

METHOD FOR BORING VERTICAL HOLE AND MACHINE THEREFOR

This invention relates to a method for boring a vertical hole in the ground and a machine useful in the practice of the method. More particularly, this invention relates to a method for boring a large-diameter vertical hole in the ground for the construction of a large-diameter concrete pile and a machine useful in the practice of the method.

As a prior art method for boring a large-diameter vertical hole in the ground to construct a concrete pile, the so-called method has heretofore been employed. Namely, a large-diameter vertical hole is bored by driving a large-diameter casing into the ground and digging out the earth in the casing by means of an excavator such as hammer grab or rotary bucket.

Dependence on such a conventional method tends to lead to a lowered work efficiency because difficulties are encountered in driving a large-diameter casing smoothly and accurately into the ground particularly where the ground has a large resistance to digging such as hard ground or the ground-digging power of the hammer grab, rotary bucket or the like is insufficient in some instances. The prior art casing methods are rather inconvenient to practice since two machines are required, one for driving a large-diameter casing into the ground and the other for lowering an excavator into the casing so as to dig out the earth in the thus-driven casing.

An object of this invention is to provide a method capable of boring a large-diameter hole efficiently and readily even in a ground having a large resistance to digging such as a hard ground and a machine useful in the practice of the method.

Another object of this invention is to provide a boring method allowing sure and easy collection and discharge of dug earth and a machine useful in the practice of the method.

5 A further object of this invention is to provide an excavator which can be mounted on a vehicle and operated safely and efficiently.

10 In one aspect of this invention, there is thus provided a method for boring a vertical hole in the ground by driving a large-diameter casing into the ground and digging out the earth in the casing, which method comprises driving the large-diameter casing into the ground while rotating the large diameter casing in one direction or alternately in both directions or rotating the large-diameter casing in a manner suitably combining both of the above modes of rotation; lowering, into the casing, a bucket-type digging unit which comprises a holder equipped with retainer blocks capable of interlocking with the inner circumferential wall of the casing and a vertically-movable, cylindrical, hollow bucket connected to the holder with their vertical axes registered, equipped with an openable closure and adapted to excavate earth; causing the retainer blocks to interlock with the inner circumferential wall of the casing so as fixedly to hold the bucket-type digging unit in the casing; opening the closure into the extension plane of the outer circumferential wall of the bucket and lowering the bucket further, thereby driving at least lower part of the closure into earth; and then closing the closure so as to trap earth in the bucket.

25 In another aspect of this invention, there is also provided a vertical hole boring machine which comprises, in combination, a rotating and driving-in unit for a large-diameter casing and a bucket-type digging unit; the rotating and driving-in unit comprising a cylindrical guide device for allowing the large-diameter casing to move up and down while being guided, a holding

device provided integrally with the guide device and adapted to hold the large-diameter casing in place by applying forces onto the outer circumferential wall of the casing, a power transmission device for rotating the cylindrical guide device by a motor, and a piston-cylinder device adapted to displace up and down a drive mechanism which includes the cylindrical guide device, the holding device provided integrally with the cylindrical guide device and the power transmission device; said bucket-type digging unit comprising a holder equipped with retainer blocks capable of interlocking the inner circumferential wall of the large-diameter casing, and a vertically movable, cylindrical, hollow bucket connected to the holder with their vertical axes registered, equipped with an openable closure and adapted to excavate earth; and the rotating and driving-in unit and bucket-type digging unit being arranged in such a way that the cylindrical guide device can be rotated by the motor through the power transmission device so as to rotate the large-diameter casing held by the holding device which is provided integrally with the cylindrical guide device, the thus-rotating large diameter casing can be driven into the ground by moving the drive mechanism downwardly by the piston-cylinder device, the bucket-type digging unit can be lowered into the thus-driven in large-diameter casing, the retainer blocks can be caused to interlock with the inner circumferential wall of the casing so as to fixedly hold the bucket-type digging unit in the large-diameter casing, and the closure can be opened into the extension plane of the outer circumferential wall of the bucket and the bucket can be lowered further, thereby driving at least lower part of the closure into earth and then closing the closure so as to trap earth in the bucket.

Certain embodiments of this invention will now be described with reference to the accompanying drawings in which:-

Figure 1A is a schematic side elevation of a rotating and driving-in unit for a large-diameter casing according to one embodiment

of the vertical hole boring machine of this invention, which rotating and driving-in unit may be employed to practice the method of this invention;

Figure 1B is a top plan view of a drive mechanism which makes up
5 the essential part of the rotating and driving-in unit of Figure 1A;

Figure 1C is a partially-cut away side elevation of the drive mechanism of Figure 1B;

Figure 2A is a partially-cut away side view of an example of a
10 device for holding a large-diameter casing;

Figure 2B is a cross-sectional view taken along line A-A of Figure 2A;

Figure 3 is a fragmentary cross-sectional view of another example of the device for holding a large-diameter casing;

15 Figure 4 illustrates the principle of the rotating and driving-in unit for a large-diameter casing according to this invention;

Figure 5A is a vertical cross-sectional view of a bucket-type digging unit according to one embodiment of the vertical hole boring machine of this invention in which the bucket is in the retracted
20 position, which bucket-type digging unit may be employed to practice the method of this invention;

Figure 5B is a vertical cross-sectional view of the same bucket-type digging unit as shown in Figure 5A, in which the bucket is in the advanced position;

Figure 6A is a vertical cross-sectional view of a bucket-type digging unit according to another embodiment of the vertical hole boring machine of this invention in which the bucket is in the retracted position, which bucket-type digging unit may be employed to practice the method of this invention;

Figure 6B is a vertical cross-sectional view of the same bucket-type digging unit as shown in Figure 6A, in which the bucket is in the advanced position;

Figures 7A through 7D illustrate sequentially a vertical hole boring method according to one embodiment of this invention;

Figure 7A is a vertical cross-section showing how a large-diameter casing and screw auger, which is adapted to bore a small-diameter hole, are driven into the ground; Figure 7B is a cross-sectional view of the casing and screw auger which have been driven in the ground; Figure 7C is a vertical cross-section showing how the screw auger is pulled up; and Figure 7D is a cross-sectional view depicting how a bucket-type digging unit of this invention is lowered into the large-diameter casing and is operated to excavate the earth;

Figure 8A is a side elevation of the vertical hole boring machine according to this invention;

Figure 8B is a top plan view of the boring machine of Figure 8A;

Figure 9 is a cross-sectional view of turntables of the vertical hole boring machine illustrated in Figures 8A and 8B;

Figure 10A is a vertical cross-sectional view showing how a reinforcement cage is lowered into a casing;

Figure 10B is a vertical cross-section illustrating the way of placing concrete; and

Figure 10C is a vertical cross-sectional view depicting how the casing is pulled up.

5 Referring first to Figures 1A to 1C, numeral 1 indicates a vehicle including crawlers. A guide mechanism 3 such as a short leader is mounted upright on the vehicle 1 in such a way that it is tiltable by means of piston-cylinder devices 2. A drive mechanism 5 is slidably attached to the leader 3 via
10 bent brackets 4.

The drive mechanism 5 comprises motors 6, 6, power transmission device 7, cylindrical guide device 8 for a large diameter casing 15 which guide device 8 is rotated by the power transmission device 7, and a holding device 9 for the large-diameter casing which holding device 9 is fixed on the cylindrical guide device 8. The drive mechanism 5 is coupled with piston-cylinder devices 10, 10 provided with the vehicle 1 and is displaceable up and down along the leader 3. Incidentally, numeral 11 designates a support such as jack or the like, provided with
20 the vehicle 1.

The above drive mechanism 5 will next be described in further detail with reference to Figure 1C. The drive shaft 6a of each of the motors 6, 6 is connected to a high-speed gear unit 12 such as, for example, a planetary gear unit formed of a planetary
25 gear 12a and rotary disc 12b. The rotary output shaft 12c of the high-speed gear unit 12 is coupled to a low-speed gear unit 13, and a rotary gear 14 fixed on the outer circumferential wall of the cylindrical guide device 8 is then connected to the low-speed gear unit 13.

The cylindrical guide device 8 has substantially the same inner diameter as the outer diameter of the casing 15 into which the guide device 8 is to be inserted. The cylindrical guide device 8 defines tapered flanges 8a respectively at both upper and lower edges thereof to facilitate the insertion or extraction of the casing 15.

A rotary cylinder 16 is provided pendant from the rotary gear 14 or cylindrical guide device 8. The holding device 9 is provided at a lower part of the cylinder 16 so as to apply forces onto the side wall of the casing 15 and hold the casing 15 in place.

The cylindrical guide device 8 and cylinder 16 are rotatably mounted on a casing 5a of the drive mechanism 5 with bearings 17, 17' interposed therebetween.

The holding device 9 may be constructed in various ways. An example of the construction of the holding device 9 will now be described with reference to Figures 2A and 2B. Namely, the holding device 9 may be constructed by swingably connecting one end of arms 19a, 19b, 19c, 19d, which are equipped respectively with bent pads 18a, 18b, 18c, 18d defining arcuate faces that, when combined, conform the outer circumferential wall of the casing 15, to the casing 9a of the holding device 9 by means of pins 20, coupling the other end of, for example, the arms 19a, 19d with a jack 21a and the other end of the arms 19b, 19c to a jack 21b by means of pins 22 so that the bent pads 18a, 18b, 18c, 18d are arranged in abutment against and conformity with the outer circumferential wall of the casing 15 and, owing to expansion or contraction of the jacks 21a, 21b, the arcuate faces of the bent pads 18a, 18b, 18c, 18d may simultaneously apply forces in four directions onto the side wall of the casing 15 so as to hold the casing 15 in place or may be concurrently

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set back from the side wall of the casing 15.

In Figure 2A, numeral 23 indicates a cross member provided above the casing 9a of the holding device 9 and integrally with the casing 9a. The cross member 23 may be detachably connected,
5 for example, to the cylinder 16 shown in Figure 1C.

Another example of the holding device 9 is illustrated in Figure 3. Namely, parts of the cylinder 16 are outwardly projected. In each of the thus-projected parts 16a, a jack 24 and a
10 sliding press 25 slidably displaced by the jack 24 and equipped with an arcuate face 25a conforming in shape with the corresponding outer circumferential wall portion of the casing 15 are housed.

Next, the operation and effect of the above rotating and driving-in unit will be described with reference to Figure 4 which illustrates the principle of the unit.

15 The casing 15 is a hollow cylinder formed, for example, of a steel pipe or the like and is generally provided with a cutting edge 15a along its lower extremity. The casing 15 is caused to extend centrally through the cylindrical guide device 8 and holding device 9 to a point below the drive mechanism 5. Upon
20 applying forces against the side wall of the casing 15 and holding the casing 15 in place by means of the holding device 9, the casing 19 has been set on the rotating and driving-in unit.

The motors 6, 6 are then actuated and their rotary outputs are transmitted to the guide device 8 via the high-speed gear unit
25 12 and low-speed gear unit 13 to rotate the guide device 8, thereby rotating the holding device 9 provided integrally with the guide device 8.

As a result, the casing 15 fixedly held by the holding device 9 is then caused to rotate. Upon contracting the piston-cylinder devices 10, 10 illustrated in Figures 1A and 1B, the casing 15 is driven into the ground.

- 5 Here, the motors 6, 6 may be operated by alternating the directions of their rotation frequently so as to cause the casing 15 to shake instead of undergoing a full rotation. This permits to drive the casing 15 more efficiently into the ground when the ground is hard.
- 10 Where the casing 15 is shaken as mentioned above, a heavy load is exerted to the transmission mechanisms between the motors 6, 6 and the casing 15. Owing to the adoption of high-speed gear unit 12, such a heavy load may however be smoothly transmitted.
- 15 When the casing 15 has been driven into the ground by a distance equivalent to the one stroke of the piston-cylinder devices 10, 10, it is necessary to release the holding device 9 from the casing 15 and expand the piston-cylinder devices 10, 10 so as to raise the drive mechanism 5 as a whole along the leader 3. Upon fixing the holding device 9 on the casing 20 15 again, it is now ready to resume the driving-in operation of the casing 15.

25 The earth in the casing 15 may be dug out by, for example, lowering the below-described bucket-type digging unit suspended as a separate equipment from a crane or the like into the casing 15 through its upper opening, scooping up the earth and elevating it to the ground surface.

When the majority of the casing 15 has been driven into the ground, another casing is lowered from a point above the drive

mechanism 5 while holding the casing 15 in place by the holding device 9. Both casings are then jointed, for example, welded together.

5 As has been described, the rotating and driving-in unit of the present invention can exhibit the following effects because the casing guide device is rotatably connected to the motors through high-speed gear unit, the guide device is attached to the casing-holding device, and these devices are displaceable up and down along the guide mechanism such as
10 the leader mounted on the vehicle.

(1) The casing may be continuously rotated or shaken, thereby making it possible to drive the casing in a manner suitable to the state of the ground;

15 (2) The rotating and driving-in unit enjoys a high degree of durability even when the casing is shaken, owing to the adoption of the high-speed gear unit;

(3) The rotating and driving-in unit assures a high degree of driving-in accuracy because the casing is driven into the ground while guided by the cylindrical guide device;
20 and new casings may be readily added if they are supported by the guide device and held in place by the holding device; and

(4) The rotating and driving-in unit permits to mount a short leader on the vehicle because the holding device can
25 hold the casing at different positions on the casing as the casing is driven in, whereby enjoying good stability of the vehicle even during its operation.

After driving the large-diameter casing into the ground while rotating same, as mentioned above, a bucket-type digging unit is lowered into the large-diameter casing so as to excavate the earth in the large-diameter casing.

5 One embodiment of the bucket-type digging unit is shown in Figure 5A. A bucket-driving hydraulic cylinder 28 is vertically fixed on the lower wall of a cylindrical hollow holder 26. The upper wall of a cylindrical bucket 27 is fixedly secured to the lower extremity of a ram 29 of the cylinder 28. Thus, the holder 26 and bucket 27 are
10 connected together with their axes registered.

In the holder 26, brackets 31, 31 are provided in the cylindrical body 30 by providing them pendant from the upper wall of the cylindrical hollow holder 26. Retainer blocks 32, 32 are supported, in a radially swingable fashion, at one end thereof on their
15 corresponding brackets 31, 31 by means of pins 33, 33, thereby allowing the abutment faces 34, 34 of the retainer blocks 32, 32 to outwardly project through their corresponding slots 35, 35 formed through the circumferential wall of the body 30. On the other hand, the lower extremity of a ram 37 of a hydraulic cylinder 36, which
20 is adapted to drive the retainer blocks 32, 32, is fixedly attached to the lower wall of the body 30 so as to position the cylinder 36 between both retainer blocks 32, 32. On the outer circumferential wall of a cover 38 fitted over the cylinder 36, there are provided bevelled cams 39, 39 which are in contact with the inner edges of
25 their corresponding retainer blocks 32, 32. Thus, by expanding or contracting the cylinder 36, the retainer blocks 32, 32 may be advanced outwardly through the outer peripheral wall of the body 30 or retreated inwardly therethrough owing to the provision of the cams 39, 39.

The bucket 27 is a cylinder having a diameter somewhat larger than that of the holder 26. A hydraulic motor 41 is disposed in a housing 40 formed in an upper part of the bucket 27 and being open downwardly. The opening of the housing 40 is closed with a lid 42. The drive shaft of the hydraulic motor 41 extends into the interior of the bucket 27. A screw 43 is placed with its shaft aligned with the drive shaft of the hydraulic motor 41 and connected to the lower extremity of the drive shaft. The screw 43 extends downwardly to a point somewhat lower than the opening lower extremity of the bucket 27 and digging edges 44 are provided along the lower edge of the helical ribbon of the screw 43.

At the opening lower extremity of the bucket 27, closure halves 45, 45 are openably provided by means of hinges 46, 46 so as to form a cone-shaped cap when closed. As opening and closing drive means for the closure halves 45, 45, hydraulic cylinders 47, 47 are fixedly disposed on the upper surface of the upper wall of the bucket 27 and along the circumferential wall of the same bucket 27. Rams 48, 48 of the hydraulic cylinders 47, 47 are connected to connector rods 49, 49, the lower extremities of which rods 49, 49 are in turn coupled to their corresponding closure halves 45, 45 at locations adjacent to hinges 46, 46. Thus, when the closure halves 45, 45 are opened owing to the expansion of the cylinder 47, 47, the closure halves 45, 45 assume positions practically in the extension plane of the outer circumferential wall of the bucket 27 as indicated by two chain-dot lines in Figure 5A.

The operation of the above bucket-type digging unit will next be described together with its effects. As shown by two chain-dot lines in Figure 5B, a large-diameter casing C of a steel pipe is driven in the ground F. A bucket-type digging

unit is then suspended by a wire W from a crane or the like. The closure halves 45, 45 are first of all opened by expanding the opening and closing cylinders 47, 47 for the closure halves 45, 45. While maintaining the above state, the
5 digging unit is then lowered into the casing C until the closure halves 45, 45 are brought into contact with the earth. Then, retainer blocks 32, 32 are outwardly advanced by expanding the cylinder 36 which is adapted to drive the retainer blocks 32, 32, thereby allowing the abutment faces 34, 34 to interlock
10 with the inner circumferential wall of the casing C. Thereafter, the hydraulic motor 41 is actuated to rotate the screw 43. Then, the cylinder 28 is expanded to slowly lower the bucket 27. As the bucket 27 is lowered, the bucket 27 is driven into the earth along the inner circumferential wall of
15 the casing C while using the closure halves 45, 45 as its leading edges so as to direct the earth to the opening of the bucket 27. At the same time, the earth thus directed to the opening of the bucket 27 is dug by the digging edges 44 of the rotary screw 43 and then transported to an upper part in
20 the bucket 27 by the rotary screw 43.

Upon completion of one stroke of the bucket-driving operation, the closure halves 45, 45 are closed by contracting the cylinders 47, 47. Then, the cylinder 36 is contracted to release the interlocking between the retainer blocks 32, 32
25 and the casing C. The bucket-type digging unit is thereafter pulled out of the casing C and carried to an earth-ejecting site, where the closure halves 45, 45 are opened and the screw 43 is rotated in the opposite direction so as to discharge the earth from the bucket 27. After completion of the earth
30 discharge operation, the bucket-type digging unit is again lowered into the casing C to repeat the same operation as described above.

Since the bucket is driven into the ground and the earth is directed to the opening of the bucket, the earth can be transported to an upper part in the bucket by the rotary screw and the earth can be readily brought into the bucket without any fault.

- 5 Another embodiment of the bucket-type digging unit will now be described with reference to Figure 6A and 6B.

Similar to the bucket-type digging unit as shown in Figures 5A and 5B, the bucket-type digging unit is formed of a cylindrical hollow holder 50 and a cylindrical hollow bucket 51 coupled with the holder 50 with their axes aligned. The bucket 51 is displaceable up and down relative to the holder 50. In the holder 50, brackets 53, 53 are provided pendant from the upper wall of the cylindrical hollow body 52. The retainer blocks 54, 54 are each supported at one end thereof, in a radially swingable fashion, on their corresponding brackets 53, 53 by means of pins 55, 55 so as to permit the abutment faces 56, 56 of the retainer blocks 54, 54 to advance outwardly through their respective slots 57, 57 formed through the circumferential wall of the body 52. On the other hand, the lower extremity of a ram 59 of a hydraulic cylinder 58, which is adapted to drive the retainer blocks 54, 54, is fixed on the centre of the lower wall of the body 52 so that the cylinder 58 is positioned between the retainer blocks 54, 54. On the outer circumferential wall of a cover 60 fitted over the cylinder 58, bevelled cams 61, 61 are provided with their bevelled faces in contact with the inner edges of their corresponding retainer blocks 54, 54 so that the bevelled cams 61, 61 may be able to advance the retainer blocks 54, 54 outwardly through the outer circumferential wall of the body 52.

In an upper part of the bucket 51, there is formed a hollow chamber 62 having a vertically extending channel 63 along

its vertical axis. Closure halves 64, 64 are openably provided at the opening lower extremity of the bucket 51 by means of hinges 65, 65. The closure halves 64, 64 forms a cone-shaped cap when closed. An actuation rod 66 is vertically fixed on the centre of the lower wall of the holder 50. The actuation rod 66 extends slidably through the channel 63 of the bucket 51 into the interior of the bucket 51. An earth-ejecting disc 67 of such a size as permitting its free vertical movement in the bucket 51 is fixedly attached to the lower extremity of the actuation rod 66. On the other hand, rams 69, 69 of bucket-driving hydraulic cylinders 68, 68 vertically fixed on the lower surface of the lower wall of the holder 50 with the actuation rod 66 interposed between the hydraulic cylinders 68, 68 are fixedly connected to the upper surface of the upper wall of the hollow chamber 62 of the bucket 61. Accordingly, when expanding the bucket-driving hydraulic cylinders 68, 68 to lower the bucket 51 while holding the holder at a predetermined position, the earth-ejecting disc 67 relatively ascends in the bucket 51 in proportion to the extent of the descent of the bucket 51 and the intrabucket space below the earth-ejecting disc 67 is thus increased. On the other hand, when the bucket 51 is raised by contracting the cylinders 68, 68, the earth-ejecting disc 67 is caused to relatively lower in the bucket 51 in proportion to the extent of the ascent of the bucket 51, thereby decreasing the intrabucket space below the earth-ejecting disc 67. The length of the actuation rod 66 is designed in such a manner that the earth-ejecting disc 67 approaches the lower extremity of the bucket 51 when the cylinders 68, 68 are fully contracted and the upper extremity of the bucket 51 when the cylinders 68, 68 are fully expanded.

Numerical 70 indicates a cylindrical outer cover extending downwardly from the lower extremity of the holder 50 with

their vertical axes registered. On the other hand, numeral 71 designates a cylindrical inner cover which extends upwardly from the upper extremity of the bucket 51 with their axes aligned. The cylindrical inner cover 71 is slidably inserted in the outer cover 70.

The closure halves 64, 64 define curved surfaces which, when the closure halves 64, 64 are opened to the extension plane of the outer circumferential wall of the bucket 51, substantially conform with the curved surfaces extended from the outer circumferential wall of the bucket 51; and, when the closure halves 64, 64 are closed to close the opening lower extremity of the bucket 51, are put together practically into a cone shape. As opening and closing means for the closure halves 64, 64, hydraulic cylinders 72, 72 are fixed along the inner circumferential wall of the hollow chamber 62 with their axes parallel to the vertical axis of the actuation rod 66. Rams 73, 73 of the hydraulic cylinders 72, 72 are coupled by pins with connector rods 74, 74, the lower extremity of which connector rods 74, 74 are connected by pins to the closure halves 64, 64 at locations adjacent to hinges 65, 65.

The operation of the above bucket-type digging unit will now be described together with its effects. As shown by two chain-dot lines in Figure 6B, a large-diameter casing C formed of a steel pipe is driven in the ground F. Then, the bucket-type digging unit is suspended by a wire W of a crane or the like. The closure halves 64, 64 are first of all opened to the extension plane of the outer circumferential wall of the bucket 51 by expanding the cylinder 72, 72. While maintaining the closure halves 64, 64 in the above state, the bucket-type digging unit is lowered into the casing C until the closure halves 64, 64 are brought into contact with the earth. By expanding the cylinder 58, the retainer blocks 54, 54 are

caused to advance outwardly, thereby interlocking at their abutment faces 56, 56 with the inner circumferential wall of the casing C. Then, the bucket 51 is slowly lowered by expanding the bucket-driving cylinders 68, 68. As the bucket 51 descends, the buckets are driven into the earth substantially along the inner circumferential wall of the casing C while making use of the opened closure halves 64, 64 as leading penetrating edges. This permits the earth to be taken into the bucket 51. At the same time, the earth-ejecting disc 67 is raised relative to the bucket 51 and the intrabucket space below the disc 67 is increased. The thus-introduced earth is held in the intrabucket space. Upon completion of one stroke of the bucket-driving operation, the closure halves 64, 64 are closed by contracting the cylinder 72, 72 and the interlocking between the retainer blocks 54, 54 and the inner circumferential wall of the casing is released by contracting the cylinder 58. Thereafter, the bucket-type digging unit is pulled out of the casing C by means of the wire W and then transported to an earth-ejecting site, where the closure halves 64, 64 are opened and the earth-ejecting disc 67 is lowered relative to the bucket 51 by contracting the cylinders 68, 68, thereby pushing out the earth from the bucket 51 by the earth-ejecting disc 67.

Upon completion of the earth-ejecting operation, the bucket-type digging unit is again lowered into the casing C to repeat the same operation as mentioned above.

When introducing the earth into the bucket by driving the bucket into the earth, the intrabucket space is sufficiently enlarged in order to facilitate the introduction of the earth. On the other hand, the thus-introduced earth can be discharged in its entirety by causing the earth-ejecting disc to lower relatively in the bucket.

However, the excavation ability of the above bucket-type digging unit is lowered when applied to a ground having a large resistance to digging such as a hard ground, because the digging power of the above digging unit is reduced compared with ordinary ground.

Where the ground has such a high resistance to digging, it is preferred to form a vertical hole in accordance with the following boring method.

As illustrated in Figure 7A by way of example, a large-diameter casing 75 of 150 cm in diameter is vertically driven into the ground E while applying a static load into the upper extremity thereof and continuously rotating the casing 75 counter-clockwise. At the same time, a pilot hole 77 of a small diameter is progressively bored along the vertical axis of the casing 75 by means of a screw auger 76 having a boring diameter about one half of the inner diameter of the casing 75. Since the boring of the pilot hole 77 in the casing 75 proceeds with the driving-in operation of the casing 75, the earth in the casing 75 becomes loose, whereby facilitating both driving-in operation of the casing 75 and boring operation of the pilot hole. It is preferable to rotate the screw auger 76 in a direction opposite to the casing 75. Excavated earth is elevated upwardly and discharged by the screw auger 76.

When the casing 75 has been driven in to a predetermined depth and the pilot hole 77 has been bored to substantially the same depth as the driven-in depth of the casing 75 (see, Figure 7B), the screw auger 76 is upwardly pulled out while stopping its rotation as illustrated in Figure 7C so as to hold the excavated earth by the helical ribbons and discharge it upwardly. Thus, the pilot hole 77 vertically and coaxially extending with the casing 75 is exposed with unexcavated earth

78 having a ring-shaped transverse cross-section left between the pilot hole 77 and the inner circumferential wall of the casing 75.

5 Thereafter, a bucket-type digging unit 79 as shown in Figures 5A and 5B or Figures 6A and 6B is lowered, as illustrated in Figure 7D, through the upper opening of the casing 75 to dig out the unexcavated earth 78 in the casing 75.

10 When digging out the unexcavated earth 78 as mentioned above, the unexcavated earth 78 has already become loose as described above and is formed into a ring-like shape in transverse cross-section around the pilot hole 77. The unexcavated earth 78 is readily broken down and dug out. A vertical hole of a predetermined large diameter is thus formed in the casing 75 by excavating and discharging the unexcavated earth 78 in its
15 entirety from the casing 75.

20 According to the above boring method, the earth in the casing becomes loose since the pilot hole is bored in the casing simultaneously with the driving-in operation of the casing. Thus, the casing can be readily driven into the ground while boring the pilot hole. Furthermore, the unexcavated earth in the casing can be easily dug out because the unexcavated earth has already been isolated from the surrounding earth by the casing into loose earth and is susceptible to collapse owing to the pilot hole formed therethrough.

25 In a vertical hole boring method of driving a casing into the ground and, at the same time, digging out the earth in the casing by such an excavator as bucket or the like to a site on the ground, a driving unit is provided generally as a separate equipment for casings of steel pipes. Thus, it is

necessary to operate an earth excavation bucket in a suspended state by using a separate crane or the like. Such inconvenience can be solved by such a boring machine as depicted in Figures 8A and 8B.

- 5 In Figure 8A, numeral 82 indicates a wheel frame provided with a crawler 83 as moving means. Instead of the crawler 83, wheels equipped with pneumatic tires may be attached to the wheel frame 82 as moving means. A base frame 85 is rotatably mounted on the wheel frame 82 via a first turntable 84 disposed
- 10 substantially at the centre of the wheel frame 82. In Figures 8A and 8B, numerals 86, 86 designate fixing jacks provided at the front and rear parts of the base frame 85. Indicated at numeral 87 is a counter weight mounted on the rear part of the base frame 85.
- 15 A leader mast 89 is mounted on a front part of the base frame 85, tiltably by piston-cylinders 88. A rotating and driving unit 90 for a casing 91 is provided displaceably up and down along the leader mast 89.
- 20 Designated at numeral 92 are bent brackets connecting the rotating and driving unit 90 to the leader mast 89. Numeral 93 indicates an adjustment cylinder suspended at one end thereof from the leader mast 89. The adjustment cylinder 93 serves as a lock when centring the bucket-type digging unit or moving the boring machine. Numeral 94 indicates a rotary
- 25 chuck adapted to hold the casing 91 along the entire circumference on the outer circumferential wall thereof and to rotate the casing 91. Designated at numeral 95 are hydraulic cylinders for pulling out the casing 91. Numeral 96 designates a hydraulic unit communicated with various jacks,
- 30 winches and hydraulic cylinders. Incidentally the casing 91 is a steel pipe commonly used as a Benoto pipe and is equipped

with a digging edge 91a along its lower edge.

An auxiliary frame 98 is rotatably mounted on the base frame 85 through a second turntable 97.

Reference is now made to Figure 9. First and second turntables 84, 97 are provided respectively with inner rims 84b, 97b and outer rims 84a, 97a with bearings interposed therebetween. Drive gears 84d, 97d of hydraulic motors 84c, 97c, provided at the sides of the rims 84a, 97a are meshed with the circumferential gears of the inner rims 84b, 97b. The boring machine can have good stability when the axes of the turntable 84, 97 are aligned to each other as shown in Figure 9.

As another embodiment, the axis of the second turntable 97 may be shifted rearwardly from the axis of the first turntable 84 so as to make a space in the front of the base frame 85 for storing the leader mast 89 when it is not in use and kept in a laid-down position.

A crane boom 99 is pivotally mounted on the auxiliary frame 98 and a bucket-type digging unit 100 is suspended from the upper extremity of the crane 99. The bucket-type digging unit 100 has such dimensions as allowing its lowering into the casing 91 through its upper opening. The bucket-type digging unit 100 has such an internal mechanism as shown in Figure 5A or 6A and its lower end can be opened as jaws.

On the auxiliary frame 98, there are additionally mounted a drive winch 101 for the bucket-type digging unit 100, a hydraulical cylinder 102 for raising and lowering the crane boom 99, a hose reel 103 for hydraulic hoses, electric cables and the like, and a counter weight 104. It is desirous to interlock the winch 101 and hose reel 103.

Now, the operation and effect of the boring machine shown in Figures 8A, 8B and 9 will be described. To move the machine in its entirety, it is necessary to drive the crawlers 83. When the machine is moved to a desired position, the base frame 85 is

5 suitably turned relative to the wheel frame 82 using the turntable 84, thereby centring the digging edge 91a of the casing 91 set on the rotating and driving unit 90 at an intended digging position on the ground. Furthermore, the jacks 86, 86 are expanded to fixedly support the base frame 85 on the ground.

10 Upon actuating the rotary chuck 94 of the rotating and driving unit 90 and rotating the casing 91, the digging edge 91a excavates the ground and the casing 91 is gradually driven into the ground. At the same time, the crane boom 99 is suitably pivoted and the bucket-type digging unit 100, suspended from the crane 99, is

15 lowered into the casing 91 through its upper opening so as to elevate and discharge the excavated earth in the casing 91 to a suitable site on the ground.

The bucket-type digging unit 100 may be shifted horizontally by revolving the auxiliary frame 98 on the base frame 85 by

20 means of the turntable 97.

When the casing 91 is driven into the ground and the bent brackets of the rotating and driving unit 90 has been lowered to the lower extremity of the leader mast 89, it is necessary to release the interlocking of the rotary chuck 94, to pull the rotating and

25 driving unit 90 upwardly, and then to chuck the circumferential wall of the casing 91 again. When the first casing 91 has been driven in the ground to its upper extremity, another casing is then joined to the upper extremity of the first casing 91. In order to pull the casing 91 out of the ground, it is necessary

30 to raise the rotating and driving

unit 90 by the extraction cylinders 95 while leaving the chuck 94 fixed on the casing 91.

As shown in Figure 10A, a reinforcement 107 is then lowered into the vertical hole 106 through the upper opening of the casing 105. Concrete is thereafter placed in the vertical hole 106 through a tremie 108 as illustrated in Figure 10B. Before the thus-placed concrete has ~~not~~ hardened, the casing 105 is upwardly pulled out while being shaken as depicted in Figure 10C. Upon completion of the hardening of the concrete, a reinforced concrete pile of a large diameter has been constructed in the ground E.

When driving a casing into the ground while excavating the earth in the casing by digging means such as bucket or the like, the prior art machine required to use a separate crane or the like to operably suspend such digging means. As has been described above, the boring machine according to this invention does not need such a separate crane to suspend and operate the digging means. The digging means may be suspended and operated using a single vehicle which is equipped with a rotating and driving unit for casings. Therefore, the boring machine according to this invention has solved the irksome of operating two types of construction vehicles and can improve the efficiency of boring work of vertical holes while ensuring safe and prime operation.

Having now fully described the invention, it will be apparent to one of ordinary skill in the art that many changes and modifications can be made thereto without departing from the scope of the invention as set forth herein.



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CLAIMS

1. A method for boring a vertical hole in the ground by driving a large-diameter casing into the ground and digging out the earth in the casing, which method comprises driving the large-diameter casing into the ground while rotating the large-diameter casing in one direction or alternately in both directions or rotating the large-diameter casing in a manner suitably combining both of the above manners for rotation; lowering, into the casing, a bucket-type digging unit which comprises a holder equipped with retainer blocks capable of interlocking with the inner circumferential wall of the casing and a vertically-movable, cylindrical, hollow bucket connected to the holder with their vertical axes registered, equipped with an openable closure and adapted to excavate earth; causing the retainer blocks to interlock with the inner circumferential wall of the casing so as to fixedly hold the bucket-type digging unit in the casing; opening the closure into the extension plane of the outer circumferential wall of the bucket and lowering the bucket further, thereby driving at least lower part of the closure into earth; and then closing the closure so as to trap earth in the bucket.
2. A method according to Claim 1, wherein earth is excavated and carried into the bucket by means of a helical conveyor equipped with a digging edge and housed in the bucket.
3. A method according to Claim 1, wherein the large-diameter casing is driven into the ground while simultaneously boring a small-diameter vertical hole through the earth in the large-diameter casing.



4. A method according to Claim 3, wherein the small diameter vertical hole is bored by means of a screw auger.
5. A method according to Claim 1 and substantially as hereinbefore described with reference to Figures 1 to 10 of the accompanying drawings.
6. A vertical hole boring machine comprising, in combination, a rotating and driving-in unit for a large-diameter casing and a bucket-type digging unit; the rotating and driving-in unit comprising a cylindrical guide device for allowing the large-diameter casing to move up and down while being guided, a holding device provided integrally with the guide device and adapted to hold the large-diameter casing in place by applying forces onto the outer circumferential wall of the casing, a power transmission device for rotating the cylindrical guide device by a motor, and a piston-cylinder device adapted to displace up and down a drive mechanism which includes the cylindrical guide device, the holding device provided integrally with the cylindrical guide device and the power transmission device; said bucket-type digging unit comprising a holder equipped with retainer blocks capable of interlocking the inner circumferential wall of the large-diameter casing, and a vertically-movable, cylindrical, hollow bucket connected to the holder with their vertical axes registered, equipped with an openable closure and adapted to excavate earth; and the rotating and driving-in unit and bucket-type digging unit being arranged in such a way that the cylindrical guide device can be rotated by the motor through the power transmission device so as to rotate the large-diameter casing held by the holding device which is provided integrally with the



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5 cylindrical guide device, the thus-rotated large-diameter casing can be driven into the ground by moving the drive mechanism downwardly by the piston-cylinder device, the bucket-type digging unit can be lowered into the thus-driven in large-diameter casing, the retainer blocks can be caused to interlock with the inner circumferential wall of the casing so as to fixedly hold the bucket-type digging unit in the large-diameter casing, and the closure can be opened into the extension plane of the outer circumferential wall of the bucket and the bucket can be lowered further, thereby driving at least lower part of the closure into earth and then closing so as to trap earth in the bucket.

15 7. A vertical hole boring machine as claimed in Claim 6, wherein the power transmission device comprises a high-speed gear unit for transmitting the rotation of the motor, a low-speed gear unit coupled with the high-speed gear unit through a rotary shaft and a further gear unit fixedly mounted on the cylindrical guide device and connected to the low-speed gear unit, thereby transmitting the rotation of the motor to the cylindrical guide device through the high-speed gear unit, 20 low-speed gear unit and further gear unit and thus rotating the large-diameter casing.

25 8. A vertical hole boring machine as claimed in Claim 6, wherein the machine is further provided with a guide mechanism for allowing the drive mechanism to move up and down while being guided, and the guide mechanism and piston-cylinder device, which is adapted to displace up and down the drive mechanism, are mounted on the deck of a vehicle.

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- 5 9. A vertical hole boring machine as claimed in Claim 6, wherein the rotating and driving-in unit for the large-diameter casing is mounted on a base frame which is in turn mounted on a vehicle through a turntable, and the bucket-type digging unit to be lowered into the large-diameter casing is suspended from a pivotally movable boom mounted on an auxiliary frame which is in turn mounted on the base frame through another turntable.
- 10 10. A vertical hole boring machine as claimed in Claim 6, wherein a helical conveyor equipped with a digging edge is further provided in the bucket-type digging unit.
- 15 11. A vertical hole boring machine as claimed in Claim 6, wherein an earth-ejecting disc attached to an actuation rod, which is fixed at one end thereof to the holder, is provided in the bucket of the bucket-type digging unit.
- 20 12. A vertical hole boring machine as claimed in Claim 6 and substantially as hereinbefore described with reference to Figures 1 to 10 of the accompanying drawings.
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