

SPECIFICATION

[Title of Invention] Resistivity sensing device using ground improvement blade

[Technical field]

[0001]

The present invention relates to a resistivity sensing device using a ground improvement blade. For details, the present invention relates to a resistivity sensing device using a ground improvement blade for monitor a ground change in a soil improving machine having a corotation preventing blade and a stirring blade. For more details, the present invention relates to a resistivity sensing device using a ground improvement blade for monitor a ground change by detecting resistivity of ground improvement drilling earth and by monitoring thereof.

[Background Art]

[0002]

Variety of construction methods for performing ground improvement have been proposed. A construction method is known in which a borehole is formed in a ground, a solidification material such as cement is injected into the drilling earth of the borehole, and a ground improvement pillar such as a pile is formed by mixing and stirring by the stirring blade and the mixture solidified. At the time of this construction work, in particular, the stirring blade and the improved soil may corotate together. To prevent this corotation, a construction method is known in which a corotation preventing blade having structure rotatable freely by a bearing on a rotation rod is provided, and this corotation preventing blade is fixed to the wall of the borehole during construction work.

[0003]

In such situation, when mixing and stirring the solidification material and the drilling earth by the stirring blade, there is a demand that to obtain how the characteristic of the ground change, and how properly stirred the drilling earth and the ground improving material. There is proposed in which to obtain the mixing state of the drilling earth and the solidifying material in real-time by installing a resistivity measurement sensor on a peripheral surface of a hollow rod between the stirring blade and a lower stirring blade, and by measuring resistivity surrounding by a sensor (Patent Literature 1).

[0004]

A technology measuring physical properties of the ground by using the resistivity (electric resistance) is known technology generally used for drilling oil, hot spring and the like, and for survey of water etc. When measuring physical properties of

the ground using the resistivity, basically 2 electrodes are installed on a measurement target place, and a electric current is applied to them, and potential is measured by another 2 electrodes installed in a vicinity area thereof. The resistance value is determined by using Ohm's law and the like from the measured electric current and voltage. Because the resistance value changes due to the physical properties and the like between the electrodes, the resistivity value is used in the measurement of the physical properties of the ground. The distance between electrodes and kind of the ground are the same, and when other conditions such as moisture are the same, the resistivity becomes the same. Kind and the like of the ground can be determined from the change of the resistivity.

[Prior art documents]

[Patent Literature]

[0005]

[Patent Literature 1] Japan Patent Publication Tokuhyo (Japan Unexamined Patent Publication) 2010-24675.

[Summary of Invention]

[Technical Problem]

[0006]

However, the resistivity measurement sensor is installed on the peripheral surface of the hollow rod in the conventional art, there is a problem that wearing or peeling off a resistivity measurement sensor from the peripheral surface due to the rod rotating always and contacting the ground improving material. Also, because the resistivity measurement sensor and the electrodes are installed adjacent on the peripheral surface of the hollow rod, the resistivity measurement sensors of the ground are placed closely with each other, and cannot detect properly the change of the ground improving material of the ground.

[0007]

The present invention has accomplished under the technical background such as described above and achieves the following purposes.

An object of the present invention is to provide resistivity sensing device using ground improvement blade to monitor a change of improved soil, a ground and the like in a soil improving machine having a corotation preventing blade and a stirring blade.

[0008]

Another object of the present invention is to provide resistivity sensing device using ground improvement blade to measure resistivity value of improved soil, ground

and the like, and to send detected signal to a computing machine on a ground in a soil improving machine having a corotation preventing blade and a stirring blade.

[0009]

Another object of the present invention is to provide resistivity sensing device using ground improvement blade to perform signal processing detected signal, in which measured by electrodes for detecting resistivity installed on a corotation preventing blade, by a computing machine, and to monitor an improved soil, a ground and the like by resistivity value, or the rate of the change in a soil improving machine having a corotation preventing blade and a stirring blade.

[0010]

Another object of the present invention is to provide resistivity sensing device using ground improvement blade to detect resistivity of improved soil inside a borehole and resistivity of ground outside the borehole by electrodes for detecting resistivity installed on a corotation preventing blade, and to monitor online an ground improvement work in a soil improving machine having a corotation preventing blade and a stirring blade.

[Solution to Problem]

[0011]

The present invention adopts the following means in order to achieve the above objects.

The resistivity sensing device using the ground improvement blade of the first invention of the present invention is comprising:

- a resistivity sensing device using a ground improvement blade, in a soil improving machine performing a ground improvement in a borehole by drilling the borehole by drilling a ground, and mixing the drilled earth and a ground improving material, said soil improving machine comprising:

- a single shaft having a discharge hole driving rotary by a rotary drive device for discharging said ground improving material,

- a blade body being fixed to said single shaft, and drilling said drilling earth and said ground improving material inside said borehole,

- a drilling hole bit being installed on a ground bottom side terminal of said single shaft and having plural drilling blades for drilling said borehole,

- a corotation preventing blade being installed rotatably on said single shaft, being stopped rotation by engaging a outside terminal of said corotation preventing blade to a peripheral wall of said borehole, and mixing and drilling a drilling earth drilled by a

relative rotation of said blade body and said drilling hole bit with said ground improving material,

wherein said resistivity sensing device comprising:

a resistivity measuring means comprising electrodes installed said corotation preventing blade and a measuring means connected said electrodes to measure physical properties of improved soil in which mixed said ground or said drilling earth and said ground improving material, for measuring a first resistivity which is said resistivity of said ground and/or a second resistivity which is resistivity of said improved soil, and for outputting said measured signals, and

a communication means connected to said resistivity measuring means for transmitting said measured signals to a ground or said single shaft.

[0012]

The resistivity sensing device using a ground improvement blade of the invention 2 of the present invention, in the invention 1, wherein said resistivity sensing device comprising:

a determination means for receiving said measured signals from said communication means; determining said physical properties of said ground or said improved soil from rate of change of said first resistivity and/or said second resistivity, and/or said first resistivity and/or said second resistivity; and outputting the determination result signal.

[0013]

The resistivity sensing device using a ground improvement blade of the invention 3 of the present invention, in the invention 2, wherein said determination means determines by an absolute value of said first resistivity and/or said second resistivity, or by rate of change of said first resistance and/or said second resistivity.

[0014]

The resistivity sensing device using a ground improvement blade of the invention 4 of the present invention, in the inventions 1 to 3, wherein said resistivity measuring means has a data processor for converting analog data of said measured signals detected by said electrodes to digital data, and for sending it to said communication means.

[0015]

The resistivity sensing device using a ground improvement blade of the invention 5 of the present invention, in the inventions 1 to 3, wherein said electrodes are installed on a part of said corotation preventing blade locating inside of said Borehole for measuring said resistivity of said improved soil.

[0016]

The resistivity sensing device using a ground improvement blade of the invention 5 of the present invention, in the inventions 1 to 3, wherein said electrodes are installed on a part of said corotation preventing blade locating inside of said Borehole for measuring said resistivity of said improved soil.

[0017]

The resistivity sensing device using a ground improvement blade of the invention 7 of the present invention, in the invention 4, wireless communication means installed on an upper part of said single shaft for receiving said resistivity measurement signal from said communication means, converting said resistivity measurement signal into a wireless signal, and transmitting it said determination means.

[0018]

The resistivity sensing device using a ground improvement blade of the invention 8 of the present invention, in the invention 7, wherein said communication means comprising (a) a receiving means installed in a lower terminal of said single shaft for receiving said resistivity signal from said resistivity measuring means, and (b) an electrical wire for connecting said receiving means and said wireless communication means through a hollow between a pipe inside said single shaft, and transmitting said resistivity signal from said receiving means to said wireless communication means.

[0019]

The resistivity sensing device using a ground improvement blade of the invention 9 of the present invention, in the invention 7, wherein said communication means is a wireless repeating means in which installed in a lower terminal of said single shaft, receiving said resistivity signal from said resistivity measuring means by connecting to said resistivity measuring means, and transmitting it to said wireless communication means by a wireless communication.

[0020]

The resistivity sensing device using a ground improvement blade of the invention 10 of the present invention, in the invention 9, wherein said communication means is ZigBee Coordinator and ZigBee End Device, or ZigBee Coordinator, ZigBee Router and ZigBee End Device conforming to ZigBee standard.

[0021]

The resistivity sensing device using a ground improvement blade of the invention 11 of the present invention, in the invention 9, wherein said communication means is conforming to Bluetooth (Registered trademark) standard.

[0022]

The resistivity sensing device using a ground improvement blade of the invention 12 of the present invention, in the invention 7, wherein wherein said wireless communication means is installed in a water swivel fixed on an upper terminal of said single shaft for providing continuously ground improving material to inside said single shaft rotating.

[0023]

The resistivity sensing device using a ground improvement blade of the invention 13 of the present invention, in the invention 8, wherein said electrical wire is connected by a electromagnetic type connecting terminal in a connecting part of said single shaft.

[0024]

The resistivity sensing device using a ground improvement blade of the invention 14 of the present invention, in the invention 7, wherein said communication means comprising a second coil for communicating with said wireless communication means by magnetic resonance coupling, and said wireless communication means comprising a wireless signal receiving means comprising a first coil for communicating with said communication means by magnetic resonance coupling.

[0025]

The resistivity sensing device using a ground improvement blade of the invention 15 of the present invention, in the invention 14, wherein said first coil is installed by winding around a water swivel fixed on an upper terminal of said single shaft, or a hose locking member for providing said ground improving material, for providing continuously said ground improving material into said single shaft, and said second coil is located by winding said corotation preventing blade by locating in peripheral surface of said single shaft.

[0026]

The resistivity sensing device using a ground improvement blade of the invention 16 of the present invention, in the inventions 1 to 15, wherein said corotation preventing blade is a cross shape.

[Advantageous Effects of Invention]

[0027]

According to the present invention, a ground resistivity is detected by using an electrode for detecting resistivity in which installed on a corotation preventing blade for monitoring a ground change, the detected signal is sent to a computing machine on a

ground, and it makes possible to measure and monitor a ground improvement work in real-time to determine how properly mixed a ground improving material and a drilling earth, whether or not it was reached to a support layer etc. Also, the detected signal detected by the electrode for detecting resistivity installed on the corotation preventing blade is processed by a computing machine, and a ground change of the drilling earth can be possible to monitor from the change of the resistivity.

[Brief Description of Drawings]

[0028]

FIG.1 is an external view illustrating a stirring head A of the first embodiment of the present invention.

FIG.2 is an external view illustrating the upper part of a rotating rod for driving a stirring head A in the first embodiment of the present invention.

FIG.3 is a longitudinal section view illustrating a section of a lower part of a rotating rod of a stirring head A in the first embodiment of the present invention.

FIG.4 is a drawing illustrating an installation state of an electrode 9 in a corotation preventing blade 4 in the first embodiment of the present invention, and FIG.4(a) is a plan view of the corotation preventing blade 4, FIG.4(b) is a front view of the corotation preventing blade 4.

FIG.5 is a block diagram illustrating an overview of a ground change monitoring device 20 which is comprising the present invention.

FIG.6 is a block diagram illustrating an overview of a receiver 25 in a round change monitoring device 20 which is comprising the present invention.

FIG.7 is a flowchart showing an example measuring resistivity in a round change monitoring device 20 which is comprising the present invention.

FIG.8 is a drawing illustrating an electrical connection of an electrode 9 in the first embodiment of the present invention.

FIG.9 is a drawing illustrating conceptually a point electrode buried in ground.

FIG.10 is a drawing an arrangement example of two electric current electrodes and two potential electrodes arranged in a square shape, and FIG.10(a) is a plan view thereof, and FIG.10(b) is a section view thereof.

FIG.11 is a drawing illustrating an arrangement example of an electrode 9 arranged in the central part of blade body 4a of a corotation preventing blade 4 in the first embodiment of the present invention.

FIG.12 is a drawing illustrating an overview of a ground change monitoring device of the third embodiment of the present invention.

FIG.13 is a drawing illustrating an example of an installation position of a resistivity measurement unit 50 of a ground change monitoring device of the third embodiment of the present invention.

FIG.14 is a drawing illustrating an example of an installation position of a communication part 51 of a ground change monitoring device of the third embodiment of the present invention.

FIG.15 is an arrangement example of electrode 9 of a ground change monitoring device of the third embodiment of the present invention.

FIG.16 is a graph showing a data example measured resistivity by a ground change monitoring device of the third embodiment of the present invention.

FIG.17 is a circuit diagram showing an example of a magnetic field resonance circuit of a ground change monitoring device of the third embodiment of the present invention.

FIG.18 is a block diagram showing an overview of a circuit example a magnetic resonance coupled communication of a ground change monitoring device of the third embodiment of the present invention, and FIG.18(a) is a block diagram illustrating a configuration example of a transmitting circuit 73, and FIG.18(b) is a block diagram illustrating a configuration example of a receiving circuit 75.

FIG.19 is a block diagram illustrating an overview of a resistivity signal processing unit 52 of a ground change monitoring device of the third embodiment of the present invention.

FIG.20 is a block diagram showing an overview of a circuit example of magnetic resonance coupled communication of a ground change monitoring device of the fourth embodiment of the present invention.

[BEST MODE FOR CARRYING OUT THE INVENTION]

[0029]

[A FIRST EMBODIMENT OF THE INVENTION]

Hereinafter, a first embodiment of the present invention will be described based on drawings. A ground change monitoring device 20, not shown, integrates into an improvement machine body of a soil improving machine movable on ground, and operates. That is, a rotating rod is linked to an output shaft of a driving motor installed in the improvement machine body, a stirring head A of the soil improving machine is driven rotary by the rotating rod which is driven by the driving motor. FIG.1 is an external view illustrating the stirring head A, and FIG.2 is an external view illustrating an upper part of the rotating rod for driving the stirring head A. A drilling hole bit 2 installed on the distal

end of the stirring head A drills a ground, which is to make a ground improvement, by the rotary drive, and drilled earth is transferred upward.

[0030]

Stirring blades 3a, 3b is fixed to a single shaft 1 of the stirring head A, and a corotation preventing blade 4 is installed rotatably on the single shaft 1. The drilled earth is drilled and mixed with a ground improving material while drilling by the stirring blades 3a, 3b and the corotation preventing blade 4, and becomes a mixed soil. Here, the stirring blades 3a, 3b and the corotation preventing blade 4 function as ground improvement blade. FIG.3 is a longitudinal section view illustrating a section of a lower part of the rotating rod of the stirring head A. As understood from this longitudinal section view, a rotation shaft of the present embodiment is the single shaft 1 having tubular form, but not a double wall tube. The drilling hole bit 2 is installed in the ground bottom side of the single shaft 1, this drilling hole bit 2 is driven by a driving motor (not shown) for driving the single shaft 1, and is rotationally driven with the single shaft 1. The external diameter of the drilling hole bit 2 conforms to the external diameter (the inner diameter of a borehole 5) of a ground improvement pillar formed in the ground.

[0031]

A plurality of blades 2a are arranged on a straight line in the radial direction of the drilling hole bit 2, and the drilling hole bit 2 performs drilling and advances in the ground while drilling the bottom surface of the ground improvement pillar. Or, at the distal end of the single shaft 1 near this drilling hole bit 2, a discharge hole 8 is arranged for injecting the ground improving material into the borehole. The ground improving material is provided via a hollow 1a of a pipe arranged at the center of the single shaft 1 from a supply device which is on the ground, and is discharged into the borehole 5 which is arranged in the bottom side of the ground drilled. Stirring blades 3b are installed on the upper part of the drilling hole bit 2. Terminals of the stirring blades 3b are fixed in radial direction by welding to the single shaft 1.

[0032]

That is, the stirring blades 3b comprising of 2 blades each having twisted plate form, the 2 blades are arranged in radial direction in opposition side of the single shaft 1. the stirring blades 3a in which have the same structure and differ 90 degree angle phase are arranged on the single shaft 1 which is positioning at an upper side of the stirring blade 3b. A bearing 7 is fixed to the single shaft 1 between the drilling hole bit 2 and the stirring blades 3b which are arranged at lower part of the single shaft 1. The corotation preventing blades 4 are arranged rotatably to the bearing 7. FIG.4 is a drawing illustrating

installation states of electrodes 9 in the corotation preventing blades 4, and FIG.4(a) is a plan view of the corotation preventing blades 4, FIG.4(b) is a front view of the corotation preventing blades 4.

[0033]

The corotation preventing blades 4, in the present example, four blade bodies 4a having plate like shape are fastened by bolts 6 and extended in radial direction at 90 degrees to each other around the single shaft 1, and blade surfaces of the corotation preventing blades 4 are arranged in parallel with the center line direction of the borehole 5. Thereby a central part 4b of the blade body 4a constitutes a quarter of a cylinder as indicated by its inner peripheral surface 4c (See FIG.4). The central parts 4b of the four blade body 4a constitute 1 cylinder. Outer peripheral end portions 4d of the corotation preventing blades 4 are arranged as contacting with the borehole 5 in longitudinal direction (See FIG.1).

[0034]

In other word, the external diameter at the distal end of the outer peripheral end portion 4d of the corotation preventing blade 4 is configured larger than a rotating circle locus of the peripheral surface of the drilling hole bit 2. A end portion 4e of the corotation preventing blade 4 in the side of the central part 4b is in parallel with the adjacent central part 4b of the corotation preventing blade 4, the terminal part 4e is fastened to the central part 4b by the bolt 6. The electrodes 9 of the ground change monitoring device 20 constituting the present invention are arranged at the outer peripheral end portions 4d of every blade bodies 4a. The ground resistivity is measured by the four electrodes 9 totally (Described in detail below.).

[0035]

[Water swivel 10]

A water swivel 10 is mounted on an upper part of the single shaft 1. The water swivel 10 is a T-joint for providing continuously the ground improving material to the single shaft 1. Therefore, the water swivel 10 is comprising of a part corotating with the single shaft 1, an shaft which is not rotating, a bearing, a seal etc. Structure and function of the water swivel 10 is publicly known, and the explanation is omitted. A rotation part of the water swivel 10 is integral with the single shaft 1 and rotates together. As described below, a wireless transmitter 22 is loaded on the rotation part of the water swivel 10 for receiving measured signals from a receiver 25 in which located under ground and for transmitting the measured signals to outside. A hose locking member 11 is arranged

integrally at a fixing part of the water swivel 10. The hose locking member 11 fixes a hose which provides the ground improving material.

[0036]

[Construction example of ground improvement method]

Next, a method for performing the ground improvement by using the soil improving machine is described. When penetrating into the ground, the single shaft 1 is driven rotary by a driving unit of the ground improvement machine. This rotation, the drilling hole bit 2 and a plurality of blades of the blade bodies 2a bite-in the ground, and transfer the drilled earth upward. With the progress of the ground penetration, the central part of the corotation preventing blade 4 is supported rotatably by the bearing 7.

[0037]

Because a perimeter end circle locus of the corotation preventing blade 4 is configured larger than the borehole 5, when drilling, the outer peripheral end portion 4d (FIG.4) of the corotation preventing blade 4 bites in a wall surface of inner side of the borehole 5, therefore the corotation preventing blade 4 becomes a rotation stop state in which the corotation preventing blade 4 is not rotating. While the corotation preventing blades 4 are in the rotation stop state, when the stirring head A is in progress in the borehole 5 but also retreating, the ground resistivity is measured by the electrodes 9 of the round change monitoring device 20. Thus, the ground state can be grasped. Because the drilling hole bit 2 and the stirring blades 3a, 3b drill while continuing rotation, the corotation preventing blades 4 are in a relative rotation state, in other words, only the corotation preventing blades 4 are in the rotation stop state and the drilling hole bit 2 and the stirring blades 3a, 3b progress in the drilling direction while biting in the surface of the borehole 5 in the rotation shaft direction.

[0038]

In this time, the ground improving material is injected simultaneously and is discharged from the discharge hole 8. Simultaneously with the drilling, by this injection, the drilling earth drilled is stirred with the ground improving material by the stirring blades 3a, 3b and the corotation preventing blades 4, and then becomes the mixed soil. As a result of this stirring, it elevates upward relatively and gradually. In this stirring, between the stirring blades 3a, 3b rotating and the corotation preventing blades 4 stopping rotating, the drilling earth is cut by shear force and is stirred while converting in the rotation direction and in the up-down direction. As well, as mentioned above, structure and function of the stirring head A is a publicly known technique.

[0039]

[Ground change monitoring device 20]

In the stirring head A described above, the ground change monitoring device 20 constituting the present invention is described below. An overview of the ground change monitoring device 20 is illustrated with a block diagram in FIG.5. The ground change monitoring device 20 is consisting of the electrodes 9 arranged at the outer peripheral end portions 4d of the corotation preventing blades 4, a receiver 21, a wireless transmitter 22, a computing machine 24 etc. The receiver 21 is comprising of and a receiver 25 connected with the electrodes 9 by electrical wires, and a repeater 26, converts analog signals detected by the electrodes 9 into digital data at the receiver 25, and sends it to the repeater 26 by wireless communication as measured signals.

[0040]

The repeater 26 transmits the measured signals to the wireless transmitter 22. The wireless transmitter 22 transmits the measured signals received from the receiver 21 to the computing machine 24. The computing machine 24 receives the measured signals, analyzes it, and output the situation of the ground improvement for displaying on a display. The wireless transmitter 22 and the repeater 26 are connected with by any communication means such as wired means, wireless means etc. In an example shown in FIG.5, they are connected by electrical wires 23. FIG.3 is illustrating a situation that the receiver 21 is arranged in the corotation preventing blade 4. The repeater 26 is arranged in the lower part of the single shaft 1.

[0041]

In general drilling work, the lower part of the single shaft 1 is located underground, therefore the repeater 26 is located underground and relays signals transmitted from the receiver 25. The repeater 26 is connected with the electrical wire 23, and transmits the measured signals to the wireless transmitter 22 via the electrical wire 23. The electrical wire 23 is arranged in a hollow 1b between pipes inside the single shaft 1 having tubular form. The receiver 25 is fixed at the corotation preventing blade 4, and the repeater 26 is fixed at the single shaft 1. The receiver 25 is arranged at the blade body 4a of the corotation preventing blade 4 or the bearing 7, and the repeater 26 is arranged at the bearing 7 respectively.

[0042]

The electrical wire 23 is wired in the hollow 1b between the pipes inside the single shaft 1 having tubular form. To wire the electrical wire 23 between the single shaft 1 and the bearing 7, as shown in FIG.3, a through hole 1c and a through hole 7a are provided. The through hole 1c is a hole through a pipe wall of the lower part of the single

shaft 1, is linked with the hollow 1b between the pipes, and passes through the through hole 7a of the bearing 7. The electrical wire 23 is wired through the through hole 1c. The through hole 7a is a through hole or a non-through hole arranged in the bearing 7, the electrical wire 23 and the repeater 26 connected at the distal end of the electrical wire 23 are arranged in the through hole 7a.

[0043]

As shown in FIG.1, to arrange the electrical wire (not shown), a groove is provided in radial direction in the blade body 4a of the corotation preventing blade 4. The blade body 4a of the corotation preventing blade 4 and a blade surface always contact with the drilling earth and the ground improving material, therefore the electrical wire and the receiver 25 are preferably arranged not to project from the blade surface as much as possible, or are preferably sealed by filler and the like to prevent from the drilling earth. The electrode 9 is arranged, as shown in FIG.4, in the front of the outer peripheral end portion of the blade body 4a of the corotation preventing blade 4. The electrode 9 is connected with the receiver 21 by the electrical wire (not shown).

[0044]

The blade body 4a of the corotation preventing blade 4 and the blade surface always contact with the drilling earth and the ground improving material, therefore the electrode 9 is arranged by embedding in the blade surface or in the blade, and is fixed by a fixing means such as screw. Also, the electrode 9 and the electrical wire can be fixed in the blade surface by adhesive. In this case, there is no need additional parts, therefore becomes cheaper. Also, the electrode 9 and the electrical wire is embedded in a groove and the like provided in the blade surface or the blade, and it is fixed by a seal over it. Because the electrode 9 is fixed at the blade surface of the corotation preventing blade 4, when the corotation preventing blade 4 rotates, the electrode 9 rotates with the corotation preventing blade 4.

[0045]

FIG.6 is a block diagram illustrating an overview of the receiver 25. Any communication means having function to transmit the measured signals by the wireless communication such as analog communication means, digital communication means can be used as the receiver 25. About structure and function of the receiver 25, not limited here, the receiver 25 shown in FIG.6 is described as an example. The receiver 25 is comprising of a wireless transmitter body 40, an antenna 47, a receiver 48, a power supplier 46 and the like stored in a housing (not shown). The wireless transmitter body

40 processes the measured signals detected receiver 48, and transmits is by wireless communication via the antenna 47.

[0046]

The wireless transmitter body 40 is comprising a central processing unit (CPU) 41 for controlling the entire device by executing predetermined commands, a memory 42 storing control program including commands, data etc, a communication part 43 for controlling communications, a receiver 44 for receiving signals detected by the electrode 9 and converting into digital signal, a bus 45 connecting these configuration parts to make data exchange each other, etc. The power supplier 46 is a secondary battery for power supply to the wireless transmitter body 30, and alkaline battery, lithium ion battery and the like can be used as the secondary battery. The power supplier 46 is preferably a small sized button battery or the like having a large capacity.

[0047]

The detected signals detected by the receiver 48 is processed by the receiver 44, digitalized and converted into digital measured signals, and transmitted to the communication part 43. The communication part 43 converts the measured signals into signal for communication, and transmits them as wireless signals by the antenna 47. The wireless signals transmitted from the antenna 47 is received by the repeater 26. The receiver 25 has an antenna, and performs wireless communication with the repeater 26. Thus, the housing of the receiver 25 is preferably made of materials which does not obstacle radio waves for wireless communication. When the housing is made of metallic material having characteristics to block radio waves, a part of the housing where the antenna is installed is preferably made of non-metallic material.

[0048]

[Repeater 26]

Any communication means having functions of receiving the measured signals transmitted from the receiver 25, and transferring them to the wireless transmitter 22 such as analog communication means, digital communication means can be used as the repeater 26 (see FIG.3, FIG.5). For example, the repeater 26 is comprising of a body and an antenna stored in a housing (not shown). The body, not shown, is comprising of a central processing unit (CPU) for controlling an entire device by executing predetermined commands, a memory storing control program including commands, data etc, a communication part for controlling communications, a receiver for receiving detected signals etc. A connecting terminal of the repeater 26 (not shown) is connected with the wireless transmitter 22 via the electrical wire 23, therefore the measured signals can be

transmitted. The present invention is not intended to invent the repeater 26, therefore the detailed description is omitted.

[0049]

[Wireless transmitter 22]

The wireless transmitter 22 is loaded in the water swivel 10, especially in a rotation part thereof. Any communication means, which is having function of receiving the measured signals transmitted from the receiver 21, and transmitting them by wireless communication, such as analog communication means, digital communication means can be used as the wireless transmitter 22. For example, the wireless transmitter 22 and the computing machine 24 communicate with each other by a communication method conforming any wireless communication standard such as Wi-Fi, Bluetooth (registered trademark). The wireless transmitter 22 is comprising, for example, a wireless transmitter body and an antenna stored in a housing (not shown). The wireless transmitter body is a device for processing the measured signals, and for sending them by wireless communication.

[0050]

The wireless transmitter body is comprising of a central processing unit (CPU) for controlling an entire device by executing predetermined commands, a memory storing control program including commands, data etc, a communication part for controlling communications, a receiver for receiving detected signals and converting them into digital signals etc. A connecting terminal of the wireless transmitter 22 is connected with the repeater 26 via the electrical wire 23, therefore the measured signals from the receiver 25 can be received. The present invention is not intended to invent the wireless transmitter 22, therefore the detailed description is omitted.

[0051]

[Computing machine 24]

The computing machine 24 is a general-purpose electronic computing machine having a central processing unit (CPU) for controlling an entire device by executing predetermined commands, a memory storing control program including commands, data etc, a communication means for communicating with the wireless transmitter 22, and an input/output means. For example, a general-purpose computing machine such as a personal computer, a tablet terminal, a smartphone can be used as the computing machine 24. The computing machine 24 communicates with the wireless transmitter 22, for example, by adopting a communication method conforming to any wireless

communication standard such as Wi-Fi, Bluetooth, etc. These wireless communication standards are publicly known, therefore the detailed description is omitted.

[0052]

When the stirring head A is driving down, the ground resistivity is measured by using electrodes 9 arranged at the outer peripheral end portions of the corotation preventing blades 4 (Step 3). The measured signals, as shown in FIG.5, are transmitted to the computing machine 24 via the receiver 25, the repeater 26, and the wireless transmitter 22 (Step 4). The computing machine 24 receives and accumulates the measured signals, and stores them in a auxiliary storage device in association with the working depth, elapsed time and the like of the stirring head A (Step 5). Thus, when the drilling hole bit 2 of the stirring head A is reached predetermined depth while drilling the ground and mixing with the improved materials, the drilling hole bit 2 stops to descend (Step 6). Then, the drilling hole bit 2 of the stirring head A starts to drive upward while rotating and performing the ground improvement (Step 6). When the stirring head A is driving upward, the ground resistivity is measured by using the electrodes 9 arranged the outer peripheral end portions 4d of the corotation preventing blades 4 (Step 7).

[0053]

The measured signals, as shown in FIG.5, are transmitted to the computing machine 24 via the receiver 25, the repeater 26, and the wireless transmitter 22 (Step 8). The computing machine 24 receives and accumulates the measured signals, and stores them in the auxiliary storage device in association with the working depth, elapsed time and the like of the stirring head A (Step 9). Thus, the computing machine 24 obtains the measured signals when the stirring head A is descending and moving upward. The ground state, the ground improvement state can be grasped by comprising the measured signals when descending and the measured signals when moving upward (Step 10).

[0054]

[About measurement]

FIG.8 illustrates an arrangement of the electrode 9. In the present embodiment of the present invention, four electrodes 9 are used, and reference numerals are assigned to the electrodes 9a, 9b, 9c and 9d respectively as shown in FIG.8. The 2 electrodes 9 arranged in the circumference of the single shaft 1 are applied electric current, voltage is measured by the rest 2 electrodes 9. An example shown in FIG.8, the voltage is measured by the electrodes 9c, 9d while flowing the electric current in the electrodes 9a, 9b. Also, the voltage can be measured by the electrodes 9a, 9b while flowing the electric current in the electrodes 9c, 9d. Generally, the voltage is measured by the adjacent 2 electrodes

while flowing the electric current in the rest electrodes. As shown conceptually in FIG.8, the voltage is measured by a voltmeter, the electric current is measured by an ammeter. In one example, when the electrodes 9a, 9b is being supplied constant electric current, the voltage can be measured by the electrodes 9c, 9d. In such a manner, only the voltage is measured, therefore the measured signals become fewer.

[0055]

Also, in one example, when change the electric current flowing in the electrodes 9a, 9b, the electric current is measured by the ammeter, the voltage is measured by the voltmeter. The measured signals are finally transmitted to the computing machine 24 from the receiver 25. The computing machine 24 processes the measured signals received, and calculates the change of the resistivity from the electric current and the voltage. The ground resistance is inversely proportional to the distance between the electrodes installed in the ground. In case of ground, below explained with reference FIG.9 that how to calculate the resistivity ρ , more specifically, theoretical equation by buried electrodes and how to calculate apparent resistant by square arrangement in the ground

[0056]

FIG.9 is illustrating conceptually point electrodes buried in the ground. Here, z indicates the buried depth of the point electrode. When there is a point electric current electrode at a point C underground in which $+I$ electric current is supplied, theoretical potential V_P at the point P can be calculated as the next equation by considering a virtual electrode (mirror image) C^* in the air.

[Equation 1]

$$V_p = \frac{\rho I}{4 \pi} \left(\frac{1}{r_1} + \frac{1}{r_2} \right)$$

Here, V_P is theoretical potential at the point P, ρ is resistivity, I is electric current at the point C, r_1 is distance between point C and point P, and r_2 is distance between the virtual electrode C^* and the point P.

[0057]

FIG.10 is a drawing an arrangement example of two electric current electrodes and two potential electrodes arranged in a square shape, and FIG.10(a) is a plan view thereof, and FIG.10(b) is a section view thereof. In FIG.10(b), the point C is illustrated in the front side, the point A is in the back side of paper and overlaps the point C, therefore the point A is not visible in the drawing. In FIG.10, the point A and the point B are

arrangement positions of the electric current electrodes, the point C and the point D are arrangement positions of the potential electrodes.

[0058]

The point A, the point B, the point C and the point D shown in FIG.10 are conceptually shown the electrodes 9 arranged at the outer peripheral end portion 4d of the blade body 4a of the corotation preventing blade 4 as shown in FIG.4. The buried depth of the point A, the point B, the point C and the point D is z. As shown in FIG.10, in the ground, theoretical potential detected by the potential electrodes is expressed as the next equation.

[Equation 2]

$$\begin{aligned} V &= \frac{\rho I}{4\pi} \left(\frac{1}{\sqrt{2}a} + \frac{1}{\sqrt{2a^2 + 4z^2}} \right) - \frac{\rho I}{4\pi} \left(\frac{1}{2a} + \frac{1}{2\sqrt{a^2 + z^2}} \right) \\ &\quad + \frac{\rho I}{4\pi} \left(\frac{1}{\sqrt{2}a} + \frac{1}{\sqrt{2a^2 + 4z^2}} \right) - \frac{\rho I}{4\pi} \left(\frac{1}{2a} + \frac{1}{2\sqrt{a^2 + z^2}} \right) \\ &= \frac{\rho I}{2\pi} \left(\frac{1}{\sqrt{2}a} - \frac{1}{2a} + \frac{1}{\sqrt{2a^2 + 4z^2}} - \frac{1}{2\sqrt{a^2 + z^2}} \right) \end{aligned}$$

Here, V is theoretical potential between the point D and the point C, ρ is resistivity, I is electric current flowing the point A and the point B, a is distance between the center point O of the corotation preventing blade 4 and the point A, the point B, the point C and the point D, z is buried depth of the electrodes.

[0059]

The apparent specific resistivity ρ_a obtained from Equation 2 is expressed as the next equation.

[Equation 3]

$$\rho_a = 2\pi \left(\frac{1}{\sqrt{2}a} - \frac{1}{2a} + \frac{1}{\sqrt{2a^2 + 4z^2}} - \frac{1}{2\sqrt{a^2 + z^2}} \right)^{-1} \frac{V}{I}$$

[0060]

By the calculation, the change of the apparent resistivity ρ_a is obtained by using Equations 1 to 3. Particularly, at the each part of the ground, the resistivity when the stirring head A descends and the apparent resistivity when the stirring head A moves upward are compared to calculate how much the ground changed. Thereby, it can be grasped whether or not the ground has been properly improved.

[0061]

[Others]

When the single shaft 1 is long, the single shaft 1 is consisting of an upper single shaft and a lower single shaft, the upper single shaft and the lower single shaft are may connect in male and female form. In this connection part, a through hole is provided, and the electrical wire 23 let through this. Also, a resseded parts or the like are provided in the lower end of the upper single shaft and the upper end of the lower single shaft, and the electrical wire 23 can be connected by non-contact terminals. This non-contact terminal is publicly known, and the detailed explanation is omitted.

[0062]

ZigBee Coordinator (hereinafter referred to as ZC) and ZigBee End Device (hereinafter referred to as ZED), which are communication devices conforming the near filed wireless communication standard ZigBee, can be used as the repeater 26 and the wireless transmitter 22. ZC as the repeater 26 is connected with the wireless transmitter 22 by the electrical wire 23. ZED is connected to the receiver 25. ZED receives the measured signals detected by the receiver 25, and transmits to ZC by wireless communication. ZC transmits the measured signals received from ZED to the wireless transmitter 22.

[0063]

The wireless communication between ZC and ZED is performed by antennas connected each of them respectively. ZigBee is standardized as IEEE 802.15.4 standard as the specifications of the lowest physical layer and data link layer among the 7 hierarchy layers of communication protocols based on the ISO reference model developed by the International Organization for Standardization (ISO). ZigBee has the features that the transfer distance of communication data is short, the transfer speed is low, and the power consumption is low. Since a device conforming ZigBee is cheep and has low power consumption, there is an advantage that it can be used over a long period, therefore the device is used in a sensor network for main purpose.

[0064]

A device conforming ZigBee operates in the frequency bands 2.4GHz, 902-928MHz, and 868-870MHz. ZC and ZED is comprising a radio circuit for controlling wireless communication, a microcomputer for performing controlling the entire device, a memory for storing data, a peripheral circuit for controlling communication with an external device connected with the device, a built-in antenna for wireless communication with the external device, a connector for external antenna for connecting the external antenna for wireless communication with the external device etc.

[0065]

The microcomputer is comprising a central processing unit (CPU), RAM, a flash memory etc. As described above, data communication by the pair of ZC and ZED conforming ZigBee standard is described. However ZigBee Router(ZR) that is a device for relaying data between ZC and ZED can be used. Basically, a device having the same configuration as ZC can be used as ZR, but it should be set as a router. The communication between ZC, ZED and ZR is publicly know, and the detailed description is omitted.

[0066]

The repeater 26 and the wireless transmitter 22 can communicate with each other in compliance with the Bluetooth standard which is a short range wireless communication standard. Bluetooth standard is a standard which can communicate within tens of meter distance or thereabouts, and is know as IEEE802.15.1. Bluetooth standard is a standard that performs wireless communication with relatively low speed between information devices by using 2.4 GHz band. The repeater 26 and the wireless transmitter 22 embed communication modules conforming to Bluetooth standard respectively, and communicate with each other. Bluetooth standard adopted to communication between the repeater 26 and the wireless transmitter 22 can adopt any version of version 1 to 5, particularly, version 3 or 4 which allows communication devices to operate with power saving is preferable. Bluetooth standard is spread and used world widely, therefore the detailed description is omitted.

[0067]

[A SECOND EMBODIMENT OF THE INVENTION]

Next, the second embodiment of the present invention is described based on drawings. In the second embodiment, a ground change monitoring device which is comprising of the present invention is basically the same as the ground change monitoring device of the first embodiment, and here is described only different parts. In the ground change monitoring device in the second embodiment, FIG.11 is a drawing illustrating an arrangement state of the electrodes 9 inside the corotation preventing blades 4.

[0068]

The corotation preventing blade 4 has structure as the same as FIG.4, and the detailed description is omitted. The electrodes 9 are arranged in the center part of every blade body 4a of the corotation preventing blade 4 respectively. The ground resistivity is measured by total of 4 electrodes 9. Thus, when the electrodes 9 are arranged, resistivity inside the ground improvement pillar in which the ground improvement is performing is

measured. In this case, the calculation of the resistivity is performed as next. When the stirring head A is descending, the ground resistivity is measured by using the electrodes 9 arranged in the central parts of blade bodies 4a of a corotation preventing blades 4.

[0069]

The measured signals are transmitted to the computing machine 24 via the receiver 25, the repeater 26, and the wireless transmitter 22. When the drilling hole bit 2 of the stirring head A is reached predetermined depth while drilling the ground, the drilling hole bit 2 stops to descend. Then, it moves upward rotately while performing the ground improvement. When the stirring head A is moving upward, the ground resistivity is measured by using the electrodes 9. The measured signals transmitted to the computing machine 24 via the receiver 25, the repeater 26, and the wireless transmitter 22 as the same as the abovementioned the first embodiment. The computing machine 24 accumulates the measured signals of when descending or moving upward the stirring head A, and stores them in the auxiliary storage device in association with the working depth, elapsed time or the like of the stirring head A. By analyzing these measured signals, the state of the ground improvement can be obtained.

[0070]

[A THIRD EMBODIMENT OF THE INVENTION]

Hereinafter, a third embodiment of the present invention will be described based on drawings. In the third embodiment, the ground change monitoring device which is comprising the present invention is basically the same as the ground change monitoring device of the first or second embodiment except a communication means, and here is described only different parts.

[0071]

FIG.12 is illustrating an overview of a ground change monitoring device of the third embodiment of the present invention. The ground change monitoring device of the third embodiment of the present invention is comprising of a resistivity measurement unit 50 arranged near the corotation preventing blade 4, a communication part 51 arranged on the upper part of the single shaft 1. As shown in FIG.13, the resistivity measurement unit 50 is arranged at the distal end of the single shaft in the borehole 5, and is comprising of electrodes 9 for detecting ground resistivity, a resistivity signal processing unit 52 processing signals detected the electrodes 9, a second coil 53 for receiving and transmitting signals to the communication part 51 by magnetic resonance coupling. The electrodes 9 are arranged at the corotation preventing blades 4 as above described the first embodiment of the present invention. The electrode 9 is a sensor for detecting the

resistivity of the ground in which is in the ground improvement, and is described detail above, therefore the detailed description is omitted.

[0072]

The resistivity signal processing unit 52 produces transmission signal to transmit by processing signals detected by the electrodes 9, and transmits the transmission signal to the communication part 51 via the second coil 53. Also, the resistivity signal processing unit 52 analyzes signals received by the second coil 53, and performs controlling the resistivity measurement unit 50. The communication part 51 is comprising of a first coil 54 for receiving signals from the resistivity measurement unit 50, a transceiver 55 for processing the signals received, a wireless transceiver 56 for transmitting signals received from the transceiver 55 to external device by wireless communication. The communication part 51 is comprising of arranged in the upper part or the like of the water swivel 10 of the single shaft 1 as the transceiver 55 and the first coil 54 as shown in FIG.14.

[0073]

[Magnetic resonance coupling]

In the magnetic resonance coupling, when 2 resonance circuits installed away from each other operate at same frequency, occurs a magnetic resonance phenomenon and electric power is transmitted from one of the resonance circuits to the other one of the resonance circuits. In detail, these 2 resonance circuits are a primary side resonance circuit and a secondary side resonant circuit, and by tuning both of them having the same resonance frequencies, occurs the magnetic resonance and can transmit electric power with high efficiency. The present invention uses such a principle of the magnetic resonance coupling, a circuit having the first coil 54 is called the primary side resonance circuit, a circuit having a second coil 53 is called the secondary side resonant circuit, and the resonance frequencies are the same respectively. In reverse, a circuit having the first coil 54 can be called the secondary side resonance circuit, and a circuit having a second coil 53 can be called the primary side resonant circuit.

[0074]

In this example, the communication is being performed by using the primary side resonance circuit having the first coil 54 and the secondary side resonant circuit having the second coil 53. In example shown in FIG.13, the second coil 53 is arranged in the central part of the corotation preventing blades 4 as winding around the single shaft 1. The detected signal from the electrodes 9 is processed at the resistivity signal processing unit 52. The signals output from the resistivity signal processing unit 52 is transmitted to the first coil 54 of the communication part 51 from the second coil 53.

[0075]

Thus, the second coil 53 is preferably arranged in close place from the resistivity signal processing unit 52, but not limited. The communication part 51 including the first coil 54 is arranged on the water swivel 10, a clamp, or the upper part of the single shaft 1. The first coil 54 is arranged as winding around the outside of the single shaft 1. If the arrangement place is not to obstacle the operating function of machine, can be arranged at the arbitrary place. As shown in FIG.14, the first coil 54 is arranged at the lower part of the water swivel 10, and the transceiver 55 is arranged on the water swivel 10. The first coil 54 and the second coil 53 are comprising of electric wire having insulation coating. The first coil 54 and the second coil 53 are arranged being concentricity with the single shaft 1 as winding the circumference of the single shaft 1. However, if to sacrifice sensitivity, there is no necessary to arrange the first coil 54 and the second coil 53 being concentricity.

[0076]

FIG.15 illustrates an arrangement of the electrodes 9. In the present embodiment of the present invention, eight electrodes 9 are used, and reference numerals are assigned to the electrodes 9e, 9f, 9g, 9h, 9i, 9j, 9k and 9l respectively as shown in FIG.15. The electrodes 9e, 9f, 9i and 9j are arranged in the front of the outer peripheral end portion 4d of the blade body 4a of the corotation preventing blade 4. The electrodes 9g, 9h, 9k and 9l are arranged at the front of the terminal part 4e of the central part 4b side of the corotation preventing blade 4. The electrode 9e and the electrode 9f are arranged at the opposition position each other.

[0077]

As the same, the electrode 9i and the electrode 9j, the electrode 9g and the electrode 9h, and the electrode 9k and the electrode 9l are arranged respectively. The electrode 9g, 9h, 9k and 9l arranged near the central part 4b of the corotation preventing blade 4 measures resistivity in the borehole 5 and circumference of the single shaft 1. In other words, the electrodes 9g, 9h, 9k and 9 measure the state of mixing of the ground improving material and the drilling earth in the borehole 5. In the present example, 2 electrodes 9k, 9l measure voltage, and electric current is measured by supplying electric current to the 2 electrodes 9g, 9h.

[0078]

Since the electrodes 9e, 9f, 9i and 9j arranged at the outer peripheral end portion 4d of the blade body 4a of the corotation preventing blade 4 are placed at the outside of the borehole, they measure resistivity of the ground outside the borehole 5. In the present

example, the 2 electrodes 9i, 9j measure voltage, and electric current is measured by supplying electric current to the 2 electrodes 9e, 9f. Thus, the resistivity inside the borehole is measured by both of the voltage and electric current. As the same, the resistivity outside the borehole is measured by both of the voltage and electric current. When electrodes 9 are arranged at the blade body 4a of the corotation preventing blade 4, the electrodes 9 are isolated from the blade body 4a by insulation material, the measuring surface is directly contact with ground, the drilling earth, the ground improving material etc.

[0079]

FIG.16 is a graph showing data example measured resistivity by the ground change monitoring device. The horizontal axis of the graph shown in FIG.16 shows value of resistivity [$\Omega \cdot m$], the vertical axis shows the depth of drilling. The ground resistivity changes by the proportion of clay, sand, stone or the like constituting the ground. More detail, data is obtained in advance while drilling, and when the ground improvement, data is obtained as the same, then they are compared. This example is shown in FIG.16. When drilling in the case of no the ground improvement, the resistance becomes higher as the drilling depth becomes deeper.

[0080]

In the first time example of drilling when the ground improvement, the resistance is constant as the drilling depth becomes deeper. This is, in the ground improvement, it indicates that the ground improving material, for example cement and the drilling earth are mixed uniformly inside the drilling pile. In the second time example of drilling when the ground improvement, the resistance becomes lower suddenly at first, then becomes constant, and becomes high at last as the drilling depth becomes deeper. This is, since the resistivity has high deviation than around soils, it may indicate that the soil is not stirred.

[0081]

In other words, in the ground improvement, when the ground improving material is injected into the drilling earth, it indicates that the corotation preventing blade may rotate together. This, using the monitoring system of the present invention, by measuring the resistivity in the ground improvement, it can be confirm whether properly mixed the ground improving material and the drilling earth. Also, in the case of layers constituting the ground are different, it can be confirm that reached to the support layer. The reason is that the resistivity is changed when reached to the support layer. To understand from the above explanation, by comprising the absolute value of the measured resistivity value, or

the rate of change or the like and the predetermined known resistivity value, it can be determine the suitability of the improved soil and the nature of the ground.

[0082]

[Circuit example of magnetic resonance coupled communication]

FIG.17 is a circuit diagram showing an overview of an circuit example of a magnetic field resonance communication the ground change monitoring device of the third embodiment of the present invention. The magnetic resonance coupled communication is comprising of a transmitting circuit part 70 and a receiving circuit part 71. As shown in FIG.17 the single shaft 1 is illustrated by dashed line, the second coil 53 and the first coil 54 are arranged winding the single shaft 1 and having distance L. The transmitting circuit part 70 is comprising the second coil 53, a capacitor 72, and a transmitting circuit 72. The second coil 53 is illustrated in FIG.12. The second coil 53 and the capacitor 72 are tuned as being resonance at the predetermined frequency, and constitutes a resonance circuit.

[0083]

The second coil 53 and the capacitor 72 are connected in parallel, the transmitting circuit 72 is connected to its output terminal. The transmitting circuit 72 is a communication means that is a load of the resonance circuit, and included in the resistivity signal processing unit 52 shown in FIG.12. The transmission signal output from the resistivity signal processing unit 52 is transmitted via a resonance circuit comprising of the second coil 53 and the capacitor 72. The receiving circuit part 71 is for receiving transmission signals output from the transmitting circuit part 70, and is comprising of the first coil 54, the capacitor 74, and receiving circuit 75. The first coil 54 is shown in FIG.12.

[0084]

The first coil 54 and the capacitor 74 are tuned to resonance at the predetermined frequency, and comprising a resonance circuit. The first coil 54 and the capacitor 74 are connected in parallel, the receiving circuit 75 is connected its output terminal. The receiving circuit 75 is a load of the resonance circuit, and is a receiving means of the magnetic resonance coupled communication including a transceiver 55 shown in FIG.12. The receiving circuit 75 receives above mentioned transmission signal via a resonance circuit comprising of the second coil 53 and a capacitor 72, processes the received signal, and transmits to a wireless transmitter/receiver 56.

[0085]

The resonance circuit comprising of the second coil 53 and the capacitor 72 and the resonance circuit comprising of the first coil 54 and the capacitor 74 operate at the

same frequency, and communicate by magnetic resonance coupling. In other words, in this magnetic resonance coupling, 2 resonance circuits, which are having a resonance state of a coil and a capacitor, coupled by magnetic field and performs power transmission. Thus, it is a wireless power transmission, and is nonradiative and combined type power transmission. The magnetic resonance coupling used in the present invention is operated at the 10kHz to 100MHz frequency.

[0086]

FIG.18 is a block diagram showing an overview of a circuit example a magnetic resonance coupled communication of a ground change monitoring device of the third embodiment of the present invention, and FIG.18(a) is a block diagram illustrating a configuration example of a transmitting circuit 73, and FIG.18(b) is a block diagram illustrating a configuration example of a receiving circuit 75. The transmitting circuit 73 is comprising a modulation part 80 for modulating as to communicate by digital signal, an amplifier 81 for amplifying digital signal and the like, and is connected to a resonance circuit including a second coil 53.

[0087]

As shown in FIG.18(a), the modulation part 80 modulates digital signal which is signal detected by the electrode 9, the amplifier 81 amplifies the modulated signal until it reaches a predetermined intensity, and transmits by the magnetic resonance coupled communication via the second coil 53 of the resonance circuit. The receiving circuit 75 is comprising a tuning part 82 for receiving signal by tuning the first coil 54, an amplifier 83 for amplifying signal, a demodulation part 84 for outputting digital signal demodulated the amplified signal received etc. The modulation part 80 can adopt modulation methods such as intensity modulation, load modulation or the like.

[0088]

As shown in FIG.18(b), the first coil 54 is coupled to the second coil 53 by the magnetic resonance coupling. Then, the tuning part 82 receives signals by tuning with the first coil 54. This signal is a signal modulated by the modulation part 80 described above. The amplifier 83 amplifies signal output from the tuning part 82 until it reaches the predetermined intensity. The demodulation part 84 demodulates the amplified signal, and output digital signal. This digital signal is the same digital signal to the digital signal before the modulation by the modulation part 80 above mentioned. The digital signal output the demodulation part 84 is transmitted to the wireless transmitter/receiver 56 (See FIG.12).

[0089]

[Resistivity signal processing unit 52]

FIG.19 is illustrating by a block diagram an overview of a concrete configuration example of a resistivity signal processing unit 52. The resistivity signal processing unit 52 is comprising a potential measurement amplifier circuit 60, a control arithmetic circuit part 61, an electric current generating circuit part 62, an electric current detection circuit part 63, a battery 64, a drive circuit part 65, a detection circuit part 66, an amplifier circuit part 67 etc. The potential measurement amplifier circuit 60 is a circuit for measuring potential of the electrode 9, and for amplifying electric signal measured.

[0090]

The control arithmetic circuit part 61 is a circuit for receiving output signals output from the potential measurement amplifier circuit 60 and the control arithmetic circuit part 61, controlling them and calculating them. The electric current generating circuit part 62 is a circuit for generate an electric current to flow to the electrode 9. The electric current detection circuit part 63 is a circuit for detecting electric current of the electrode 9. The battery 64 is a battery for supplying necessary electrical power to the resistivity signal processing unit 52, and is comprising of arbitrary accumulation means such as a primary battery and a secondary battery. The drive circuit part 65 is a circuit for controlling the second coil 53, the control arithmetic circuit part 61 or the like, particularly, controls the second coil 53, and adjusts the resonance frequency.

[0091]

The detection circuit part 66 is a circuit for detecting signal that is related to the resistivity from the arithmetic signals which is output from the control arithmetic circuit part 61. The control arithmetic circuit part 61 converts the resistivity signal from the high frequency signal or the like into DC signal and output it. This resistivity signal is amplified by the amplifier circuit part 67, and transmitted to the second coil 53. The communication between the first coil 54 and second coil 53 is communication by magnetic resonance coupling via the single shaft 1. The first coil 54, not shown in FIG.19, is connected to the capacitor, and is comprising a resonance circuit (see FIG.17).

[0092]

[A FOURTH EMBODIMENT OF THE INVENTION]

Hereinafter, a fourth embodiment of the present invention will be described based on drawings. In the fourth embodiment, a ground change monitoring device which is comprising the present invention is basically the same as the ground change monitoring device of the third embodiment, and here is described only different parts. FIG.20 is a block diagram showing an overview of another circuit example of magnetic resonance

coupled communication of the ground change monitoring device of the fourth embodiment of the present invention.

[0093]

A circuit 90 shown in FIG.20 is a circuit that is realized the transmitting circuit and the receiving circuit, which are used for the magnetic resonance coupled communication, as one circuit. The circuit 90 is comprising of a coil 91, a switch 92, an amplifier 93, a modulation part 94, a tuning part 95, an amplifier 96, a demodulation part 97. The coil 91 has a function of both a transmitting coil and a receiving coil for magnetic resonance coupled communication . By switching the switch 92, the circuit 90 can switches the transmitting circuit having sending function and the receiving circuit having receiving function. In an example of FIG.20, as shown by solid line, when the switch 92 is connected to the first nodal side, the circuit 90 becomes a transmitting circuit. As shown by dashed line, when the switch 92 is connected to the second nodal site, the circuit 90 becomes a receiving circuit. Here, the circuit 90 is described as the transmitting circuit. At first, the switch 92 is connect to the first nodal side, the circuit 90 operates as a transmitting circuit. The digital signal is modulated by the modulation part 94, amplified by the amplifier 93, and transmitted via the resonance circuit including the coil 91 by magnetic resonance coupled communication.

[0094]

Next, the circuit 90 is described as a receiving circuit. The switch 92 is connected to the second nodal side, and the circuit 90 operates as a receiving circuit. The coil 91 is coupled with the coil of a communication partner by magnetic resonance coupling, and the tuning part 95 receives signals by tuning the coil 91. The signal output from the tuning part 95 is amplified by the amplifier 96 until it reaches predetermined intensity. The demodulation part 97 demodulates this amplified signal, and outputs digital signal. Thus, only by switching the switch 92 of the circuit 90, it can be used as a transmitting circuit and as a receiving circuit. As the switch 92 can be used any kind of switch which can operate ON-ON operation such as a push button switch such as 2 contact (bi-directional contact switch, double throw switch), a toggle switch.

[0095]

[OTHER EMBODIMENTS OF THE INVENTION]

In the embodiment mentioned above, the resistivity value was to measure physical properties of the ground and the improved soil, but if necessary, it may be to measure resistivity value of the drilling earth. The measurement of the physical properties were measured when moving upward while mixing the drilling earth and the ground

improving material, but the physical properties of the ground may be measured at the very first ground drilling. Also, in the physical properties of the improved soil, in the case of performing the drilling multiple times, the physical properties are measured every drilling, and the drilling effect may be verified.

[Industrial Applicability]

[0096]

The present invention may be utilized in the fields of civil work and construction. Particularly, in soft ground or the like, it may be utilized in the fields of performing a ground improvement for foundations of structures and buildings such as bridges that are necessary the ground improvement for keeping stability.

[REFERENCE SIGNS LIST]

[0097]

A...Stirring head

1...Single shaft

2...Drilling hole bit

3a, 3b...Stirring blade

4...Corotation preventing blade

4a...Blade body

4d...Outer peripheral end portion(Circumference of corotation preventing blade

4)

5...Borehole

7...Bearing

8...Discharge hole

9...Electrode

10...Water swivel

11...Hose locking member

20...Ground change monitoring device

21...Receiver

22...Wireless transmitter

23...Electrical wire

24...Computing machine

25...Receiver

26...Repeater

50...Resistivity measurement unit

51...Communication part

52...Resistivity signal processing unit
53...Second coil
54...First coil
55...Transceiver
56...Wireless transceiver
60...Potential measurement amplifier
61...Control arithmetic circuit part
62...Electric current generating circuit part
63...Electric current detection circuit part
64...Battery
65...Drive circuit part
66...Detection circuit part
67...Amplifier circuit part
70...Transmitting circuit part
71...Receiving circuit part
72...Capacitor
73...Transmitting circuit
75...Receiving circuit
80...Modulation part
81...Amplifier
82...Tuning part
83...Amplifier
84...Demodulation part
90...Circuit
91...Coil
92...Switch
93...Amplifier
94...Modulation part
95...Tuning part
96...Amplifier
97...Demodulation part

CLAIMS

1. A resistivity sensing device using a ground improvement blade, in a soil improving machine performing a ground improvement in a borehole by drilling the borehole by drilling a ground, and mixing the drilled earth and a ground improving material, said soil improving machine comprising:

- a single shaft having a discharge hole driving rotary by a rotary drive device for discharging said ground improving material,

- a blade body being fixed to said single shaft, and drilling said drilling earth and said ground improving material inside said borehole,

- a drilling hole bit being installed on a ground bottom side terminal of said single shaft and having plural drilling blades for drilling said borehole,

- a corotation preventing blade being installed rotatably on said single shaft, being stopped rotation by engaging a outside terminal of said corotation preventing blade to a peripheral wall of said borehole, and mixing and drilling a drilling earth drilled by a relative rotation of said blade body and said drilling hole bit with said ground improving material,

- wherein said resistivity sensing device comprising:

- a resistivity measuring means comprising electrodes installed said corotation preventing blade and a measuring means connected said electrodes to measure physical properties of improved soil in which mixed said ground or said drilling earth and said ground improving material, for measuring a first resistivity which is said resistivity of said ground and/or a second resistivity which is resistivity of said improved soil, and for outputting said measured signals, and

- a communication means connected to said resistivity measuring means for transmitting said measured signals to a ground or said single shaft.

2. The resistivity sensing device using a ground improvement blade according to claim 1, wherein said resistivity sensing device comprising:

- a determination means for receiving said measured signals from said communication means; determining said physical properties of said ground or said improved soil from rate of change of said first resistivity and/or said second resistivity, and/or said first resistivity and/or said second resistivity; and outputting the determination result signal.

a display means for displaying said determination result signal on a display device.

3. The resistivity sensing device using a ground improvement blade according to claim 2, wherein said determination means determines by an absolute value of said first resistivity and/or said second resistivity, or by rate of change of said first resistance and/or said second resistivity.

4. The resistivity sensing device using a ground improvement blade according to a claim selected from claims 1 to 3, wherein said resistivity measuring means has a data processor for converting analog data of said measured signals detected by said electrodes to digital data, and for sending it to said communication means.

5. The resistivity sensing device using a ground improvement blade according to a claim selected from claims 1 to 3, wherein said electrodes are installed on a part of said corotation preventing blade locating inside of said Borehole for measuring said resistivity of said improved soil.

6. The resistivity sensing device using a ground improvement blade according to a claim selected from claims 1 to 3, wherein said electrodes are installed on a part of said corotation preventing blade locating a peripheral surface of said borehole for measuring said resistivity of said ground of a peripheral surface of said borehole.

7. The resistivity sensing device using a ground improvement blade according to claim 4, wherein said resistivity sensing device comprising:

wireless communication means installed on an upper part of said single shaft for receiving said resistivity measurement signal from said communication means, converting said resistivity measurement signal into a wireless signal, and transmitting it said determination means.

8. The resistivity sensing device using a ground improvement blade according to claim 7, wherein said communication means comprising (a) a receiving means installed in a lower terminal of said single shaft for receiving said resistivity signal from said resistivity measuring means, and (b) an electrical wire for connecting said receiving means and said wireless communication means through a hollow between a pipe inside

said single shaft, and transmitting said resistivity signal from said receiving means to said wireless communication means.

9. The resistivity sensing device using a ground improvement blade according to claim 7, wherein said communication means is a wireless repeating means in which installed in a lower terminal of said single shaft, receiving said resistivity signal from said resistivity measuring means by connecting to said resistivity measuring means, and transmitting it to said wireless communication means by a wireless communication.

10. The resistivity sensing device using a ground improvement blade according to claim 9, wherein said communication means is ZigBee Coordinator and ZigBee End Device, or ZigBee Coordinator, ZigBee Router and ZigBee End Device conforming to ZigBee standard.

11. The resistivity sensing device using a ground improvement blade according to claim 9, wherein said communication means is conforming to Bluetooth standard.

12. The resistivity sensing device using a ground improvement blade according to claim 7, wherein said wireless communication means is installed in a water swivel fixed on an upper terminal of said single shaft for providing continuously ground improving material to inside said single shaft rotating.

13. The resistivity sensing device using a ground improvement blade according to claim 8, wherein said electrical wire is connected by a electromagnetic type connecting terminal in a connecting part of said single shaft.

14. The resistivity sensing device using a ground improvement blade according to claim 7, wherein said communication means comprising a second coil for communicating with said wireless communication means by magnetic resonance coupling, and

said wireless communication means comprising a wireless signal receiving means comprising of a first coil for communicating with said communication means by magnetic resonance coupling.

15. The resistivity sensing device using a ground improvement blade according to claim 14, wherein said first coil is installed by winding around a water swivel fixed on an upper terminal of said single shaft, or a hose locking member for providing said ground improving material, for providing continuously said ground improving material into said single shaft, and

said second coil is located by winding said corotation preventing blade by locating in peripheral surface of said single shaft.

16. The resistivity sensing device using a ground improvement blade according to a claim selected from claims 1 to 15, wherein said corotation preventing blade is a cross shape.