DESCRIPTION

DRILLING SYSTEM AND DRILLING METHOD

TECHNICAL FIELD

[0001]

The present invention relates to a drilling system and drilling method using a casing and a hammer inserted in the casing, and relates more specifically to a drilling system and drilling method capable of further improving workability to efficiently drill a vertical hole in hard ground.

BACKGROUND ART

[0002]

A down-the-hole-hammer method has been known in which a vertical striking force is applied to a hammer inserted in a casing with the pressure of air while the casing and the hammer are rotationally driven with a driving motor or the like to drill the ground (see Patent Document 1, for example).

[0003]

In the method proposed in Patent Document 1, a sleeve body inserted in the casing is mounted on mount portions protruding from the inner side of the casing, and a weight with the sleeve body suspended thereon is moved downward to move liners outward in the rod radial direction and press the liners against the inner peripheral surface of the casing. A hammer rod inserted in the casing and the casing are integrated via the liners thus moved radially outward and, in this state, the casing is rotationally driven with a rotationally driving apparatus. In this way, a vertical hole can be drilled with casing bits and hammer bits. To drill the ground deeper, the hammer rod may simply be moved downward, and another hammer rod does not need to be added. This enables efficient drilling of a vertical

hole.

[0004]

However, the difference between the inner diameter of the casing and the outer diameter of the sleeve body is relatively small. Thus, in order to insert the sleeve body suspended by a crane into the casing along with the hammer and the hammer rod, accurate positioning is necessary. Accordingly, the insertion requires some time. Moreover, if unwanted obstacles such as crushed stones get in between upper wedge pieces and lower wedge pieces that press the liners, the liners cannot make the expanding and contrasting movement smoothly. Furthermore, if a hose connected to the hammer rod cannot be smoothly fed toward and pulled away from the casing according to the vertical movement of the hammer rod, troubles such as impeding the movement of the hammer rod and damaging the hose occur. Thus, there is still room for improvement to further improve workability to efficiently drill a vertical hole in hard ground.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0005]

Patent Document 1: Japanese patent application Kokai publication No. 2019-78123

SUMMARY

[0006]

This present disclosure provides a drilling system and drilling method capable of further improving workability to efficiently drill a vertical hole in hard ground.

[0007]

In one aspect, a drilling system according to the present disclosure is a drilling system including: a casing having a casing bit at a lower end portion thereof; a rotationally driving apparatus which holds an outer peripheral surface of this casing and rotationally drives the casing; a hammer having a hammer bit at a lower end portion thereof; a hammer rod to a lower end of which this hammer is attached and which is inserted in the casing; a weight and sleeve body inserted over the hammer rod inside the casing and restricted from rotating in a rod circumferential direction and being movable in a vertical direction; a liner placed on the weight or the sleeve body and being movable in a rod radial direction between an outer peripheral surface of the hammer rod and an inner peripheral surface of the casing; a mount portion which protrudes from an inner side of the casing and on which the sleeve body is mounted; an upper wedge piece protruding downward from the weight; a lower wedge piece placed on an inner side of the liner in the rod radial direction; and a hose connected to the hammer rod, the drilling system being such that the sleeve body is placed in a state of being suspended downward from the weight, the weight is suspendable from the hammer rod from an intermediate position on the hammer rod in the vertical direction, and as the weight moves downward relative to the sleeve body mounted on the mount portion, the upper wedge piece pushes the lower wedge piece, thereby making the liner move outward in the rod radial direction and press the inner peripheral surface of the casing, and in this state the casing is rotationally driven by the rotationally driving apparatus, so that the casing and the hammer are rotationally driven together, while a vertical striking force is applied to the

hammer with air supplied through the hose to thereby drill ground with the casing bit and the hammer bit, the drilling system characterized in that a plurality of the mount portions are disposed so as to be spaced in a circumferential direction of the casing, and the drilling system comprises: a plurality of insertion guides having an inclined portion protruding downward from a flange portion at a lower end of the sleeve body and inclined toward a tube axis of the sleeve body, and disposed on a peripheral edge portion of a lower end of the flange portion so as to be spaced in the circumferential direction; a wedge piece cover isolating the upper wedge piece and the lower wedge piece from an external space; and a hose holder suspended from a crane and holding the hose such that the hose is movable in a hose longitudinal direction.

[0008]

In another aspect, a drilling method according to the present disclosure is a drilling method including: inserting a hammer rod with a hammer attached to a lower end thereof into a casing, the hammer having a hammer bit at a lower end portion thereof, bringing a weight and sleeve body inserted over the hammer rod inside the casing into a state of being restricted from rotating in a rod circumferential direction and being movable in a vertical direction, placing a liner on the weight or the sleeve body, the liner being movable in a rod radial direction between an outer peripheral surface of the hammer rod and an inner peripheral surface of the casing, providing an upper wedge piece protruding downward from the weight and a lower wedge piece placed on an inner side of the liner in the rod radial direction, placing the sleeve body in a state of being suspended downward from the weight, rendering the weight

suspendable from the

hammer rod from an intermediate position on the hammer rod in the vertical direction, moving the weight downward relative to the sleeve body mounted on a mount portion protruding from an inner side of the casing to thereby make the upper wedge piece push the lower wedge piece, thereby making the liner move outward in the rod radial direction and press the inner peripheral surface of the casing, and rotationally driving the casing and the hammer together with a rotationally driving apparatus holding an outer peripheral surface of the casing while applying a vertical striking force to the hammer with air supplied through a hose connected to the hammer rod to thereby drill ground with a casing bit provided at a lower end portion of the casing and the hammer bit provided at the lower end portion of the hammer, the drilling method characterized in that it includes: disposing a plurality of the mount portions such that the mount portions are spaced in a circumferential direction of the casing; and designing a specification such that a plurality of insertion guides are disposed on a peripheral edge portion of a lower end of a flange portion at a lower end of the sleeve body so as to be spaced in the circumferential direction, each of the insertion guides having an inclined portion protruding downward from the flange portion and inclined toward a tube axis of the sleeve body; and drilling the ground with the upper wedge piece and the lower wedge piece isolated from an external space by a wedge piece cover and with the hose held so as to be movable in a hose longitudinal direction by a hose holder suspended from a crane.

[0009]

In one example, the hammer rod with the weight suspended thereon is moved downward to mount the

sleeve body on the mount portion protruding from the inner side of the casing, and the weight with the sleeve body suspended thereon is moved downward to make the liner move outward in the rod radial direction and press the inner peripheral surface of the casing via the upper wedge piece and the lower wedge piece. The hammer rod and the casing are integrated via this liner. Thus, by rotationally driving the casing and the hammer with the rotationally driving apparatus, a vertical hole can be drilled even in hard ground with the casing bit and the hammer bit. Moreover, by moving the hammer rod downward, the ground can be drilled deeper without adding another hammer rod. This is advantageous in efficiently drilling a vertical hole.

[0010]

In another example, the plurality of insertion guides are provided on the lower side of the flange portion at the lower end of the sleeve body. Thus, even when the difference between the inner diameter of the casing and the outer diameter of the sleeve body (flange portion) is small, the sleeve body (and the hammer and the hammer rod) can be smoothly inserted into the casing by bringing the insertion guides into abutment with the opening in the upper end of the casing. Moreover, the upper wedge piece and the lower wedge piece are isolated from the external space by the wedge piece cover. Thus, unwanted obstacles such as crushed stones are prevented from getting in between the upper wedge piece and the lower wedge piece. This makes it possible stably perform drilling work for a long period. In addition, the hose is held so as to be movable in the hose longitudinal direction by the hose holder suspended by a crane. In this way, the hose can be smoothly fed toward and pulled away from the casing according to the progress of drilling work.

This is

advantageous in further improving the workability.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

[Fig. 1] Fig. 1 is an explanatory diagram exemplarily illustrating a front view of a general entirety of a drilling system of the present invention with the inside of a casing seen through.

[Fig. 2] Fig. 2 is an explanatory diagram exemplarily illustrating a front view of members disposed inside the casing in Fig. 1.

[Fig. 3] Fig. 3 is an explanatory diagram exemplarily illustrating a top view of a hammer and a hammer rod in Fig. 2.

[Fig. 4] Fig. 4 is an explanatory diagram exemplarily illustrating a front view of the hammer and the hammer rod in Fig. 2.

[Fig. 5] Fig. 5 is an explanatory diagram exemplarily illustrating a front view of a weight and a sleeve body in Fig. 2 in an assembled state.

[Fig. 6] Fig. 6 is a set of explanatory diagrams exemplarily illustrating the weight in Fig. 5, Fig. 6A being a front view and Fig. 6B being a bottom view.

[Fig. 7] Fig. 6 is an explanatory diagram exemplarily illustrating a top view of the sleeve body in Fig. 5 and its surroundings.

[Fig. 8] Fig. 8 is an explanatory diagram exemplarily illustrating a front view of the sleeve body in Fig. 5 and its surroundings.

[Fig. 9] Fig. 9 is an explanatory diagram exemplarily illustrating a front view of a state where the hammer rod starts

being inserted into the casing from an opening in its upper end, with the inside of the casing seen through.

[Fig. 10] Fig. 10 is an explanatory diagram exemplarily illustrating a front view of a state where the hammer rod in Fig. 9 is moved downward farther, with the inside of the casing seen through.

[Fig. 11] Fig. 11 is an explanatory diagram exemplarily illustrating a front view of a state where the hammer rod without insertion guides attached thereto starts being inserted into the casing from the opening in its upper end, with the inside of the casing seen through.

[Fig. 12] Fig. 12 is an explanatory diagram exemplarily illustrating a front view of a state where the hammer rod in Fig. 1 is moved downward to mount the sleeve body on mount portions, with the inside of the casing seen through.

[Fig. 13] Fig. 13 is an explanatory diagram exemplarily illustrating a plan view of an arrangement of the mount portions and the insertion guides in Fig. 12.

[Fig. 14] Fig. 14 is a set of explanatory diagram exemplarily illustrating how a modification of the mount portions and a modification of the insertion guides interfere with each other, Fig. 14A being a plan view, Figs. 14B and 11C being views as seen from the arrows X and Y in FIG. 14A, respectively, Fig. 14D being a plan view of a state where the insertion guide in Fig. 14A has moved downward along the inclined surface of the mount portion, Figs. 14E and 14F being views as seen from the arrows X and Y in FIG. 14D, respectively.

[Fig. 15] Fig. 15 is an explanatory diagram exemplarily illustrating a front view of a state where the hammer rod and the weight in Fig. 12 are moved downward farther.

[Fig. 16] Fig. 16 is an explanatory diagram exemplarily illustrating a front view of a state where the hammer rod in Fig. 15 is moved downward farther.

[Fig. 17] Fig. 17 is an explanatory diagram exemplarily illustrating a front view of a state where the casing and the hammer in Fig. 16 are rotationally driven to drill the ground.

MODE FOR CARRYING OUT THE INVENTION

[0012]

A drilling system and drilling method of the present invention will be described below based on an embodiment illustrated in the drawings.

[0013]

A drilling system of the present invention exemplarily illustrated in Figs. 1 and 2 includes: a casing 1 of a hollow cylindrical shape; a rotationally driving apparatus 17 that holds the outer peripheral surface of this casing 1 and rotationally drives the casing 1; a hammer 3 of a solid cylindrical shape; a hammer rod 5 of a hollow cylindrical shape at the lower end of which the hammer 3 is provided; a hose 10 connected to the hammer rod 5; and a hose holder 16. At a lower end portion of the casing 1, casing bits 2a are disposed so as to be spaced in the circumferential direction. Also, at the lower end portion of the casing 1, multiple mount portions 2c protruding from the inner side of the casing 1 are disposed so as to be spaced in the circumferential direction of the casing 1. Inside cutters 2b are provided on the lower end surfaces of the mount portions 2c so as to protrude downward.

[0014]

This drilling system further has a weight 8 and sleeve body 12 to be inserted over the hammer rod 5 inside the casing

1, and liners 14 placed on the weight 8 or the sleeve body 12. While the liners 14 are placed on the sleeve body 12 in this embodiment, the configuration may be such that the liners 14 are provided on the weight 8. Wedge piece covers 13 are attached to a lower end portion of the weight 8.

[0015]

The casing 1 includes multiple casing parts 1a and 1b vertically connected to each other with bolts and the like, and the casing bits 2a are provided at a lower end portion of the bottom casing part 1a. The number of casing parts 1a and 1b forming the casing 1 is not limited to two, and can be any number corresponding to the drilling depth.

[0016]

The hammer rod 5 in this embodiment includes two hammer rods 5a and 5b vertically connected to each other with bolts and the like, and the hammer 3 is coupled to the lower end of the bottom hammer rod 5a. In this embodiment, the top hammer rod 5b is used as a weight rod in order to apply a downward load to the hammer 3. The weight rod 5b may be optionally provided, and the hammer rod 5 may be formed only of the single hammer rod 5a.

[0017]

A swivel joint 9 is connected to the upper end of the hammer rod 5, and the hose 10 is coupled to the swivel joint 9 via a hose connecting portion 11. The hose 10 connected to the hammer rod 5 communicates with introduction channels 3a and 7a to be described later. A locking hole 9a is provided at the upper end of the swivel joint 9. A suspension wire 20 of a crane or the like is locked to the locking hole 9a. Thus, the vertical position of the hammer 3 can be controlled by operating the crane

suspending the hammer 3.

[0018]

The hose holder 16 has a frame 16a and rotary rollers 16b rotatably supported by the frame 16a, and holds the hose 20 such that the hose is movable in the hose longitudinal direction. In this embodiment, two rotary rollers 16b disposed in tandem hold the hose 20 to prevent the hose 20 from kinking. There may be a single rotary roller 16b, but it is desirable to dispose multiple rotary rollers 16b in tandem. The hose holder 16 is suspended by a crane that is not the crane that suspends the hammer rod 3. The hose holder 16 is suspended by the crane so as to be turnable about a vertical axis.

[0019]

The introduction channel 3a is provided in the hammer 3, and the introduction channel 7a is provided in the hammer rod 5. The introduction channels 3a and 7a form an introduction channel that allows penetrating from the lower end of the hammer 3 to an upper end portion of the hammer rod 5 communicate with each other. Vertically extending discharge grooves 3b are formed in the side surface of the hammer 3.

[0020]

Air is supplied through the introduction channels 7a and 3a from the hose 10, which is connected to an air supply source installed on the ground. With the pressure of the supplied air, a vertical striking force is applied to the hammer 3. Also, with the pressure of the supplied air, drilled matter is moved upward through the discharge grooves 3b and accumulated inside the casing 1.

[0021]

The rotationally driving apparatus 17 has driving motors

17a, rotary gears 17b rotationally driven by the driving motors 17a, multiple chuck pieces 19 that rotate with the rotary gears 17b, and four support legs 18 each including a hydraulic cylinder. The multiple chuck pieces 19 are annularly disposed so as to surround the outer periphery of the casing 1, which vertically penetrates through the rotationally driving apparatus 17. Each chuck pieces 19 moves so as to project and retract in the radial direction of the casing 1.

[0022]

The chuck pieces 19 having moved toward the tube axis of the casing 1 hold the outer peripheral surface of the casing 1. Also, as the cylinders of the support legs 18 move so as to project or retract, the above constituent parts of the rotationally driving apparatus 17 integrally move up or down. The casing 1 is rotationally driven about the tube axis of the casing 1 as the rotationally driving apparatus 17 is actuated with the chuck pieces 19 holding the outer peripheral surface of the casing 1.

[0023]

As exemplarily illustrated in Figs. 3 and 4, hammer bits 4 are provided in a protruding fashion on the lower surface of the hammer 3 and, in the side surface, the discharge grooves 3b are formed extending from the lower end to the upper end. It is preferable that multiple discharge grooves 3b be disposed so as to be spaced in the circumferential direction of the hammer 3. In this embodiment, four discharge grooves 3b are disposed at equal intervals in the circumferential direction. The hammer rod 5 (5a, 5b) is provided with fitting keys 6a extending in the tube axial direction of the tube. Multiple fitting keys 6a are disposed so as to protrude outward from the outer

peripheral surface of the hammer rod 5 and be spaced in the rod circumferential direction. While two fitting keys 6a are disposed at equal intervals in the rod circumferential direction of the hammer rod 5 in this embodiment, the number of fitting keys 6a to be disposed is set to be two to six, for example.

[0024]

The bottom hammer rod 5a is provided with weight holding keys 6b extending in the tube axial direction in addition to the fitting keys 6a. Multiple weight holding keys 6b are disposed so as to protrude outward from the outer peripheral surface of the hammer rod 5a and be spaced in the rod circumferential direction. The weight holding keys 6b are each disposed between the fitting keys 6a adjacent in the rod circumferential direction of the hammer rod 5a. While two weight holding keys 6b are disposed at equal intervals in the rod circumferential direction of the hammer rod 5a in this embodiment, the number of weight holding keys 6b is set to be two to six, for example.

[0025]

While the fitting keys 6a extend over the entire length of the hammer rod 5 (5a, 5b) in the tube axial direction from its lower end to its upper end, the weight holding keys 6b extend from the lower end of the hammer rod 5a to an intermediate position in the tube axial direction. That is, the weight holding keys 6b have their upper end surfaces at an intermediate position on the hammer rod 5 in the tube axial direction.

[0026]

As exemplarily illustrated in Fig. 5, inside the casing 1, the sleeve body 12 is placed in a state of being suspended

downward from the weight 8. A tubular portion 12a forming the sleeve body 12 is inserted in the weight 8. In this embodiment, the weight 8 and the sleeve body 12 are vertically connected to each other by springs 15a. Multiple (four) springs 15a are disposed so as to be spaced in the circumferential direction. While the springs 15a apply a biasing force that moves the weight 8 downward relative to the sleeve body 12, the springs 15a can be provided optionally.

[0027]

Also, on the lower surface of the weight 8, upper wedge pieces 13a are suspended which are pinned with coupling pins 15b extending horizontally. Multiple (four) upper wedge pieces 13a are disposed so as to be spaced in the circumferential direction.

[0028]

As exemplarily illustrated in Fig. 6, the weight 8 is in a hollow cylindrical shape. At an upper end portion of the weight 8, a locking portion 8b is provided which protrudes radially inward from the inner peripheral surface of the upper end portion. Key grooves 8a are provided which extend from the lower end to the upper end of this locking portion 8b. The key grooves 8a correspond to the fitting keys 6a. Thus, the same number of key grooves 8a as the fitting keys 6a are disposed so as to be spaced in the circumferential direction.

[0029]

Moreover, in the inner peripheral surface of the weight 8, stopper grooves 8c are provided which extend from the lower end of the weight 8 to the locking portion 8b. That is, the upper ends of the stopper grooves 8c are closed by the locking portion 8b. Later-described stoppers 12e provided on the

sleeve body 12 are fitted to the stopper grooves 8c. Fasteners are attached to lower end portions of the stopper grooves 8c after the stoppers 12e are fitted to the stopper grooves 8c.

[0030]

At the lower surface of the weight 8, attachment portions to attach the springs 15a and the upper wedge pieces 13a are provided so as to be spaced in the circumferential direction. Also, the multiple wedge piece covers 13c are detachably attached to the lower surface of the weight 8 so as to be spaced in the circumferential direction. The wedge piece covers 13c are made of deformable rubber or the like, and isolate the upper wedge pieces 13a and lower wedge pieces 13b from the external space.

[0031]

As exemplarily illustrated in Figs. 7 and 8, the sleeve body 12 has the tubular portion 12a and a flange portion 12b connected to the lower end of the tubular portion 12a. The flange portion 12b is formed annularly so as to protrude from the outer periphery of the tubular portion 12a. The flange portion 12b is a part of the sleeve body 12 with the largest outer diameter. The outer diameter of the flange portion 12b is smaller than the inner diameter of the casing 1 by, for example, 10 mm to 100 mm, more preferably by 10 mm to 60 mm, and further preferably by 20 mm to 50 mm. When the difference between the inner diameter of the casing 1 and the outer diameter of the flange portion 12b is excessively large, stones crushed by drilling and the like may easily enter the space above the flange portion 12b. When the difference is excessively small, it may be difficult for the sleeve body 12 to smoothly move up and down inside the casing 1.

[0032]

In the inner peripheral surface of the tubular portion 12a, key grooves 12d are provided which extend from the lower end to the upper end. Multiple key grooves 12d are disposed so as to be spaced in the circumferential direction. In this embodiment, four key grooves 12d are disposed at equal intervals in the circumferential direction of the tubular portion 12a. The fitting keys 6a and the weight holding keys 6b are fitted to the key grooves 12d. Thus, the same number of key grooves 12d as the total number of fitting keys 6a and weight holding keys 6b are provided.

[0033]

At an upper end portion of the tubular portion 12a, the stoppers 12e are disposed so as to be spaced in the circumferential direction, the stoppers 12e protruding radially outward. The tubular portion 12a is inserted in the weight 8 with the stoppers 12e fitted to the stopper grooves 8c provided in the weight 8, and the circumferential positions of the key grooves 8a and the key grooves 12d coincide with each other as well. Fitting the stoppers 12e to the stopper grooves 8c renders the sleeve body 12 movable only in the tube axial direction (vertical direction) relative to the weight 8 and restricts movement in the circumferential direction. Since fasteners are attached to the lower end portions of the stopper grooves 8c in the weight 8, the fasteners blocks downward movement of the stoppers 12e when the sleeve body 12 moves downward relative to the weight 8. Thus, the sleeve body 12 will not get separated from the weight 8 even without the springs 15a.

[0034]

On the upper surface of the flange portion 12b, wedge holding portions 12c are disposed so as to be spaced in the circumferential direction. While four wedge holding portions 12c are disposed at equal intervals in the circumferential direction in this embodiment, the number of wedge holding portions 12c to be disposed is set to be two to six, for example.

[0035]

The wedge holding portions 12c hold the lower wedge pieces 13b. The lower wedge pieces 13b and the upper wedge pieces 13a are provided such that the upper wedge pieces 13a are movable downward with their mutually facing inclined surfaces in abutment with each other. Each pair of an upper wedge piece 13a and a lower wedge piece 13b is surrounded by a wedge piece cover 13c, wedge holding portions 12c, and the tubular portion 12a to be isolated form the external space. Even when the gap between the lower end of the weight 8 and the upper ends of the wedge holding portions 12c changes, the rubber-made wedge piece covers 13c deform so as to absorb this change. Accordingly, the lower wedge pieces 13b and the upper wedge pieces 13a are always kept isolated from the external space. Note that this isolation from the external space means that the upper wedge pieces 13a and the lower wedge pieces 13 are substantially isolated from obstacles present outside such as crushed stones and earth and sand, and does not mean performance that ensures airtightness and watertightness.

[0036]

In plan view, the liners 14, which have an arc shape, are attached to the outer peripheral surfaces of the lower wedge pieces 13b. The liners 14 move in the rod radial direction of the hammer rod 5 along with the lower wedge pieces 13b moving

in the rod radial direction while being guided by the wedge holding portions 12c. Moreover, at the upper surface of the flange portion 12b, attachment portions to fix the springs 15a are disposed so as to be spaced in the circumferential direction.

[0037]

On a peripheral edge portion of the lower end of the flange portion 12b, multiple insertion guides 12G are disposed so as to be spaced in the circumferential direction of the sleeve body 12. Each insertion guide 12G has an inclined portion protruding downward and being inclined toward the tube axis of the sleeve body 12 (inclined outer surface). Specifically, the insertion guide 12G has a triangular shape with an inclined surface extending downward toward the inside of the sleeve body 12. In this embodiment, a circular ring body formed of the insertion guides 12G fixed so as to be spaced in the circumferential direction is detachably attached to the lower end surface of the flange portion 12b with bolts and the like. Each insertion guide 12G may be directly placed on the lower end surface of the flange portion 12b.

[0038]

It is desirable that the inclined portions of the insertion guides 12G extend downward from the peripheral edge of the flange portion 12b. An inclination angle a of these inclined portions with respect to the tube axis of the sleeve body 12 (casing 1) is set to be 30° to 60°, for example. The specifications are such that, compared to the upper ends of the inclined portions of the insertion guides 12G, the lower ends are situated radially inward of the casing 1 by 30 mm or more and more preferably 50 mm or more without interfering with the

hammer 3.

[0039]

As exemplarily illustrated in Fig. 5, the tubular portion 12a of the sleeve body 12 is inserted in the weight 8. Inside the casing 1, the weight 8 and the sleeve body 12 in this state are inserted over the hammer rod 5 as exemplarily illustrated in Fig. 2. In this state, the fitting keys 6a are fitted to the key grooves 8a and the key grooves 12d, and the weight holding keys 6b are fitted only to the key grooves 12d.

[0040]

In this way, in the drilling system, the weight 8 and the sleeve body 12 inserted over the hammer rod 5 inside the casing 1 are restricted from rotating in the rod circumferential direction and are rendered movable in the vertical direction. Moreover, the liners 14 are rendered movable in the rod radial direction between the outer peripheral surface of the hammer rod 5 and the inner peripheral surface of the casing 1.

[0041]

A method of forming a vertical hole in the ground by drilling the ground with this drilling system will be described below.

[0042]

As exemplarily illustrated in Fig. 2, the weight 8 and the sleeve body 12 are inserted over the hammer rod 5 with the hammer 3 attached to its lower end, so that the weight 8 and the sleeve body 12 are restricted from rotating in the rod circumferential direction and rendered movable in the vertical direction. By locking the upper end surfaces of the weight holding keys 6b to the locking portion 8b of the weight 8, the weight 8 is suspended from the hammer rod 5 from an intermediate

position on the hammer rod 5 in the vertical direction. As a result, the sleeve body 12 is placed in a state of being suspended downward from the weight 8. The sleeve body 12 is suspended down to a predetermined position by the springs 15a stretched between the weight 8 and the flange portion 12b.

[0043]

The upper wedge pieces 13a protruding downward from the weight 8 have been inserted in the wedge holding portions 12c and in abutment with the lower wedge pieces 13b held by the wedge holding portions 12c, but have not sufficiently moved downward relative to the lower wedge pieces 13b. Accordingly, the lower wedge pieces 13b have hardly been moved outward in the rod radial direction of the hammer rod 5. The liners 14 are thus situated radially inward of the outer edge of the flange portion 12b. The hammer 3 is at a position where it projects downward beyond the flange portion 12b. The wedge piece covers 13c are vertically interposed between the weight 8 and the wedge piece covers 13c, so that the upper wedge pieces 13a and the lower wedge pieces 13b are each isolated from the external space.

[0044]

This hammer rod 5 is suspended with the suspension wire 20 and inserted into the casing 1 buried in the ground. The hose 10 is coupled to the swivel joint 9 at the upper end of the hammer rod 5 via the hose connecting portion 11 to be in the state exemplarily illustrated in Fig. 1.

[0045]

As exemplarily illustrated in Fig. 9, the multiple insertion guides 12G are provided on the lower side of the sleeve body 12. Thus, even when the difference between the inner diameter of the casing 1 and the outer diameter of the sleeve

body 12 is small (e.g., 30 mm or less), the sleeve body 12 (and the hammer 3 and the hammer rod 5) can be positioned at an appropriate position for inserting the sleeve body 12 (and the hammer 3 and the hammer rod 5) into the casing 1 by bringing the inclined portions of the insertion guides 12G suspended by a crane into abutment with the opening in the upper end of the casing 1. Thereafter, as exemplarily illustrated in Fig. 10, by simply moving the sleeve body 12 (and the hammer 3 and the hammer rod 5) downward, the sleeve body 12 (and the hammer 3 and the hammer rod 5) can be smoothly inserted into the casing 1. An accurate crane operation to position the sleeve body 12 at the appropriate position is not required. This contributes to speeding up the work.

[0046]

As exemplarily illustrated in Fig. 11, without the insertion guides 12G on the sleeve body 12, the flange portion 12b and the upper end of the casing 1 may interfere with each other if the difference between the inner diameter of the casing 1 and the outer diameter of the sleeve body 12 is small (e.g., 50 mm or less). This prevents smooth insertion of the sleeve body 12 (and the hammer 3 and the hammer rod 5) into the casing 1. Also, positioning the sleeve body 12 (and the hammer 3 and the hammer rod 5) at the appropriate position will require an accurate crane operation. This may be a major factor that hinders speeding up of the work.

[0047]

Next, as exemplarily illustrated in Fig. 12, the hammer rod 5 is moved farther downward to mount the flange portion 12b on the mount portions 2c. The mount portions 2c and the inside cutters 2b are disposed at such positions as not to interfere

with the hammer 3 or the hammer rod 5. Thus, the hammer 3 and the hammer rod 5, which are to be moved up and down, can come into and out of the casing 1.

[0048]

When four mount portions 2c and four insertion guides 12G are each disposed at equal intervals in the circumferential direction of the casing 1 as exemplarily illustrated in Fig. 13, it is possible that the insertion guides 12G are mounted on the mount portions 2c, and the flange portion 12b cannot be mounted on the mount portions 2c. To address this, a structure may be employed in which the number of either mount portions 2c or insertion guides 12G is four and they are disposed at equal intervals in the circumferential direction of the casing 1 whereas the number of the other of the mount portions 2c or the insertion guides 12G is three and they are disposed at equal intervals in the circumferential direction of the casing 1. This can significantly lower the risk of the insertion guides 12G being mounted on the mount portions 2c.

[0049]

Instead of this measure to devise the numbers and arrangements of the mount portions 2c and the insertion guides 12G or in addition to this measure, a specification can be employed in which, as exemplarily illustrated in Fig. 14, the upper surfaces of the mount portions 2c are inclined surfaces inclined in one direction in a point of view directed toward a radially outer side from the center of the casing 1 in plan view (the point of view exemplarily illustrated in Fig. 14B). Specifically, even when the insertion guides 12G are to be mounted on the mount portions 2c as exemplarily illustrated in Figs. 14A, 14B, and 14C, the insertion guides 12G move downward

along the inclined surfaces of the mount portions 2c as exemplarily illustrated in Figs. 14D, 14E, and 14F. This enables the flange portion 12b to be mounted on the mount portions 2c.

[0050]

The specifications may be such that the lower ends of the insertion guides 12G have an inclined surface inclined in the same direction as the inclined surfaces of the mount portions 2c in a point of view directed toward a radially outer side from the center of the sleeve body 12 in plan view (the point of view exemplarily illustrated in Fig. 14B). In Fig. 14B, the lower end of the insertion guide 12G has a V-shape having an inclined surface inclined in the same direction as the inclined surface of the mount portion 2c and an inclined surface inclined in the opposite direction to this inclined surface. Alternatively, a shape inclined in one direction may be employed which only has an inclined surface inclined in the same direction as the inclined surface of the mount portion 2c. Still alternatively, the specifications can be such that the lower ends of the insertion guides 12G are formed in an arc shape in the point of view directed toward a radially outer side from the center of the sleeve body 12 in plan view (the point of view exemplarily illustrated in Fig. 14B).

[0051]

As the hammer rod 5 is moved farther downward from the state of Fig. 12 as exemplarily illustrated in Fig. 15, the weight 8 moves downward with the weight of the weight 8 and the biasing force of the springs 15a. The sleeve body 12 does not move in the vertical direction since the flange portion 12b is mounted on the mount portions 2c. Accordingly, the inclined

surfaces of the upper wedge pieces 13a moving downward push the inclined surfaces of the lower wedge pieces 13b, so that the liners 14 move outward in the rod radial direction. As a result, the liners 14 press the inner peripheral surface of the casing 1, so that the casing 1 and the hammer 3 become integrated via the liners 14.

[0052]

Then, as exemplarily illustrated in Fig. 16, the hammer rod 5 is moved downward as appropriate to place the hammer 3 at a predetermined depth. The outer peripheral surface of the casing 1 is held with the chuck pieces 19 of the rotationally driving apparatus 17.

[0053]

In this state, as exemplarily illustrated in Fig. 17, the rotationally driving apparatus 17 is actuated to rotationally drive the casing 1 and also rotationally drive the hammer 3 together to thereby start drilling the ground. With the rotational driving by the rotationally driving apparatus 17, the cylinders of the support legs 18 are gradually retracted to move the casing 1 downward. At the time of starting drilling, for example, the vertical position of the hammer 3 is adjusted to perform drilling with the hammer 3 before the casing 1.

[0054]

While air is supplied through the introduction channel 7a from the hose 10 to apply a vertical striking force to the hammer 3 with the pressure of the supplied air, the ground is drilled with the rotationally driven casing bits 2a, inside cutters 2b, and hammer bits 4. The drilled matter resulting from the drilling is moved upward through the discharge grooves 3b and accumulated into the casing 1 by the pressure of the air

supplied through the introduction channels 7a and 3a. The drilled matter accumulated in the casing 1 is discharged onto the ground with a hammer grab or the like after a vertical hole is formed.

[0055]

To drill the ground deeper, another casing part is added to the casing 1 to extend it, the support legs 18 of the rotationally driving apparatus 17 are brought back to the extended state, and the outer peripheral surface of the extended casing 1 is held with the chuck pieces 19. Then, the hammer 3 may be rotationally driven along with the casing 1 by following the same procedure as described above to drill the ground.

[0056]

According to the present invention, rotation of the casing 1 is transmitted through the liners 14 to the hammer rod 5 and to the hammer 3, so that the casing 1 and the hammer 3 are rotationally driven together. In this way, a vertical hole can be drilled even in hard ground with the casing bits 2a and the hammer bits 4. In this embodiment, the inside cutters 2b also drill the ground. A vertical hole can thus be drilled more efficiently.

[0057]

By moving the hammer rod 5 downward, the ground can be drilled deeper without adding another hammer rod 5. In other words, work of adding another hammer rod 5 can be omitted. This is advantageous in efficiently drilling a vertical hole.

[0058]

To move the liners 14 pressing the inner peripheral surface of the casing 1 inward in the rod radial direction to release the integration of the casing 1 and the hammer 3, the

hammer rod 5 is moved upward to lock the upper end surfaces of the weight holding keys 6b to the locking portion 8b of the weight 8, and the weight 8 is moved upward relative to the sleeve body 12. As a result, the upper wedge pieces 13a move upward relative to the lower wedge pieces 13b, thereby eliminating the pressing force pressing the liners 14 outward in the rod radial direction. In this way, the integration of the casing 1 and the hammer 3 can be released.

[0059]

As described above, in the present invention, the integration of the casing 1 and the hammer 3 and the releasing of the integration via the liners 14 can be done only by vertically moving the hammer rod 5. This simplifies the drilling work, which is advantageous in improving the work efficiency.

[0060]

Also, employing a configuration which applies a biasing force to move the weight 8 downward relative to the sleeve body 12 by using the springs 15a as in this embodiment makes it possible to press the liners 14 against the inner peripheral surface of the casing more strongly. This enables the casing 1 and the hammer 3 to be integrated with each other more firmly.

[0061]

The hose 10 is held so as to be movable in the hose longitudinal direction by the hose holder 16 suspended by a crane, and is therefore smoothly fed toward and pulled away from the casing with vertical movement of the hammer rod 5. This prevents a situation where the hose 10 is kept from being fed or pulled, thereby interrupting the work, or the hose 10 is intensely pulled and breaks. Thus, the hose holder 16 enables

the hose 10 to be smoothly moved according to the progress of drilling work. This is advantageous in further improving the workability. Moreover, since the hose holder 16 is suspended by a crane so as to be turnable about a vertical axis, the hose 10 is prevented from getting twisted.

[0062]

The sleeve body 12 is put in an environment where unwanted obstacles such as crushed stones and earth and sand are present as the ground is drilled. If such obstacles get in between the upper wedge pieces 13a and the lower wedge pieces 13b from the outside, they cause a trouble such as blocking the proper abutment between the upper wedge pieces 13a and the lower wedge pieces 13b or firmly attaching the upper wedge pieces 13a and the lower wedge pieces 13b to each other, making it difficult to separate them from each other. However, the present invention can prevent such a trouble since the upper wedge pieces 13a and the lower wedge pieces 13b are always isolated from the external space by the wedge piece covers 13c. Hence, it is possible to avoid unexpected work interruptions and carry out drilling work consistently over a long period. It is also possible to reduce the frequency of maintenance.

[0063]

The springs 15a can be isolated from the external space with spring covers similar to the wedge piece covers 13c. These spring covers prevent unwanted obstacles from getting into the springs 15a from the outside. This can prevent the smooth expansion and contraction of the springs 15a from being blocked.

EXPLANATION OF REFERENCE NUMERALS

[0064]

1 casing

1a, 1b casing part

2a casing bit

2b inside cutter

2c mount portion

3 hammer

3a introduction channel

3b discharge groove

4 hammer bit

5 (5a, 5b) hammer rod

6a fitting key

6b weight holding key

7a introduction channel

8 weight

8a key groove

8b locking portion

8c stopper groove

9 swivel joint

9a locking hole

10 hose

11 hose connecting portion

12 sleeve body

12a tubular portion

12b flange portion

12c wedge holding portion

12d key groove

12e stopper

12G insertion guide

13a upper wedge piece

13b lower wedge piece

13c wedge piece cover

14	liner
15a	spring
15b	coupling pin
16	hose holder
16a	frame
16b	rotary roller
17	rotationally driving apparatus
17a	driving motor
17b	rotary gear
18	support leg
19	chuck piece
20	suspension wire

CLAIMS

[Claim 1] A drilling system including:

a casing having a casing bit at a lower end portion thereof;

a rotationally driving apparatus which holds an outer peripheral surface of this casing and rotationally drives the casing;

a hammer having a hammer bit at a lower end portion thereof;

a hammer rod to a lower end of which this hammer is attached and which is inserted in the casing;

a weight and sleeve body inserted over the hammer rod inside the casing and restricted from rotating in a rod circumferential direction and being movable in a vertical direction;

a liner placed on the weight or the sleeve body and being movable in a rod radial direction between an outer peripheral surface of the hammer rod and an inner peripheral surface of the casing;

a mount portion which protrudes from an inner side of the casing and on which the sleeve body is mounted;

an upper wedge piece protruding downward from the weight;

a lower wedge piece placed on an inner side of the liner in the rod radial direction; and

a hose connected to the hammer rod,

the drilling system being such that the sleeve body is placed in a state of being suspended downward from the weight, the weight is suspendable from the hammer rod from an intermediate position on the hammer rod in the vertical direction, and as the weight moves downward relative to the

sleeve body mounted on the mount portion, the upper wedge piece pushes the lower wedge piece, thereby making the liner move outward in the rod radial direction and press the inner peripheral surface of the casing, and in this state the casing is rotationally driven by the rotationally driving apparatus, so that the casing and the hammer are rotationally driven together, while a vertical striking force is applied to the hammer with air supplied through the hose to thereby drill ground with the casing bit and the hammer bit, the drilling system characterized in that

a plurality of the mount portions are disposed so as to be spaced in a circumferential direction of the casing, and

the drilling system comprises:

a plurality of insertion guides having an inclined portion protruding downward from a flange portion at a lower end of the sleeve body and inclined toward a tube axis of the sleeve body, and disposed on a peripheral edge portion of a lower end of the flange portion so as to be spaced in the circumferential direction;

a wedge piece cover isolating the upper wedge piece and the lower wedge piece from an external space; and

a hose holder suspended from a crane and holding the hose such that the hose is movable in a hose longitudinal direction.

[Claim 2] The drilling system according to claim 1, wherein upper surfaces of the mount portions are inclined surfaces inclined in one direction in a point of view directed toward a radially outer side from a center of the casing in plan view.

[Claim 3] The drilling system according to claim 2, wherein

lower ends of the insertion guides have an inclined surface inclined in a same direction as the inclined surfaces in a point of view directed toward a radially outer side from a center of the sleeve body in plan view.

[Claim 4] The drilling system according to claim 2, wherein lower ends of the insertion guides are formed in an arc shape in a point of view directed toward a radially outer side from a center of the sleeve body in plan view.

[Claim 5] The drilling system according to any one of claims 1 to 4, comprising:

a spring connecting the sleeve body and the weight, the drilling system being configured to apply a biasing force which moves the weight downward relative to the sleeve body with this spring; and

a spring cover isolating the spring from an external space.

[Claim 6] The drilling system according to any one of claims 1 to 5, wherein an outer diameter of the flange portion is smaller than an inner diameter of the casing by 10 mm to 100 mm.

[Claim 7] A drilling method including:

inserting a hammer rod with a hammer attached to a lower end thereof into a casing, the hammer having a hammer bit at a lower end portion thereof,

bringing a weight and sleeve body inserted over the hammer rod inside the casing into a state of being restricted from rotating in a rod circumferential direction and being movable

in a vertical direction,

placing a liner on the weight or the sleeve body, the liner being movable in a rod radial direction between an outer peripheral surface of the hammer rod and an inner peripheral surface of the casing,

providing an upper wedge piece protruding downward from the weight and a lower wedge piece placed on an inner side of the liner in the rod radial direction,

placing the sleeve body in a state of being suspended downward from the weight,

rendering the weight suspendable from the hammer rod from an intermediate position on the hammer rod in the vertical direction,

moving the weight downward relative to the sleeve body mounted on a mount portion protruding from an inner side of the casing to thereby make the upper wedge piece push the lower wedge piece, thereby making the liner move outward in the rod radial direction and press the inner peripheral surface of the casing, and rotationally driving the casing and the hammer together with a rotationally driving apparatus holding an outer peripheral surface of the casing while applying a vertical striking force to the hammer with air supplied through a hose connected to the hammer rod to thereby drill ground with a casing bit provided at a lower end portion of the casing and the hammer bit provided at the lower end portion of the hammer,

the drilling method characterized in that it comprises:

disposing a plurality of the mount portions such that the mount portions are spaced in a circumferential direction of the casing; and

designing a specification such that a plurality of

insertion guides are disposed on a peripheral edge portion of a lower end of a flange portion at a lower end of the sleeve body so as to be spaced in the circumferential direction, each of the insertion guides having an inclined portion protruding downward from the flange portion and inclined toward a tube axis of the sleeve body; and

drilling the ground with the upper wedge piece and the lower wedge piece isolated from an external space by a wedge piece cover and with the hose held so as to be movable in a hose longitudinal direction by a hose holder suspended from a crane.