bearing plate slot forming device of the equipment in accordance with the invention, which has both the pile hole forming device and the pile branch hole and/or force-bearing plate slot forming device;

Fig. 9 is a schematic view of the second embodiment of the branch hole and/or force-bearing plate slot forming device of the equipment in

accordance with the invention, which has both the pile hole forming device and the pile branch hole and/or force-bearing plate slot forming device;

Fig. 10 is a schematic view showing the retracted state of the forming device shown in Fig. 9;

Fig. 11 is a schematic plan view showing the working state of the forming device shown in Fig. 9;

Fig. 12 is a schematic view of the fourth embodiment of the branch hole and/or force-bearing plate slot forming device of the equipment in accordance with the invention;

Fig. 13 is a schematic view showing the retracted state of the forming device shown in Fig. 12.

Fig. 14 is a schematic view of a further embodiment of the branch hole and/or force-bearing plate slot forming device of the equipment in accordance with the invention;

Fig. 15 is a perspective view of another special equipment in accordance with the invention;

Fig. 16 is a perspective view of the control system for the branch hole forming device of the equipment in accordance with the invention.

Detailed Description of the Preferred Embodiments

The construction method of pile foundation, as the concrete pile structure construction method of the invention, comprises the following steps: first, carrying out a geological prospecting to the ground of a construction area to learn the soil body conditions of the ground in the area, and of course, a trial piling can also be done to learn the geological conditions; on the basis of the results of the geological prospecting, determining preliminary the number, length, diameter and position of the pile as well as the number, length, diameter and position of the wings of

a pile; drilling downwards to a prescribed depth at a pile position by means of a drilling machine to form a pile hole as shown in Fig. 1A; thereafter, putting a pile wing hole forming device into the pile hole to compress the soil body by means of the pile-wing-hole forming device at the preliminary determined pile wing position, the compression mechanism in the device is connected to a pressure gauge, the modulus of elasticity or the coefficient of friction resistance can be obtained in accordance with the value on the pressure gauge, and then it can be determined whether the soil layer at that level is suitable for constructing a pile wing; and if the soil layer is too soft, the initial design requirements of the pile wing at that level can be met by adjusting the level or the size of the pile wing or the number of the wings at the soil layer. Referring to Fig. 1B, the above-mentioned adjustment of the level of the pile wing refers to detecting by compression the soil layer in the vicinity of the soft soil layer by means of the pile-wing-hole forming device until a required force-sustaining layer is found, and then forming the pile wing holes of the required number or size at the soil layer determined in the above-mentioned manner. If the soil layer satisfies the requirements, the preliminary determined pile wing holes can be directly constructed and the prescribed pile wing holes (that is, pile branch holes and/or force-bearing pile plate slots) can be formed in above manner in the pile holes. Then, the entire pile hole is scanned using a scanner to examine the quality of the pile wing holes and the wall of the pile hole. As shown in Fig. 1C, prestressed reinforcing steels are then inserted and concrete is poured. When the concrete attain a certain strength, the prestressed reinforcing steels are tensioned and anchored.

The first embodiment of the method in accordance with the invention, by which a pile hole and pile branch hole(s) and/or force-

bearing plate slot(s) are formed simultaneously, includes the following steps: forming a pile hole using the equipment 1 of the invention, as shown in Fig. 2A, the equipment comprises a branch hole and/or force-bearing plate slot forming device 2 and a drilling device 3, the pile wing hole forming device 2 is connected with a pressure bar (not shown), and the pressure bar is connected with a pressure gauge (not shown) on the ground; afterwards, compressing the soil body of the hole wall upwards in a inclined direction, as shown in Fig. 2B; and finally, with the soil body at the top of the cavity thus formed as a supporting point, compressing the soil body of the hole wall downwards in a inclined direction to form a branch hole and/or force-bearing plate slot, as shown in Fig. 2C. The branch hole and/or force-bearing plate slot can be formed either when the inventive equipment is lowered down to form the pile hole or when the inventive equipment is lifted up after the pile hole has been formed.

The second embodiment of the method in accordance with the invention, by which a pile shaft hole and pile branch hole(s) and/or force-bearing plate slot(s) are formed simultaneously, includes the following steps: forming a pile hole using the equipment of the invention, the equipment comprises a branch hole and/or force-bearing plate slot forming device 2 and a drilling device 3, the pile wing hole forming device 2 is connected with a pressure bar (not shown), and the pressure bar is connected with a pressure gauge (not shown) on the ground, as shown in Fig. 3A; at the same time to form the pile hole or after the pile hole has been formed, forming the pile branch hole(s) and/or force-bearing plate slot(s) by compressing the soil body of the hole wall upwards and downwards simultaneously in an inclined direction by means of the inventive equipment, as shown in Fig. 3B; and finally,

forming the pile branch hole(s) or the force-bearing plate slot(s) with the shape as shown in Fig. 3C after compression.

The third embodiment of the method in accordance with the invention, by which a pile hole and pile branch hole(s) and/or force-bearing plate slot(s) are formed simultaneously, includes the following steps: forming the pile hole using the equipment 1 of the present invention which comprises a branch hole and/or force-bearing plate slot forming device 2 and a drilling device 3, the pile wing hole forming device 2 is connected with a pressure bar (not shown), and the pressure bar is connected with a pressure gauge (not shown) on the ground, as shown in Fig. 4A; during the process of forming the pile hole or after the pile hole has been formed, forming the branch hole(s) and/or force-bearing plate slot(s) by compressing the soil body in an inclined direction by means of the branch hole and/or force-bearing plate slot forming device 2, as shown in Fig. 4B. The dotted lines in Fig. 4B show the final state after compression; and after compression, the state shown in Fig. 4C will be obtained.

The fourth embodiment of the method in accordance with the invention, by which a pile hole and pile branch hole(s) and/or force-bearing plate slot(s) are formed simultaneously, includes the following steps: forming the pile hole using the equipment 1 of the invention which comprises a branch hole and/or force-bearing plate slot forming device 2 and a drilling device 3, the pile wing hole forming device 2 is connected with a pressure bar (not shown), and the pressure bar is connected with a pressure gauge (not shown) on the ground, as shown in Fig. 5A; during the process of forming the pile hole using the equipment 1 or when the equipment is lifted up after the pile hole has been formed, forming a horizontal slot 4 in the wall of the pile hole, as shown in Fig. 5B;

thereafter, forming branch hole(s) and/or force bearing plate slot(s) by compressing the soil body downwards from the horizontal slot 4 by means of the specific branch hole and/or force-bearing plate slot forming device 2 (the device will be described hereinafter) of the inventive equipment 1, as shown in Fig. 5C.

Fig. 6 shows an embodiment of the inventive equipment which has both a pile hole forming device and a pile branch hole and/or force-bearing plate slot forming device. The equipment 1 includes a submersible drill 3. The submersible drill comprises a drill rod 5, the drill rod 5 is provided with a power unit 6 and a pump 6A. At the bottom of drill rod there is provided a drill bit 7, and the drill rod is also provided with one or more branch hole and/or force-bearing plate slot forming devices 2.

Fig. 7 is another embodiment of the equipment in accordance with the invention. The equipment comprises an spiral auger 8 which includes a driving gear 9 at the top, a spiral blade and a drill rod 11. The drill rod 11 is further provided with one or more branch hole and/or force-bearing plate slot forming device 2.

Fig. 8 is one form of the branch hole and/or force-bearing plate slot forming device in the equipment of the invention. The device 2 comprises two compressing members 17 which can extend out horizontally, as shown in Fig. 8. Between the two compressing members there is provided an hydraulic cylinder 18 as the actuator, when the hydraulic cylinder 18 extends out, the compressing members 17 can be caused to extend out in a horizontal direction. The two compressing members are also connected with one end of an vertical hydraulic cylinder 19, when the hydraulic cylinder 19 extends out, the compressing members 17 can be caused to compress the soil body downwards. The

forming device 2 is particularly suitable for the method illustrated in Fig. 4.

Fig. 9 and 10 show the third form of the branch hole and/or force-bearing plate slot forming device used in the equipment of the invention. The device 2 includes an outer pipe 29, a plurality of forming mechanisms and an passage 29A through which reinforcement materials can be put in are provided inside the pipe 29. The outer pipe has holes for the forming mechanisms to extend out, and outside the outer pipe there is provided a pump station connected with the hydraulic cylinders in the forming mechanisms through oil lines (not shown). As shown in Fig. 10, the forming mechanism is provided with a vertical driving rod 30 driven by the above-mentioned hydraulic cylinder (not shown). The rod 30 is hinged to an upper bow-type compressing arm 32 via a vertically movable axle 31. The upper bow-type compressing arm 32 is hinged to a lower branch plate 34 integral with a lower bow-type compressing arm via a transversely movable axle 33. The bottom of the plate 34 is hinged to a fixed lower axle 35, and the axle 35 is fixed relative to the outer pipe 39. The upper end of an upper branch plate 36 is hinged to an fixed upper axle 37 which is fixed relative to the outer pipe 29. In Figs. 9 and 10, only the left one (half) of the two sets of symmetrical forming mechanisms is shown, and the right set is not shown in the figures since it is identical to the left one. Naturally, one, three or more sets of synchronous mechanisms can be provided as required. On the inner side of the upper branch plate 36 there are provided guide plates 38, and a free end 39 of the upper branch plate 36 is located at the connection point of the upper bow-type compressing arm 32 and the transversely movable axle 33. There are two guide plates 38 all together, there is a guide plate on either side of the upper branch plate 36. The guide plates 38 extend

downwards in the plane direction of the upper branch plate 36 from the free end 39 of the upper branch plate 36, on the extensions thereof there are formed guide grooves 38A for the transversely movable axle 33. Also hinged to the transversely movable axle 33 is an upper branch slide plate 40 which abuts against the inner side of the upper branch plate 36 and extends upwards. On either side of the lower branch plate 34 there is provided a compound lower branch plate 41 the bottom of which is hinged to the fixed lower axle 35. The compound lower branch plate 41 is provided with a limit stop 43 at the free end 42 thereof, and on the inner side of the upper bow-type compressing arm 32 there is provided a pressing block 44. Fig. 9 shows the mechanism in an extended state, and Fig. 10 showed an retracted state. As shown in Fig. 11, the forming device 2 further includes four retaining boards 45 (there are two retaining boards on each side) which are arranged on the two sides of the upper branch plate 36 respectively. When guide arms 46 at the lower end of the upper branch plate 36, which are on the inner side of the retaining plates 45, are inserted in advance, it is impossible for the uncompressed original soil 48 within the effective width 47 of the branch plate to collapse towards the spaces of the finished hole on both sides, and the upper branch slide plate 40 effectively prevent the soil body above the upper branch plate 36 from collapsing downwards, thus the soil body below the branch force-bearing plate is compactly compressed. The advantages of above-mentioned device lie in that the rising of the whole device occurred during the construction of the pile branch hole and/or force-bearing plate slot, and the defects of the finished cavity such as having an irregular shape and being east to collapse, can be avoided.

Fig. 12 is the fourth form of the pile branch hole and/or force-bearing plate slot forming device. The device 2 has a similar structure to

that shown in Fig. 10, the difference lies in that the upper branch plate in the device shown in Fig. 10 is pressed out first, and then the lower branch plate, so the device of Fig. 10 is suitable for the method shown in Fig. 3. The device 2 shown in Fig. 11 is also provided with the upper and lower branch plates 50, 51, but they are pressed out simultaneously, therefore it is suitable for the method shown in Fig. 4. The device 2 shown in Fig. 12 is further provided with an upper bow-type compressing arm 52 and a lower bow-type compressing arm 53, the upper bow-type compressing arm 52 is integrally connected with the upper branch plate 50, and the lower bow-type compressing arm 53 is integrally connected with the lower branch plate 51. The top of the upper bow-type compressing arm 52 is hinged to the vertical rod 54 which is driven by a hydraulic cylinder as an actuator. The other end of the upper bow-type compressing arm 52 is hinged to the lower bow-type compressing arm 53, the other end of the lower bow-type compressing arm 53 is hinged to the outer pipe 55. The outer pipe 55 has holes for the above-mentioned mechanisms to extend out. Fig. 13 shows the retracted state of the device.

The above-mentioned compression forming device can be provided with a plurality of compressing plates or members disposed circumferentially, thereby a force-bearing plate can be formed by one to two operations during construction.

Fig. 14 shows another pile branch hole and/or force-bearing plate slot forming device 2 in the equipment of the invention. The device includes an outer sleeve 62 inside which there are provided two pairs of bow-type compressing arms. Each pair of bow-type compressing arms includes an upper bow-type compressing arm 63 and a lower bow-type compressing arm 64. The top of the upper bow-type compressing arm 63

is hinged to a connecting member 65, and the bottom of the upper bow-type compressing arm 63 is hinged to the lower bow-type compressing arm 64. The bottom of the lower bow-type compressing arm 64 is connected to a connecting member 66. At the top of the outer sleeve 62 there is provided a cylinder 67 as an actuator inside which there are provided an upper piston 68 and a lower piston 69. The upper piston 68 is rigidly connected to the connecting member 66 through a piston rod 70, and the lower piston 69 is rigidly connected to the connecting member 65 through a piston rod 71. In the wall of the hydraulic cylinder 67 there are formed a fluid passage mouth 72 in the middle, a fluid passage mouth 73 at the bottom, and a fluid passage mouth 74 at the top. In the initial state, i.e. the state shown by dash-and-dot lines in the figure, the bow-type compressing arms of the equipment are in a retracted state, and the two pistons 68 and 69 in the cylinder 67 are located at the intermediate position in the cylinder. When the bow-type compressing arms are to be pressed out, oil is provided to the mouth 72 of the hydraulic cylinder by means of a pump, and oil passes through the mouths 73 and 74. Thus, the upper piston 68 rises gradually to move the piston rod 70 upwards, thereby moving the connecting member 66 upwards; and the lower piston 69 descends gradually to move the piston rod 71 downwards, thereby moving the connecting member 65 downwards. Since the upper and lower bow-type compressing arms 63 and 64 are of the same length and the pistons 68 and 69 in the hydraulic cylinder are also disposed oppositely and symmetrically, the connecting member 65 and 66 will move simultaneously to cause the hinged points of the upper and lower bow-type compressing arms to move linearly in a horizontal direction, with the result that an isosceles triangle-like branch hole can be formed by compression in a horizontal direction, and a force-bearing plate slot of

a pile can be formed by gradually rotating the device and pressing the upper and lower bow-type compressing arms out.

As shown in Fig. 15, another special equipment 1' of the invention comprises a caterpillar running gear 90; a swivel table 91; an control system 93 for the pile branch hole forming device and a driver's cab 92 positioned on the rotary table 91; a boom 94, the bottom of the boom is connected with the swivel table 91, and a branch hole and/or force-bearing plate slot forming device 2' is suspended from the top of the boom through a suspension cable. The device 2' is guided and fixed by a gripper block 95, and the rear end of the gripper block 95 is connected with the swivel table 91. The control system 93 of the pile branch hole forming device is substantially the same as the control system 73' of the pile branch hole forming device shown in Fig. 16 (which will be described later), only the former is positioned on the travelling special equipment 1' of the invention, while the latter is positioned on the ground and separated from the branch hole and/or force-bearing plate slot forming device.

As shown in Fig. 16, the control system for the pile wing hole forming device in the equipment can also be a control system 73', which is positioned on the ground, for the above-mentioned pile wing hole forming device. The system 73' includes a hydraulic system 76 and a computer monitoring system 87. The hydraulic system 76 comprises a hydraulic pressure display.

The computer monitoring system 87 includes a data processing unit which converts the relevant signals into digital signals and carry out operations on the relevant digital signals, a display and a memory for the various digital signals, an operation keyboard, a image display system showing the actual forming situations of the pile hole and the pile wing

hole and a printer.

As can be seen from Fig. 16, the components included in the computer monitoring system 87 comprise an control board 78 on which there is disposed a keyboard 79, a display 80, an audio amplifier 81, an image display 82 showing the actual forming situations of the pile hole and pile wing hole, and a control rod 83 for the pile wing hole forming device.

The image display system 82 is a night-vision observation system which can detect the quality of a dry hole. The system includes a color videocamera capable of taking pictures, a monitor for showing the pictures taken by the videocamera, a sealed container for receiving the videocamera and the power source, an observation head, a light source for picture-taking and a video recorder. The observation head includes a horizontal observation head for observing the hole wall and a vertical observation head for observing the hole bottom (not shown).

The image display system includes an ultrasonic scanner (not shown) for detecting the quality of a wet hole.

The computer monitoring system includes an unit (not shown) for controlling the manipulation of the pile wing hole forming device.

What is claimed is

1. A construction method of pile structure, comprising the following steps:

a) Carrying out an exploration to the pile ground to generally learn the conditions of the soil layer of the ground and determining the size of the piles and the preliminary size and position of the pile wings ;

b) Forming a pile hole to a prescribed depth in the ground according to the pile size derived from said exploration;

c) Obtaining the actual mechanical properties of the soil body in the vicinity of said preliminary position by exploring the soil body of the pile hole wall in the vicinity of the preliminary position of said pile wings by means of pile-wing-hole forming device, thereby determining the final size and final position of the pile wings;

d) compressing , according to said final size of the pile wings, the soil body of pile hole wall at said final position of the pile wings by means of the pile-wing-hole forming device, thereby forming the pile wing hole;

e) Pouring concrete into the finished pile hole and pile wing hole to form a concrete pile;

f) Constructing other piles in the pile structure according to the above-mentioned steps, thereby forming a pile structure composed of a plurality of concrete piles.

2. The construction method as claimed in Claim 1, wherein in said step c), in the case that the mechanical properties of the soil body at said preliminary position are poor, moving the pile-wing-hole forming device along the pile hole wall to continue the exploration of the soil body of the hole wall until a required soil layer is found, and using the position of



said required soil layer as the final position of a corresponding pile wing.

3. The construction method as claimed in claim 2, wherein said pile wings are pile branches.

4. The construction method as claimed in Claim 1 wherein in said step c), in the case that the mechanical properties of the explored soil body at said preliminary position are poor, still using the position of said soil layer as the final position of a corresponding pile wing; but in said step d), forming a pile wing with a size larger than the corresponding preliminary size at said position.

5. The construction method as claimed in Claim 1 wherein in said step c), in the case that the mechanical properties of the explored soil body at said preliminary position are poor, still using the position of said soil layer as the final position of a corresponding pile wing; but in step d), forming a plurality of pile wings having the corresponding preliminary size in the area of said soil layer, the number of which is larger than the preliminary determined number of the pile wings at said position.

6. The construction method as claimed in Claim 1 or 4, wherein said pile wings are pile force-bearing plates and/or pile branches.

7. The construction method as claimed in claim 1, wherein said mechanical properties of soil body are the compressive mechanical properties of soil body .

8. The construction method as claimed in Claim 1, wherein said mechanical properties of soil body comprise the friction resistance coefficient of soil body.

9. The construction method as claimed in Claim 1, wherein in said step c), the mechanical properties of soil body are determined by means of sensors.

10. The construction method as claimed in Claim 1, wherein after



the pile hole and pile wing holes are formed, a pile-hole-quality detector is inserted into the pile hole to detect the quality of the pile hole and pile wing holes.

11. The construction method as claimed in Claim 10, wherein for the pile hole and pile wing holes in which there is no water, the quality detection of said holes is carried out by means of a night-vision observation system.

12. The construction method as claimed in Claim 10, Wherein for the pile hole and pile wing holes in which there is slurry, the quality detection of said holes is carried out by means of an ultrasonic scanner.

13. The construction method as claimed in Claim 1, wherein after concrete has been poured into the pile hole and pile wing holes, when said concrete attains a certain strength, the quality of the pile and pile wings is detected by means of an ultrasonic detector.

14. The construction method as claimed in Claim 1, wherein in said step c), the final size and position of pile wings are calculated by means of a computer system.

15. The construction method as claimed in Claim 1, wherein during construction, the manipulation of the pile-wing-hole forming device is controlled by a computer system.

16. The construction method as claimed in Claim 1, wherein during construction, the measured values of mechanical properties of soil body and the signals associated with the quality, size and position of the formed pile and pile wings are converted into digital signals and stored in the computer system.

17. The construction method as claimed in Claim 11 or 12, wherein the actual forming condition of said pipe hole and pile wing holes are displayed through an image display so as to facilitate monitoring.



18. The construction method as claimed in Claim 1, wherein reinforcing bars or reinforcing cages are inserted before pouring concrete.

19. The construction method as claimed in Claim 1, wherein prestressed reinforcing steels are inserted before pouring concrete, and the prestressed reinforcing steels are prestressed and anchored after the concrete attains a certain strength.

20. The construction method as claimed in Claim 1, wherein in said step e), said pouring of concrete is conducted by a tremie method, a series tube method and a pumped concrete method.

21. The construction method as claimed in Claim 1, wherein in said step b), said pile hole is formed by a positive circulation method, a counter circulation method, an spiral auger drilling method, an jet soil-flushing method, a manual hole-digging method, dipper or grab bucket soil-removing method, sleeve-driven and soil-squeezing method, or a hammering-punching method.

22. The construction method as claimed in Claim 1, wherein in said step b), said pile hole is formed as such that a pilot hole is formed at the pile position; a guard tube is lowered into the pilot hole; an impact hammer is used to impact the ground along the guard tube to form a hole; thereafter the guard tube is lift out, and then loosened earth bucket is put in.

23. The construction method as claimed in Claim 1, wherein in said step b), said pile hole is formed by an spiral auger drilling method, and said step d) is accomplished as follows, according to design requirements, the soil layer at the end of the force-bearing plate in an intermediate pile wing is hammered to consolidate in layers; after the loosened soil bucket is put onto the hole bottom, a pile-wing-hole forming device is put in to



form pile wing holes through compression at the consolidation positions in layers; and the loosened soil bucket is lift out to form a force-bearing plate at the bottom of the pile.

24. The construction method as claimed in Claim 23, wherein said step b) includes clearing up the loosened soil at the hole bottom, that is, the drill bit is made to idle at the initial depth until the prescribed requirement is satisfied; and in said step d) the pile wing holes are formed as such: according to the design level, compression and expansion signs for the pile wings are marked in the conspicuous positions on the upper and lower sections of the pile-wing-hole forming device, and the pile wings are formed through compression and expansion in the order from top to bottom; and after the loosened soil bucket is lift out, the force-bearing plate slot at the hole bottom of the pile wings is formed.

25. The construction method as claimed in Claim 1, wherein in said step b), said pile hole is formed by a slurry wainscot drilling method, and said step d) is proceeded as such: the pile-wing-hole forming device is slinged, and then slowly lowered into the pile hole after the pile-wing-hole forming device substantially stops sway or rotation; while said device is being putting in, an oil supply pipe and an oil return pipe are locked by special oil pipe clips at 3~5m intervals on a coupling tube of the upper and lower sections of the pile-wing-hole forming device; depth size is marked on the coupling tube of the upper and lower sections of the pile-wing-hole forming device; and according to the required levels, the pile wing holes are formed through compression in a prescribed order.

26. The construction method as claimed in Claim 1, wherein after said step e) is carried out, slurry is injected under pressure onto the pile



hole bottom and the pile wing ends through a preset slurry tube to consolidate the surrounding soil body of said portions.

27. The construction method as claimed in Claim 1, wherein the angle between the compression direction of said pile wing hole and the direction perpendicular to the pile hole wall is $\pm 90^\circ$.

28. The construction method as claimed in Claim 1, wherein said pile wing holes are formed by compressing the surrounding soil body of the pile hole wall in the direction parallel to the pile hole axis.

29. The construction method as claimed in Claim 1, wherein, firstly, a first cavity of a pile wing hole is formed by compressing the soil body in the first prescribed area at the selected position of the pile hole wall upwards in a direction inclined relative to the pile shaft hole axis, and then a second cavity of the pile wing hole is formed by compressing the soil body in the second prescribed area at said selected position of the pile hole wall downwards in a direction inclined relative to the pile hole axis, said first cavity and second cavity jointly constitute the pile wing hole.

30. The construction method as claimed in Claim 1, wherein a first cavity of a pile wing hole is formed by compressing the soil body in a first prescribed area at a selected position of the pile hole wall upwards in a direction inclined relative to the pile hole axis, and at the same time, a second cavity of the pile wing hole is formed by compressing the soil body in a second prescribed area at said selected position of the pile hole wall downwards in a direction inclined relative to the pile hole axis, said first cavity and second cavity jointly constitute the pile wing hole.

31. The construction method as claimed in Claim 1, wherein said pile wing hole is formed by only compressing the soil body in a prescribed area at a selected position of the pile hole wall downwards in



a direction inclined relative to the pile hole axis.

32. The construction method as claimed in Claim 1, wherein, first, a horizontal cavity is formed in the surrounding soil body in a prescribed area at a selected position of the pile hole wall, and then the surrounding soil body of the pile hole wall located below said cavity is compressed downwards in a direction parallel to the pile shaft hole axis to form the pile wing hole.

33. The construction method as claimed in Claim 1, wherein during the forming process of a pile wing hole, reinforcement material for the pile wing is injected.

34. The construction method as claimed in Claim 1, wherein part of pile body material is poured during the forming process of the pile wing hole, and the other part is poured after said process; the pile hole wall is protected through a wall-protection fluid.

35. The construction method as claimed in Claim 1, wherein said wall-protection fluid is cement slurry, the cement slurry is injected into the pile hole as the pile hole forming device is lifted after the pile hole has been formed by means of the pile hole forming device, until a position in the pile hole where no collapse will occur; after the pile wing holes are formed, a slurry-supplementing tube is inserted to the pile hole bottom and, aggregate is put in at the same time; and then cement slurry is pressed under high pressure into the pile hole through the opening at the bottom of the slurry-supplementing tube via the slurry-supplementing tube until entire pile hole is filled up.

36. The construction method as claimed in Claim 1, wherein the pile body material is poured into the pile hole and pile wing holes after the pile wing holes are formed.

37. The construction method as claimed in Claim 1, wherein said





pile wing hole is formed by compression into a shape with the size along the axis of the pile hole being larger.

38. The construction method as claimed in Claim 1, wherein said pile wing hole is formed by compression into an spiral hole extending along the pile hole axis.

39. The construction method as claimed in Claim 1, wherein said pile wing hole is formed during the process of lifting out the pile hole forming device after the pile hole has been formed.

40. The construction method as claimed in Claim 1, wherein said finished pile is a neat concrete pile.

41. The construction method as claimed in Claim 1, wherein said piles are arranged in rows to form a support and guard pile structure.

42. The construction method as claimed in Claimed 41, wherein the tops of the piles in said support and guard pile structure are connected through a connecting beam and the pile wings formed on individual piles.

43. A special equipment for carrying out the method as claimed in Claim 1, wherein said equipment comprises a pile-wing-hole forming device, and on said device there is provided a detector for detecting the mechanical properties of soil body of the ground when forming a pile wing hole with the device.

44. The method as claimed in Claim 43, wherein said detector is a sensor.

45. The method as claimed in Claim 44, wherein said sensor comprises a pressure head, said pressure head is connected to an actuating hydraulic cylinder, and said actuating hydraulic cylinder is connected to a pressure display.

46. The method as claimed in Claim 41, wherein said detector is a





detecting instrument for friction resistance properties of the soil body.

47. The method as claimed in Claim 41, wherein said equipment further comprises a control system for said pile-wing-hole forming device, said system comprises a hydraulic unit and a computer monitoring system.

48. The method as claimed in Claim 47, wherein said hydraulic unit comprises a hydraulic pressure display.

49. The method as claimed in Claim 47, wherein said computer monitoring system comprises a data processing unit for converting relevant signals into digital signals and carrying out operations on the relevant signals, a display and a memory for the various digital signals, an operation keyboard, and an image display system for showing the actual forming conditions of a pile hole and pile wing holes.

50. The method as claimed in Claim 49, wherein said computer monitoring system comprises an control panel, and on said control panel there are provided a keyboard, a display, an audio amplifier, an image display showing the actual forming conditions of a pile hole and pile wing holes, a control rod for the pile-wing-hole forming device, and a printer.

51. The method as claimed in Claim 49, wherein said image display system is a night-vision observation system capable of detecting the forming quality of a dry hole, and said system comprises a color videocamera capable of taking pictures, a monitor for showing the pictures taken by the videocamera, a sealed sleeve for receiving said videocamera and a power source, an observation head, a light source for picture-taking, and a video recorder.

52. The method as claimed in Claim 51, wherein said observation head comprises a horizontal observation head for observing the hole wall





and a vertical observation head for observing hole bottom.

53. The method as claimed in Claim 49, wherein said image display system comprises an ultrasonic scanner for detecting the forming quality of a wet hole.

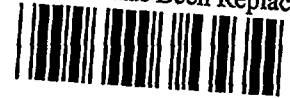
54. The method as claimed in Claim 47, wherein said computer monitoring system comprises an unit for controlling the operation of the pile-wing-hole forming device.

55. The method as claimed in Claim 45, wherein said pile-wing-hole forming device is of a hydraulically actuated type which comprises a bow-type compression mechanism for forming the pile wing holes, the extending portion of said bow-type compression mechanism constitutes the pressure head for said detector.

56. The method as claimed in Claim 43, wherein said detector is a detecting instrument for the friction resistance properties of the soil body.

57. The method as claimed in Claim 43 or 45, wherein said pile-wing-hole forming device comprises a pile-wing-hole forming mechanism, the mechanism includes a first bow-type compressing arm and a second bow-type compressing arm, the ends of said first bow-type compressing arm and second bow-type compressing arm are hinged to each other, the other end of the first bow-type compressing arm is hinged to a first connecting member and the other end of the second bow-type compressing arm is hinged to a second connecting member; said first connecting member is rigidly connected to the end of a piston rod of an actuating hydraulic cylinder, and said second connecting member is rigidly connected to the end of the other piston rod of said actuating hydraulic cylinder; said two piston rods are disposed coaxially and move oppositely while working; and said actuating hydraulic cylinder includes





two pistons which are disposed coaxially and parallelly and move oppositely while working, said two piston rods are rigidly connected to said two pistons respectively.

58. The method as claimed in Claim 43 or 45, wherein said pile-wing-hole forming device comprises a plurality of sets of pile-wing-hole forming mechanism, said sets of pile hole forming mechanism are arranged at intervals along the longitudinal and/or transverse directions of the equipment.

59 The method as claimed in Claim 43 or 45, wherein said pile-wing-hole forming device comprises a plurality of sets of pile-wing-hole forming mechanism, said sets of pile-wing-hole forming mechanism are arranged symmetrically relative to the longitudinal axis of the equipment.

60. The method as claimed in Claim 43 or 45, wherein said equipment comprises a pile hole forming device, said pile-wing-hole forming device is provided on said pile hole forming device.

61. The method as inclined in Claim 43, 45 or 60, wherein said pile-wing-hole forming device comprises a main support member on which there is fixed an driving gear and, and said device further comprise a pile-wing-hole forming mechanism, said mechanism includes a first bow-type compressing arm and a second bow-type compressing arm, one end of said first bow-type compressing arm is hinged to a driving rod driven by said driving gear, and the other and of said first bow-type compressing arm is hinged to one end of the second bow-type compressing arm, the other end of the second bow-type compressing arm is hinged to a first fixed member, the first fixed member is on one side of the hinge point of the first bow-type compressing arm and the driving rod and is on one side of the moving axis of the hinge point of the first and second bow-type compressing arms relative to the hinge point of the





driving rod and the first bow-type compressing arm; said second fixed member is hinged to one end of a first branch plate, and the other end of the first branch plate is a free end; the inner side of the first branch plate abuts against the hinge portion of the first and second bow-type compressing arms, and is provided with a guide plate, on said guide plate there is formed a guide groove in the direction parallel to the first branch plate; the first and second bow-type compressing arms are hinged through a transversely movable axle, said guide groove permits said transversely movable axle to slide therein and extends towards the second bow-type compressing arm from the position where the transversely movable axle is located when it has not yet moved outwards transversely.

62. The method as claimed in Claim 43, 45 or 60, wherein said equipment comprises a main support member which is provided with an driving gear, and the equipment is further provided with a pile-wing-hole forming mechanism; said mechanism includes a first bow-type compressing arm and a second bow-type compressing arm; one end of said first bow-type compressing arm is hinged to a driving rod, and said driving rod is driven by said driving gear, the other end of said first bow-type compressing arm is hinged to one end of the second bow-type compressing arm, and the other end of the second bow-type compressing arm is hinged to a fixed member which is fixed to the main support member; and the first bow-type compressing arm has a first branch plate integrally formed thereon, and the second bow-type compressing arm has a second branch plate integrally formed thereon.

63. The method as claimed in Claim 43, 45 or 60, wherein said equipment comprises a telescopic power compressing device which can linearly compresses the surrounding soil body of a pile hole wall





downwards in a direction inclined relative to the pile hole axis.

64. The method as claimed in Claim 43, 45 or 60, wherein said equipment comprises a compressing member which can insert horizontally into the surrounding soil body of a pile hole wall, the member is connected with a driving gear, and thus it can compress the surrounding soil body of the hole wall downwards in a direction parallel to the pile hole axis when inserted into the surrounding soil body of the hole wall.

65. The method as claimed in Claim 43, wherein said equipment comprises a pile hole forming device, said device is an clay digger forming device.

66. The method as claimed in Claim 65, wherein said clay digger forming device is a submersible driller, an jet soil-flushing hole-forming device, a bit driller, an overall casing driller, a positive circulation driller, a counter circulation driller, a grab soil-removing device or a dipper soil-removing device.

67. The method as claimed in Claim 65, wherein said clay digger forming device is an auger driller which includes a drilling rod, said drilling rod is a hollow pipe and is provided with a pile-wing-hole forming device; and at the bottom of the hollow drilling rod there is formed a nozzle communicated therewith, through the nozzle pile body material or a wall-protection fluid is injected, and the top of the drilling rod is communicated with the supplying fluid of the injected material.

68. The method as claimed in Claim 43, wherein said equipment comprises a caterpillar running gear; a swivel table; and a driver's cab, a control system for the pile-wing-hole forming device on the swivel table; and a boom; the bottom of said boom is connected to the swivel table, and the branch hole and/or force-bearing plate slot forming device is





suspended from the top of the boom through a suspension cable, said device is guided and fixed by a gripper block, and the rear end of said gripper block is connected with said swivel table.

69. The method as claimed in Claim 43, wherein said equipment comprises an control system for the pile-wing-hole forming device, which is placed on the ground and is separated from the pile-wing-hole forming device.



* C L M S *

Abstract of the Disclosure

A method of constructing a pile structure and an apparatus thereof, the method includes the following steps: making a geological survey in ground to obtain the initial size of the pile shaft and the initial size and position of the protrusions on the side wall of pile, making a hole of pile shaft, making a measurement to the side wall of the hole by the means for forming a hole of the protrusions to decide the actual size and position of the protrusions, making a hole of the protrusions by pressing the ground with the means, the hole of the pile shaft and the holes of the protrusions are injected with concrete to form a concrete pile, making the other piles by the above steps to form pile structure. According to the method, knowing a geological information at the position of each pile simultaneously with executing the construction, so that the actual bearing capability/deformation is obtained at once, and ununiformal settlement of a building is avoided.

Fig.1C

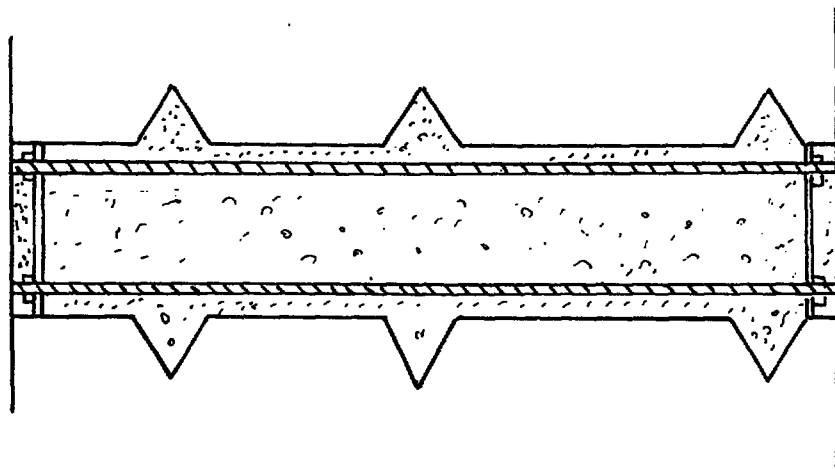


Fig.1B

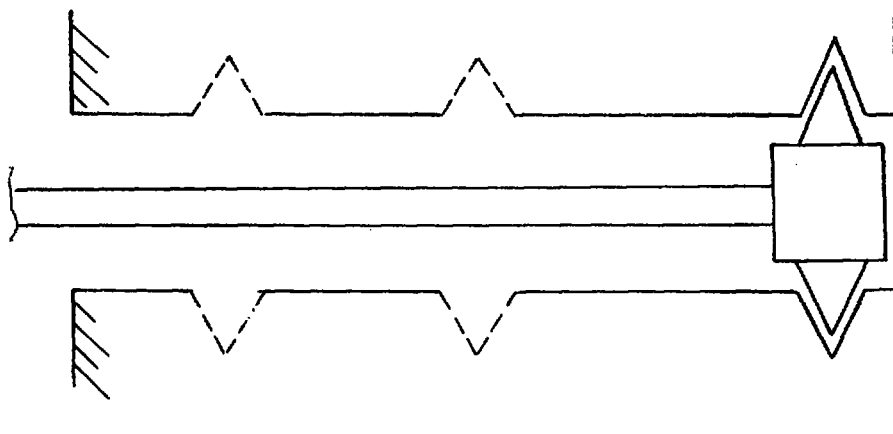
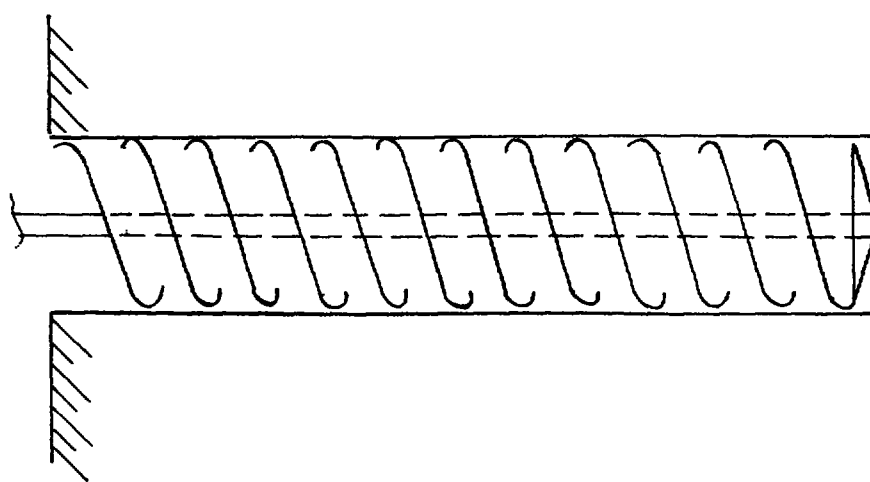


Fig.1A



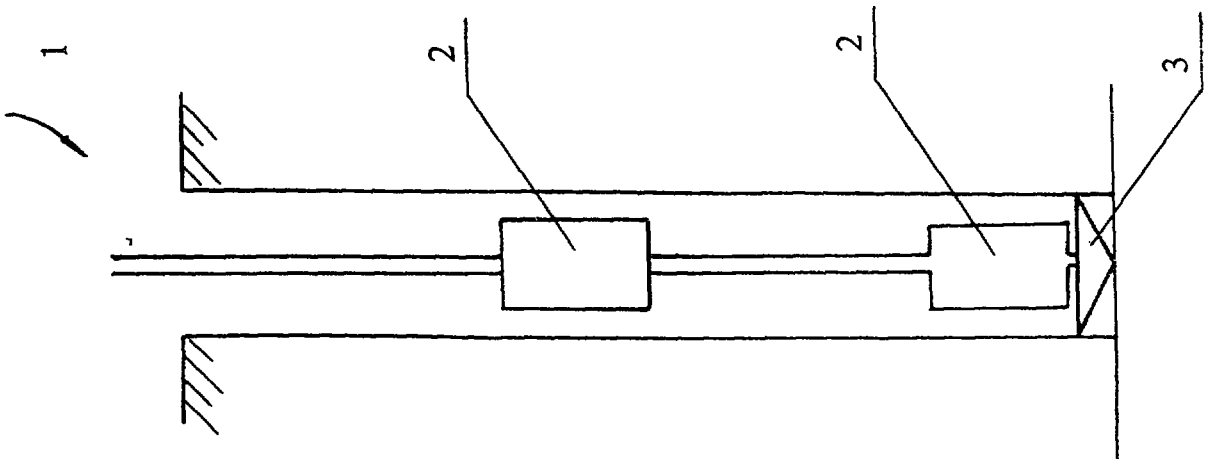


Fig. 2A

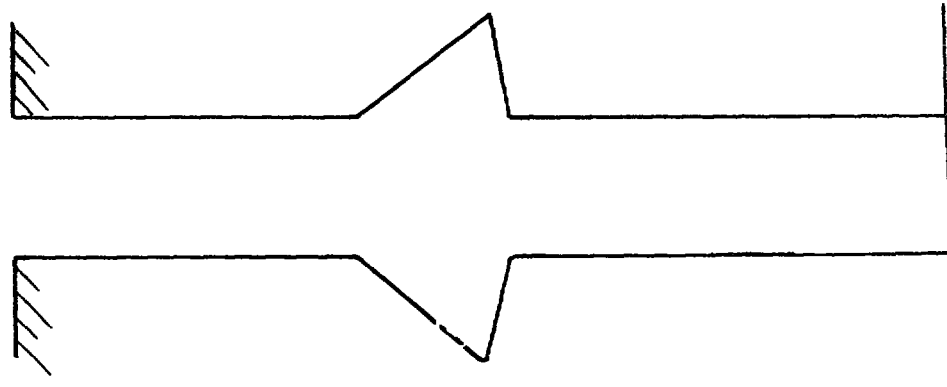


Fig. 2B

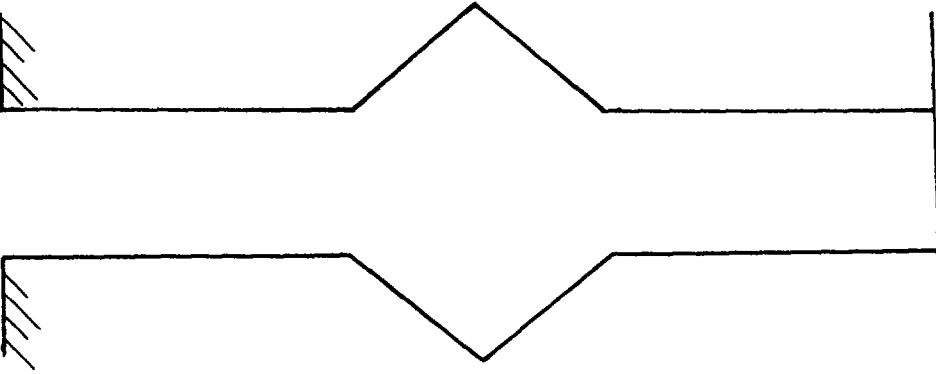


Fig. 2C

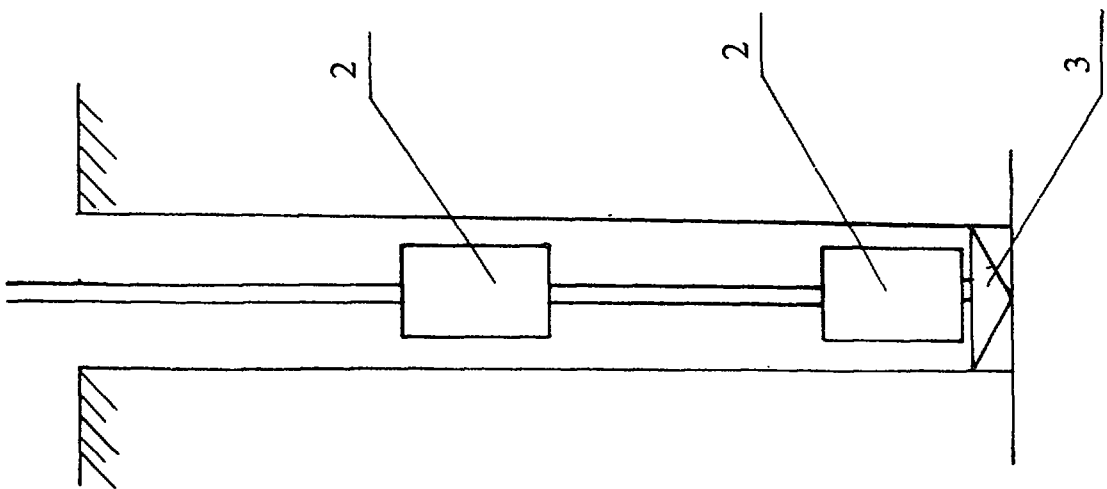


Fig. 3A

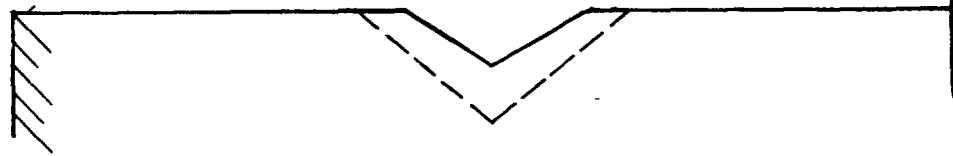
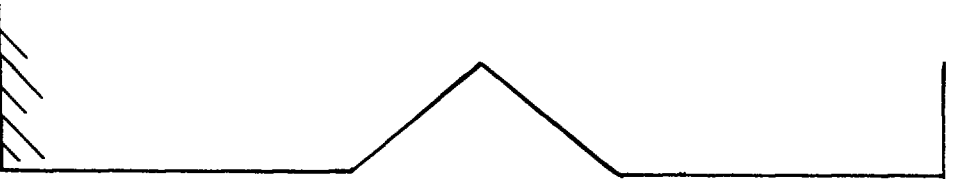
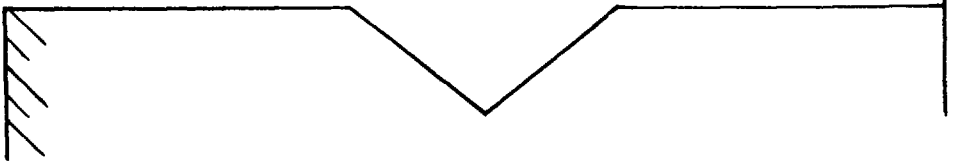


Fig. 3B



Fig. 3C



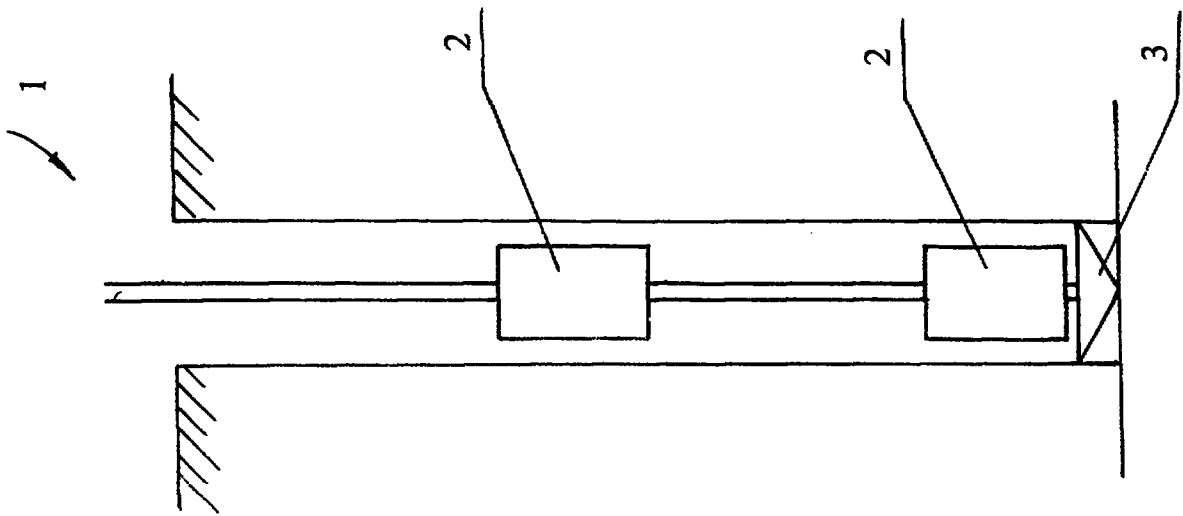


Fig. 4A

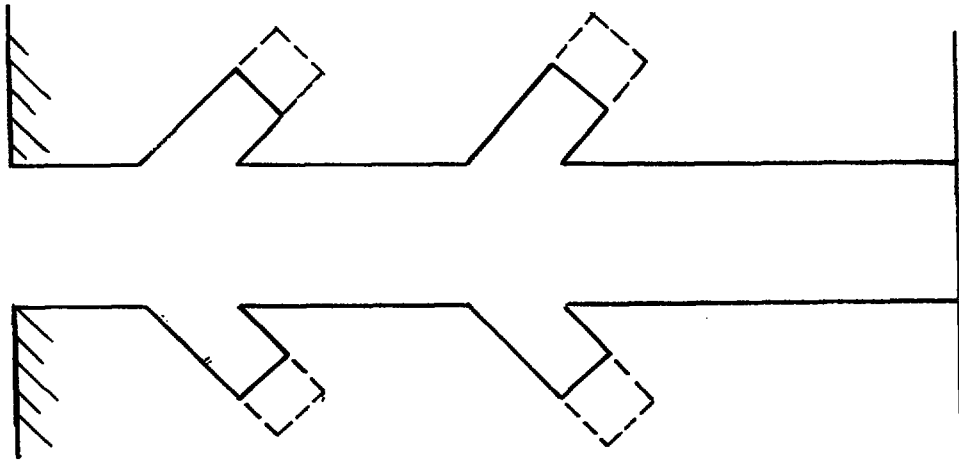


Fig. 4B

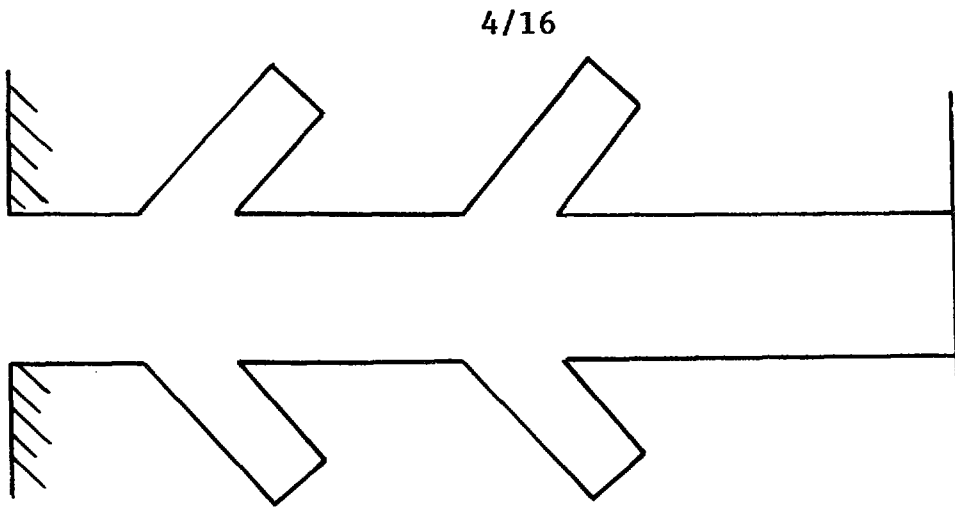


Fig. 4C

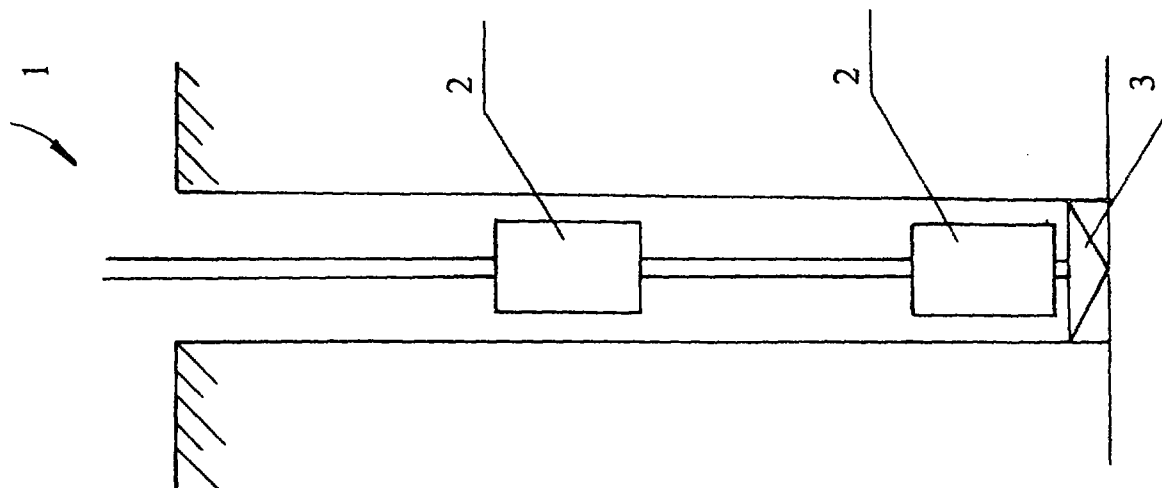


Fig. 5A

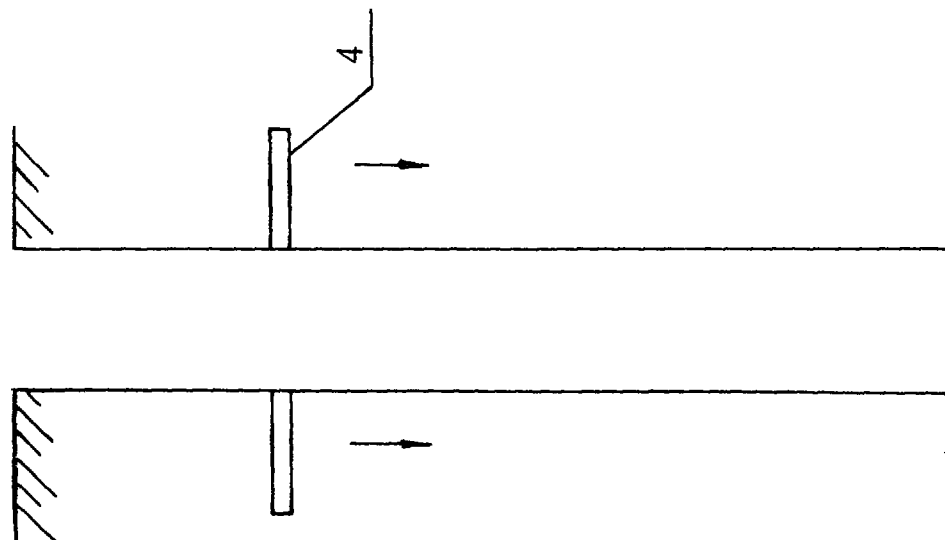


Fig. 5B

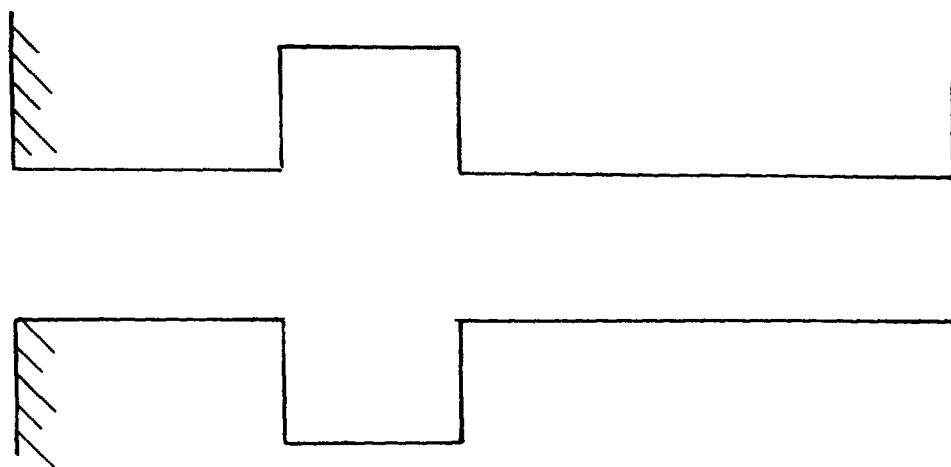


Fig. 5C

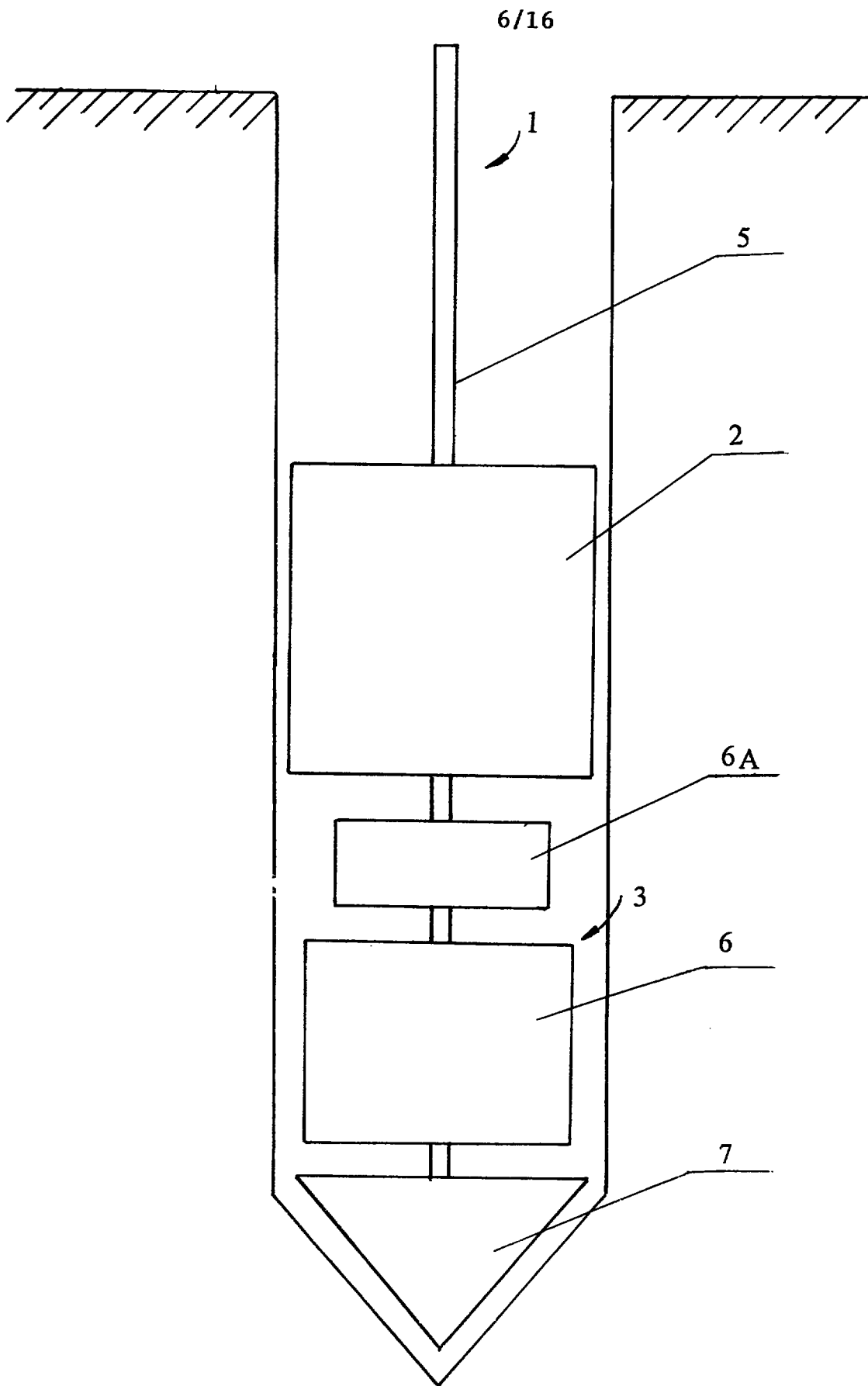


Fig.6

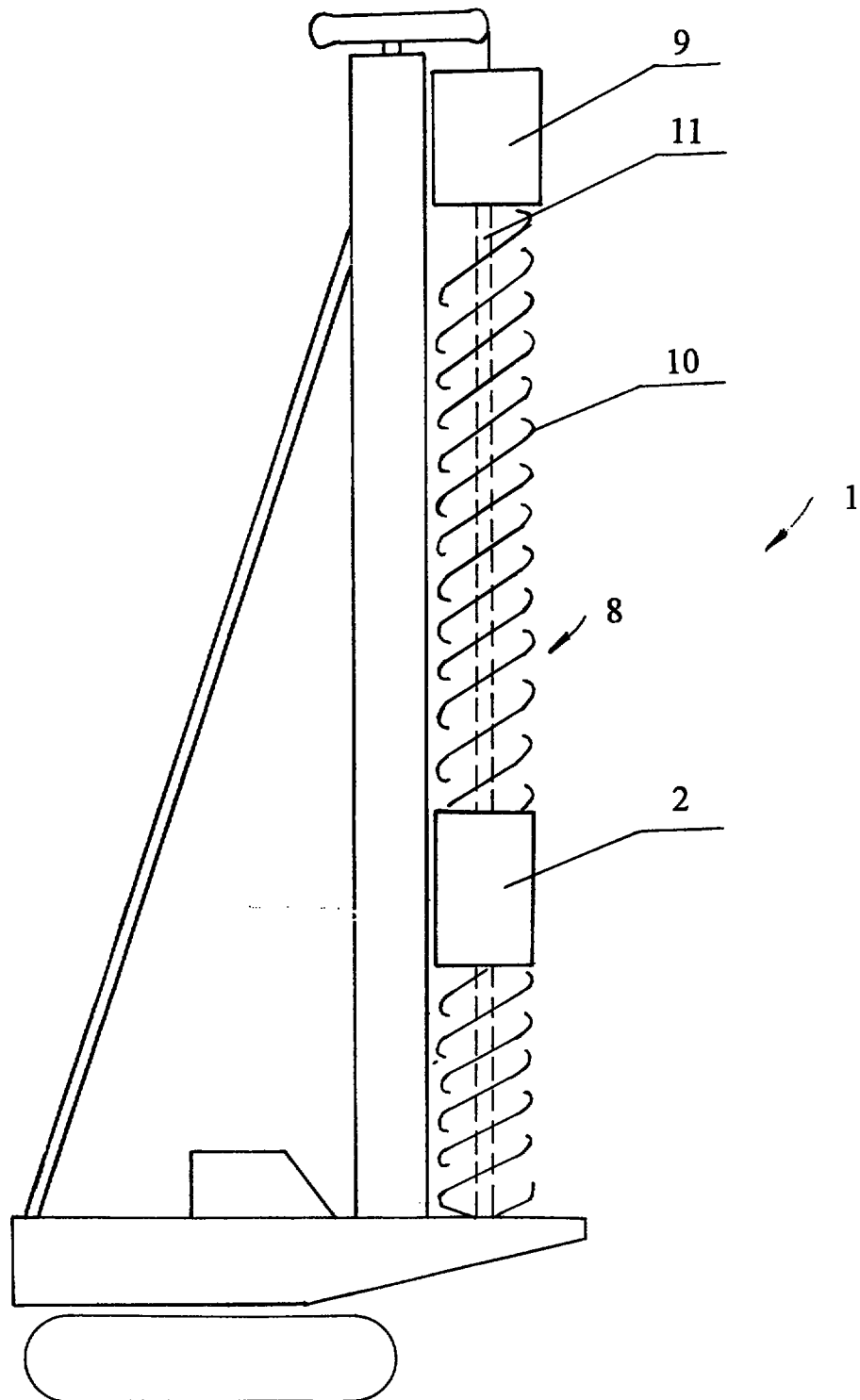


Fig. 7

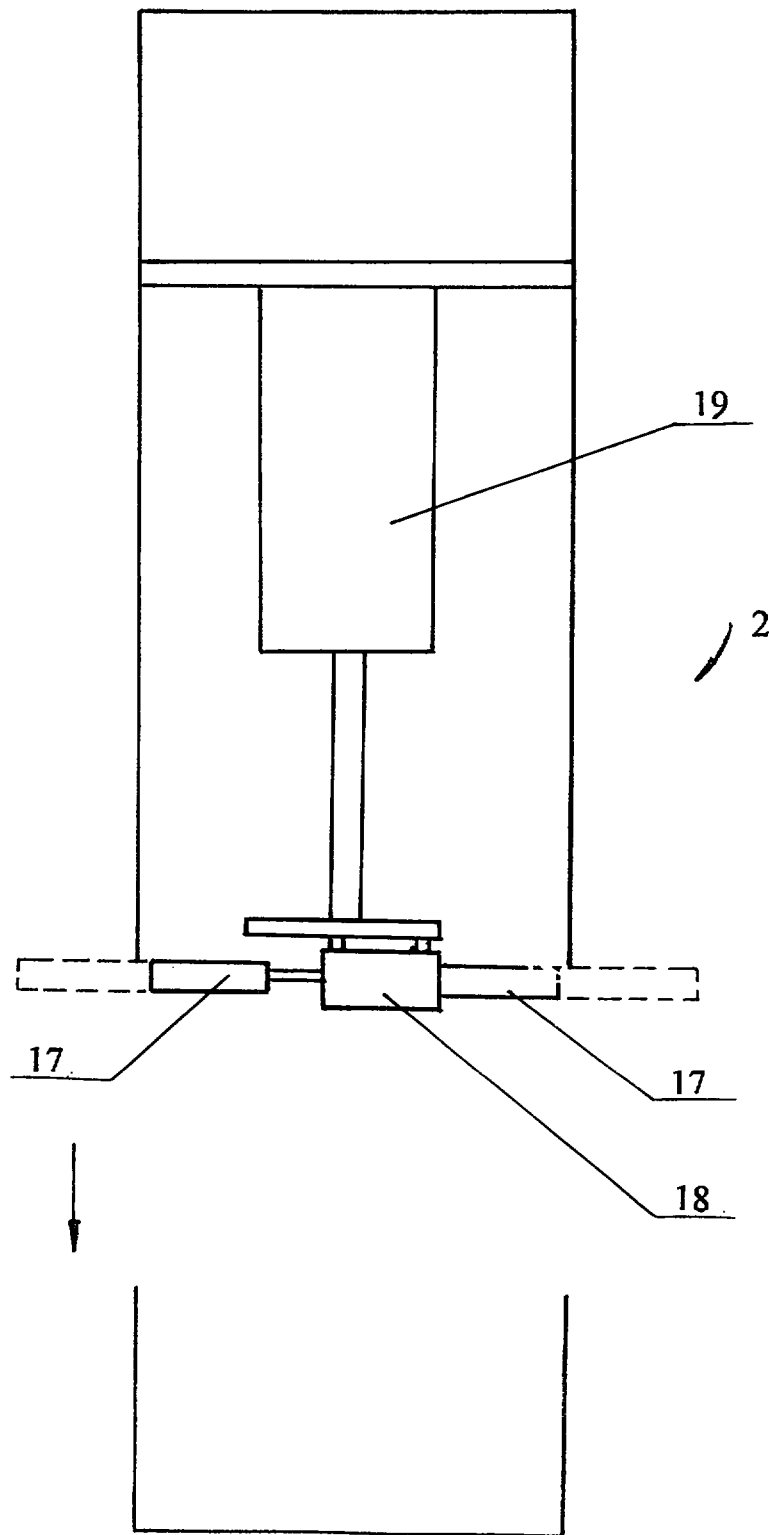


Fig. 8

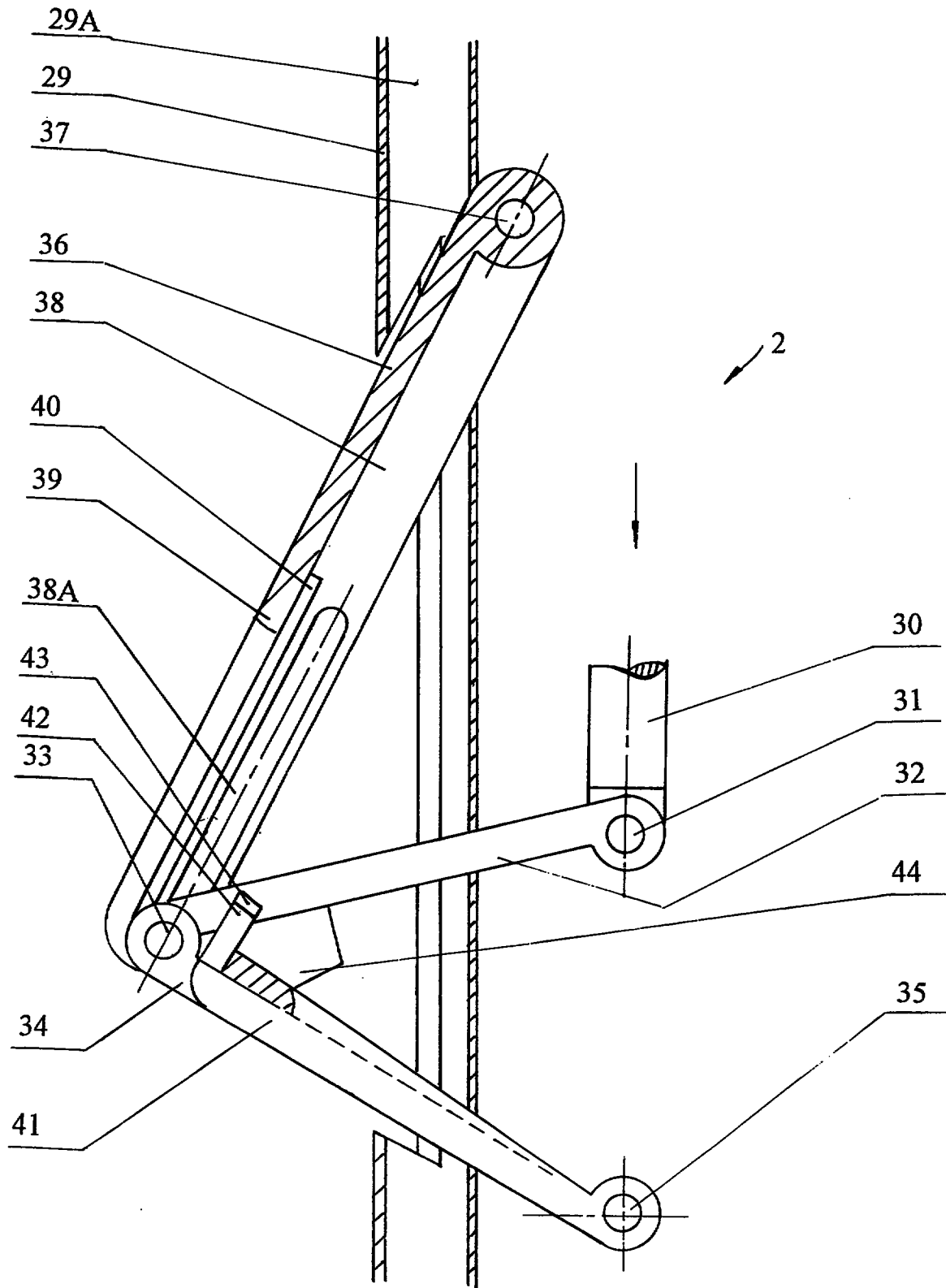


Fig. 9

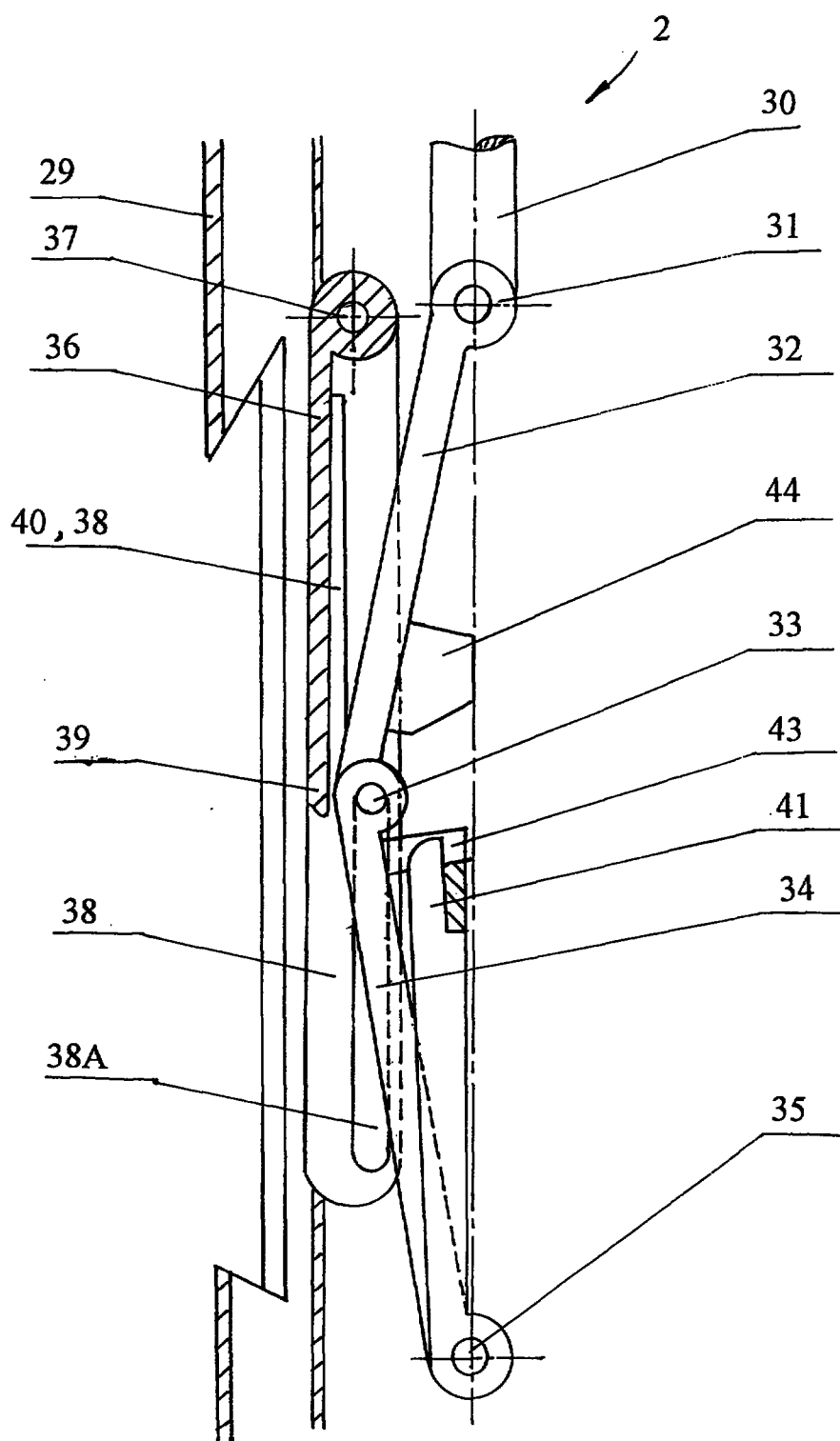


Fig.10

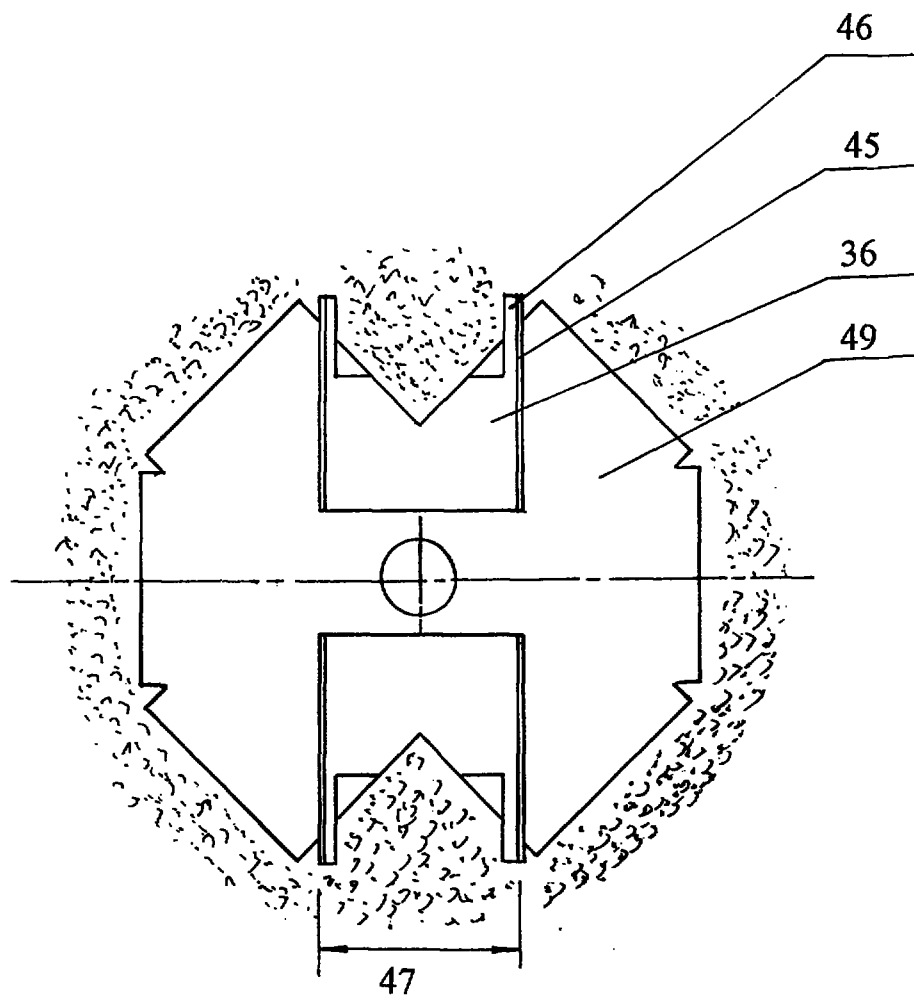


Fig.11

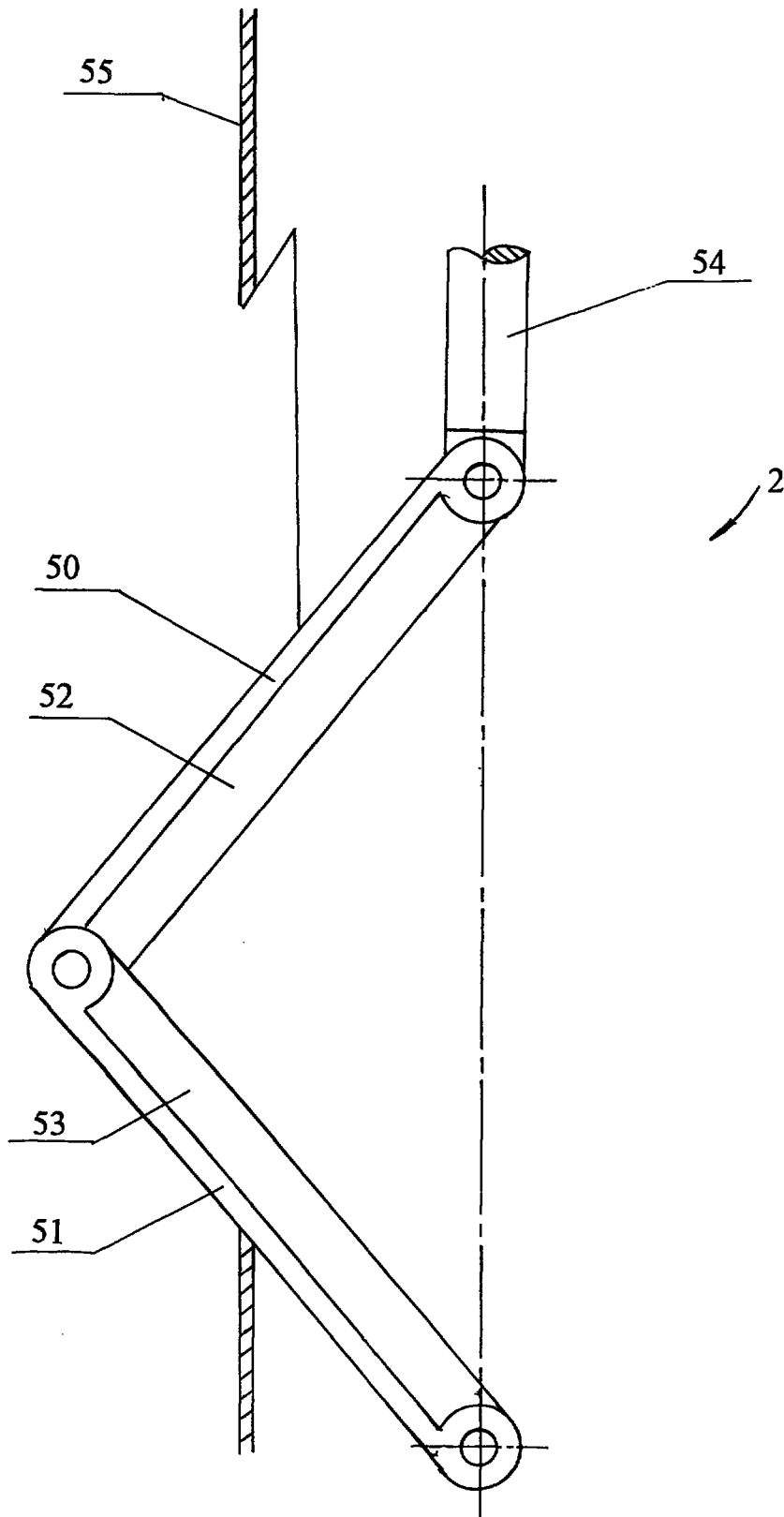


Fig.12

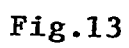


Fig.13

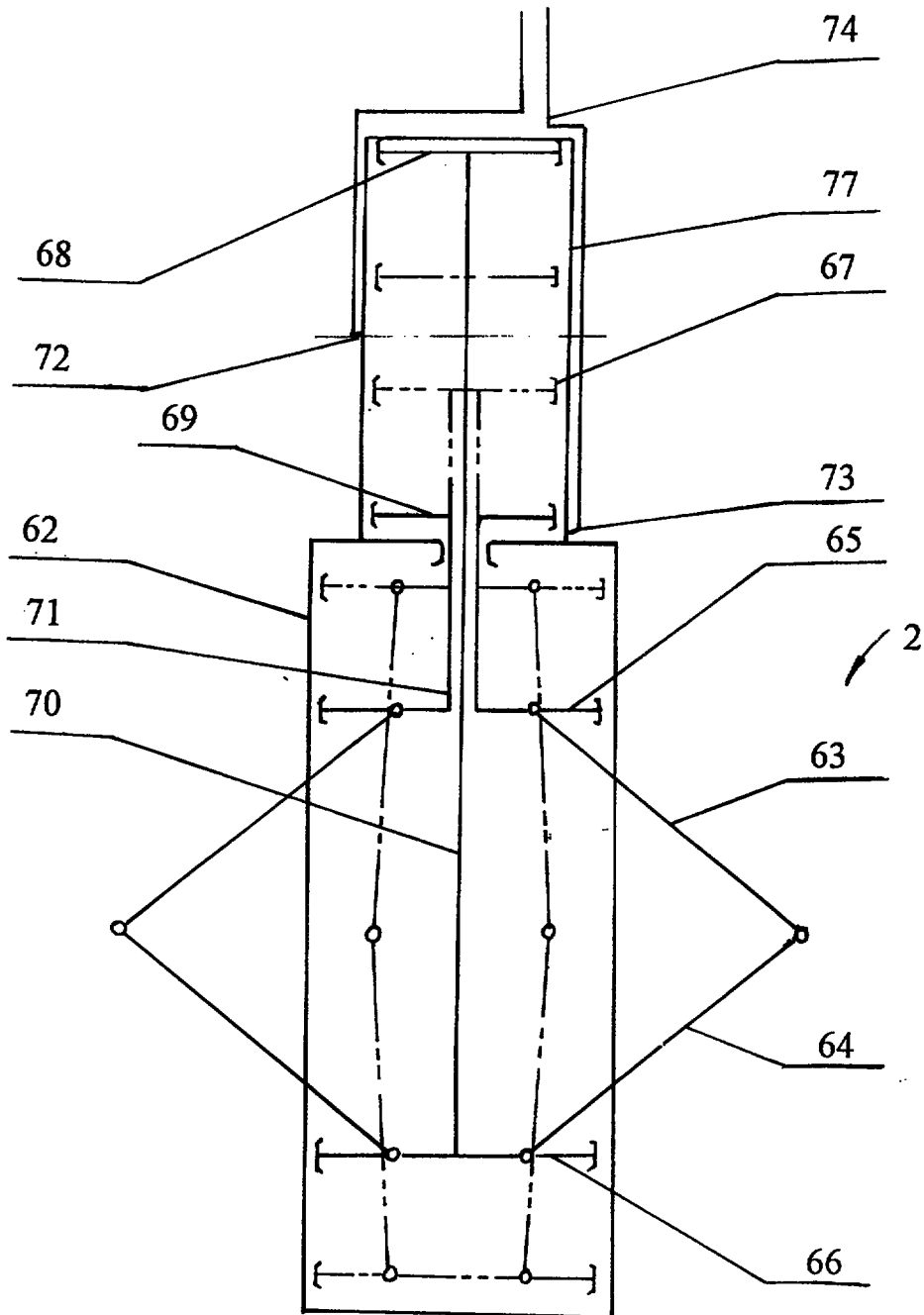
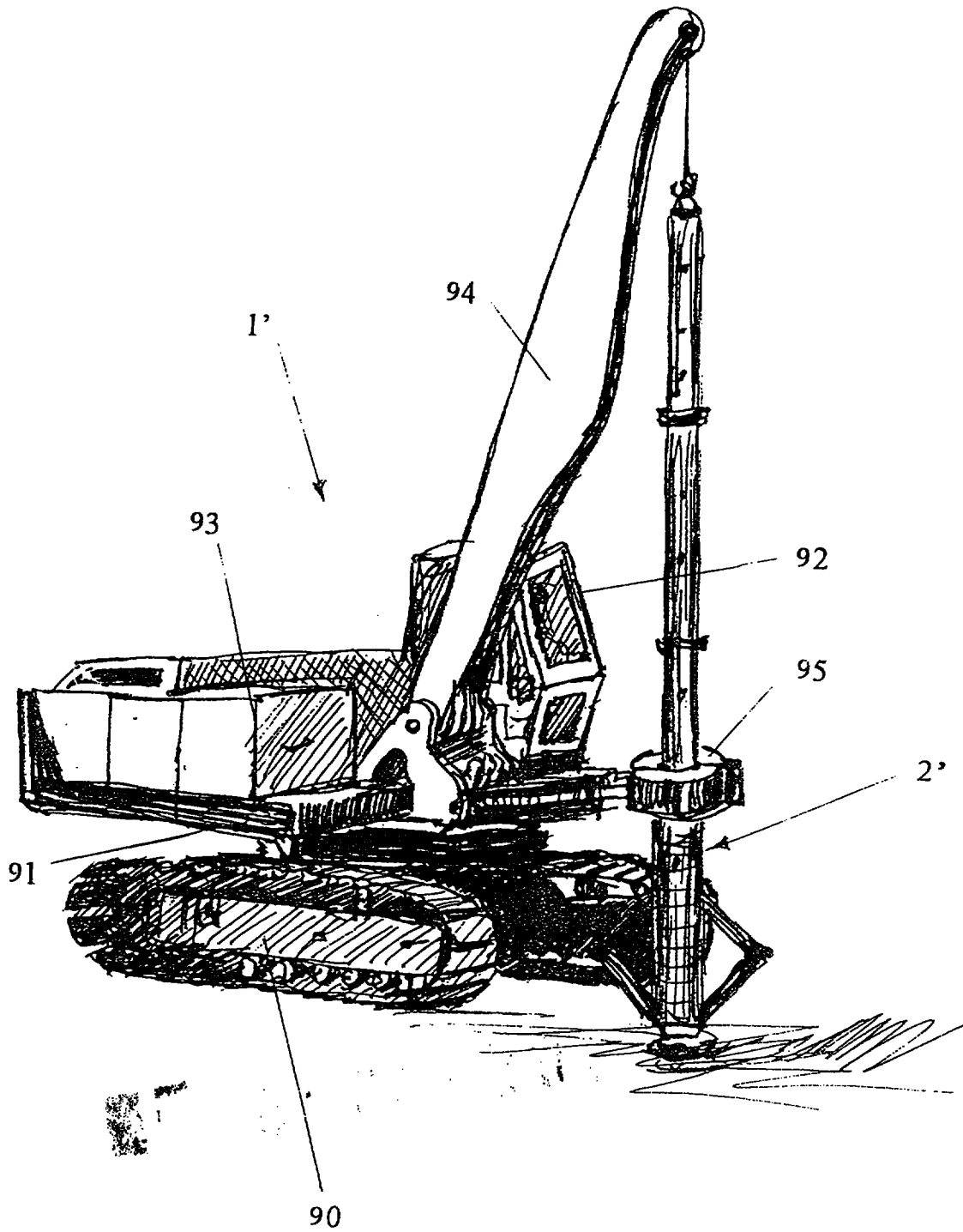


Fig. 14

Fig.15



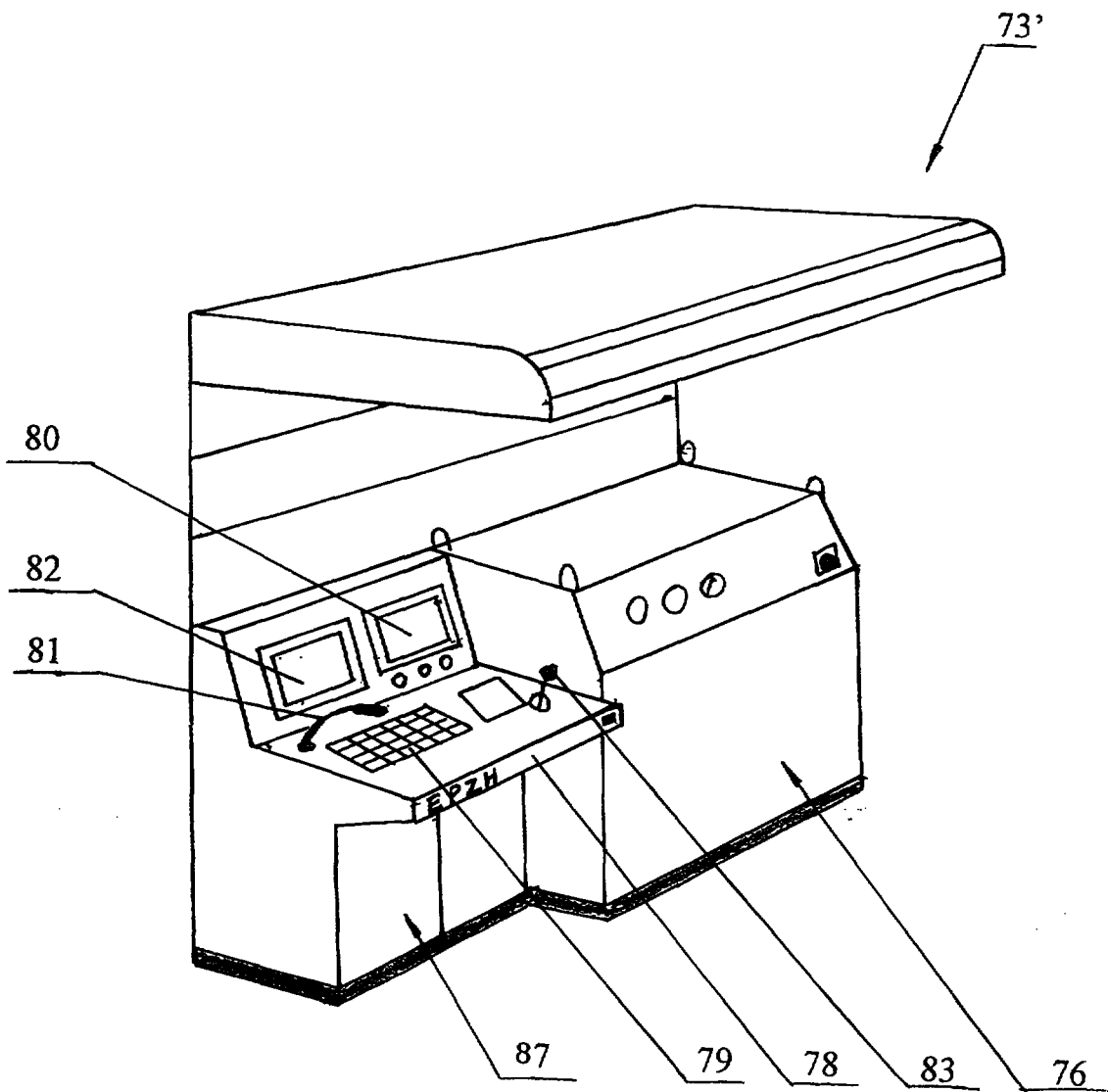


Fig.16

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pile wing hole is formed by compression into a shape with the size along the axis of the pile hole being larger.

38. The construction method as claimed in Claim 1, wherein said pile wing hole is formed by compression into an spiral hole extending along the pile hole axis.

39. The construction method as claimed in Claim 1, wherein said pile wing hole is formed during the process of lifting out the pile hole forming device after the pile hole has been formed.

40. The construction method as claimed in Claim 1, wherein said finished pile is a neat concrete pile.

41. The construction method as claimed in Claim 1, wherein said piles are arranged in rows to form a support and guard pile structure.

42. The construction method as claimed in Claimed 41, wherein the tops of the piles in said support and guard pile structure are connected through a connecting beam and the pile wings formed on individual piles.

43. A special equipment for carrying out the method as claimed in Claim 1, wherein said equipment comprises a pile-wing-hole forming device, and on said device there is provided a detector for detecting the mechanical properties of soil body of the ground when forming a pile wing hole with the device.

44. The equipment as claimed in Claim 43, wherein said detector is a sensor.

45. The equipment as claimed in Claim 44, wherein said sensor comprises a pressure head, said pressure head is connected to an actuating hydraulic cylinder, and said actuating hydraulic cylinder is connected to a pressure display.

46. The equipment as claimed in Claim 41, wherein said detector is



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a detecting instrument for friction resistance properties of the soil body.

47. The equipment as claimed in Claim 41, wherein said equipment further comprises a control system for said pile-wing-hole forming device, said system comprises a hydraulic unit and a computer monitoring system.

48. The equipment as claimed in Claim 47, wherein said hydraulic unit comprises a hydraulic pressure display.

49. The equipment as claimed in Claim 47, wherein said computer monitoring system comprises a data processing unit for converting relevant signals into digital signals and carrying out operations on the relevant signals, a display and a memory for the various digital signals, an operation keyboard, and an image display system for showing the actual forming conditions of a pile hole and pile wing holes.

50. The equipment as claimed in Claim 49, wherein said computer monitoring system comprises an control panel, and on said control panel there are provided a keyboard, a display, an audio amplifier, an image display showing the actual forming conditions of a pile hole and pile wing holes, a control rod for the pile-wing-hole forming device, and a printer.

51. The equipment as claimed in Claim 49, wherein said image display system is a night-vision observation system capable of detecting the forming quality of a dry hole, and said system comprises a color videocamera capable of taking pictures, a monitor for showing the pictures taken by the videocamera, a sealed sleeve for receiving said videocamera and a power source, an observation head, a light source for picture-taking, and a video recorder.

52. The equipment as claimed in Claim 51, wherein said observation head comprises a horizontal observation head for observing the hole wall



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and a vertical observation head for observing hole bottom.

53. The equipment as claimed in Claim 49, wherein said image display system comprises an ultrasonic scanner for detecting the forming quality of a wet hole.

54. The equipment as claimed in Claim 47, wherein said computer monitoring system comprises an unit for controlling the operation of the pile-wing-hole forming device.

55. The equipment as claimed in Claim 45, wherein said pile-wing-hole forming device is of a hydraulically actuated type which comprises a bow-type compression mechanism for forming the pile wing holes, the extending portion of said bow-type compression mechanism constitutes the pressure head for said detector.

56. The equipment as claimed in Claim 43, wherein said detector is a detecting instrument for the friction resistance properties of the soil body.

57. The equipment as claimed in Claim 43 or 45, wherein said pile-wing-hole forming device comprises a pile-wing-hole forming mechanism, the mechanism includes a first bow-type compressing arm and a second bow-type compressing arm, the ends of said first bow-type compressing arm and second bow-type compressing arm are hinged to each other, the other end of the first bow-type compressing arm is hinged to a first connecting member and the other end of the second bow-type compressing arm is hinged to a second connecting member; said first connecting member is rigidly connected to the end of a piston rod of an actuating hydraulic cylinder, and said second connecting member is rigidly connected to the end of the other piston rod of said actuating hydraulic cylinder; said two piston rods are disposed coaxially and move oppositely while working; and said actuating hydraulic cylinder includes



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two pistons which are disposed coaxially and parallelly and move oppositely while working, said two piston rods are rigidly connected to said two pistons respectively.

58. The equipment as claimed in Claim 43 or 45, wherein said pile-wing-hole forming device comprises a plurality of sets of pile-wing-hole forming mechanism, said sets of pile hole forming mechanism are arranged at intervals along the longitudinal and/or transverse directions of the equipment.

59 The equipment as claimed in Claim 43 or 45, wherein said pile-wing-hole forming device comprises a plurality of sets of pile-wing-hole forming mechanism, said sets of pile-wing-hole forming mechanism are arranged symmetrically relative to the longitudinal axis of the equipment.

60. The equipment as claimed in Claim 43 or 45, wherein said equipment comprises a pile hole forming device, said pile-wing-hole forming device is provided on said pile hole forming device.

61. The equipment as inclined in Claim 43, 45 or 60, wherein said pile-wing-hole forming device comprises a main support member on which there is fixed an driving gear and, and said device further comprise a pile-wing-hole forming mechanism, said mechanism includes a first bow-type compressing arm and a second bow-type compressing arm, one end of said first bow-type compressing arm is hinged to a driving rod driven by said driving gear, and the other and of said first bow-type compressing arm is hinged to one end of the second bow-type compressing arm, the other end of the second bow-type compressing arm is hinged to a first fixed member, the first fixed member is on one side of the hinge point of the first bow-type compressing arm and the driving rod and is on one side of the moving axis of the hinge point of the first and second bow-type compressing arms relative to the hinge point of the



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driving rod and the first bow-type compressing arm; said second fixed member is hinged to one end of a first branch plate, and the other end of the first branch plate is a free end; the inner side of the first branch plate abuts against the hinge portion of the first and second bow-type compressing arms, and is provided with a guide plate, on said guide plate there is formed a guide groove in the direction parallel to the first branch plate; the first and second bow-type compressing arms are hinged through a transversely movable axle, said guide groove permits said transversely movable axle to slide therein and extends towards the second bow-type compressing arm from the position where the transversely movable axle is located when it has not yet moved outwards transversely.

62. The equipment as claimed in Claim 43, 45 or 60, wherein said equipment comprises a main support member which is provided with an driving gear, and the equipment is further provided with a pile-wing-hole forming mechanism; said mechanism includes a first bow-type compressing arm and a second bow-type compressing arm; one end of said first bow-type compressing arm is hinged to a driving rod, and said driving rod is driven by said driving gear, the other end of said first bow-type compressing arm is hinged to one end of the second bow-type compressing arm, and the other end of the second bow-type compressing arm is hinged to a fixed member which is fixed to the main support member; and the first bow-type compressing arm has a first branch plate integrally formed thereon, and the second bow-type compressing arm has a second branch plate integrally formed thereon.

63. The equipment as claimed in Claim 43, 45 or 60, wherein said equipment comprises a telescopic power compressing device which can linearly compresses the surrounding soil body of a pile hole wall



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downwards in a direction inclined relative to the pile hole axis.

64. The equipment as claimed in Claim 43, 45 or 60, wherein said equipment comprises a compressing member which can insert horizontally into the surrounding soil body of a pile hole wall, the member is connected with a driving gear, and thus it can compress the surrounding soil body of the hole wall downwards in a direction parallel to the pile hole axis when inserted into the surrounding soil body of the hole wall.

65. The equipment as claimed in Claim 43, wherein said equipment comprises a pile hole forming device, said device is an clay digger forming device.

66. The equipment as claimed in Claim 65, wherein said clay digger forming device is a submersible driller, an jet soil-flushing hole-forming device, a bit driller, an overall casing driller, a positive circulation driller, a counter circulation driller, a grab soil-removing device or a dipper soil-removing device.

67. The equipment as claimed in Claim 65, wherein said clay digger forming device is an auger driller which includes a drilling rod, said drilling rod is a hollow pipe and is provided with a pile-wing-hole forming device; and at the bottom of the hollow drilling rod there is formed a nozzle communicated therewith, through the nozzle pile body material or a wall-protection fluid is injected, and the top of the drilling rod is communicated with the supplying fluid of the injected material.

68. The equipment as claimed in Claim 43, wherein said equipment comprises a caterpillar running gear; a swivel table; and a driver's cab, a control system for the pile-wing-hole forming device on the swivel table; and a boom; the bottom of said boom is connected to the swivel table, and the branch hole and/or force-bearing plate slot forming device is



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suspended from the top of the boom through a suspension cable, said device is guided and fixed by a gripper block, and the rear end of said gripper block is connected with said swivel table.

69. The equipment as claimed in Claim 43, wherein said equipment comprises an control system for the pile-wing-hole forming device, which is placed on the ground and is separated from the pile-wing-hole forming device.

