03 MAY 2005

A METHOD OF TRANSMITTING INFORMATION ALONG A STRING OF DRILLING RODS

The present invention relates to a method of transmitting information via a string of special rods used in making columns in the ground that are stronger than the surrounding terrain, the string of rods also making it possible to transmit such information between a top end close to the surface of the ground and a bottom end carrying drilling tools.

The technique of consolidating ground by destructuring the terrain with a jet of liquid under very high pressure, often referred to as "jet grouting" consists in making columns of concrete in the ground (in situ mixing of terrain with a binder delivered by the fluid of the jet) starting from a borehole by using a string of rods into which the high pressure fluid is delivered in order to make the column. One of these jet methods makes use of two fluids and is referred to as a "dual jet" method. A first fluid is a liquid for destructuring the terrain and the other fluid is air for improving the effectiveness of the liquid jet. The technique is performed conventionally by using a dual column string of rods, i.e. a column having an internal pipe enabling both fluids to be taken to the bottom of the borehole. The central pipe conveys the jet liquid, generally a mixture of water and cement, while the annular space between the outer wall of the tube and the internal pipe conveys compressed air.

It is becoming more and more frequent to make deep jet-grouted columns which need to be accurately positioned in order to constitute a shell or "stem" in the ground or a mass of terrain treated by this method. In order to be able to make such a structure properly, it is necessary to measure continuously both the position of drilling during the drilling stage and the diameter of the column during the jet stage serving to make the column in the previously drilled borehole. For this

03 MAY 2005

purpose position-sensors such as a tiltmeter, a magnetometer, a gyro, and devices for measuring diameter are fitted to the bottom end of the string of rods. These sensors must be capable of communicating with the surface so that the data they provide is transmitted in real time to make it possible to make the necessary corrections immediately so as to obtain the required quality for the structure that is being built.

To achieve such transmission of information, proposals have already been made in French patent applications Nos. 2 777 595 and 2 777 594 to use a current loop for conveying information in which one of the conductors is the drilling fluid itself and the other is either the rod or else the terrain. Transmitter and receiver coils are placed on said electrical circuit for transmitting and receiving information in the form of electrical pulses. For this purpose is it necessary to use rods which include internal insulation, and the fluid must be electrically conductive.

A first object of the invention is to provide a medium for transmitting information using a string of rods implementing the dual jet technique, which medium is simpler to implement and can be used with standard dual jet rods.

To achieve this object, the invention provides a method of transmitting information between the bottom and top ends of a string of rods, each rod comprising an outer conducive wall and a coaxial inner pipe of conductive material for conveying liquid under pressure, the annular space between said pipe and said outer wall being filled with an electrically insulating fluid, the method being characterized in that it comprises the following steps:

placing a first inductive coupling coil in the vicinity of the bottom end of the string of rods in said annular space so that said coil surrounds said pipe;

03 MAY 2005

applying an electrical signal to said coil that is representative of the information to be transmitted;

placing a second inductive coupling coil close to the top end of the string of drilling rods in said annular space so that said second coil surrounds said pipe; and

picking up an electrical signal representative of the transmitted information from said second coil.

Another object of the invention is to provide a string of rods for implementing the dual jet technique which provides improved transmission of information.

To achieve this object, the invention provides a string of drilling rods fitted with information transmission means, each rod comprising a conductive outer wall, a coaxial inner pipe that is likewise conductive for conveying a flow of liquid under pressure, the annular space between the outer wall and the inner pipe being filled with an insulating fluid, the string being characterized in that the information transmission means comprise:

- a first inductive coupling coil placed close to the bottom end of said string of rods in said annular space in such a manner that said coil surrounds said pipe;

- means for applying an electrical signal to said coil that is representative of information to be transmitted;

- a second inductive coupling coil placed close to the top end of said string of rods in the annular space in such a manner that said coil surrounds said pipe; and

- means for picking up the electrical signal created in said second coil.

It will be understood that in the invention the current loop is constituted by conductive elements formed by the outer wall of the rods and by the inner pipe within the same rods, with these elements being separated by the insulating gas that fills the annular space

03 MAY 2005

between these two coaxial tubes. It can thus be seen that this transmission of information does not require any modification to standard rods. It merely requires inductive coupling coils to be installed in the bottom drilling rod and in the top drilling rod. In this embodiment, the bottom coil acts as a transmitter and the top coil acts as a receiver enabling information to be transmitted to the installations that process and make use of the information and that are situated on the surface of the ground.

It will also be understood that the information applied to the first coil, i.e. the bottom coil, is the information delivered by the sensors mounted in the bottom portion of the string of rods, and that the same information, possibly after being transformed, is collected by the top coil and transmitted to the processing assemblies located on the surface of the ground.

Other characteristics and advantages of the invention will appear better on reading the following description of various embodiments of the invention given as non-limiting examples. The description refers to the accompanying figures, in which:

- Figure 1 is an elevation view of a conventional type of equipment for drilling by jet grouting;
- Figure 2 is a simplified view of the string of rods fitted with transmission means;
- Figure 3 is a more detailed view showing the information transmission means located at the top end and at the bottom end of the string of rods; and
- Figure 4 shows one way in which the information for transmission can be encoded.

Figure 1 is a simplified diagram showing a dual jet drilling machine. This figure shows a platform 10 preferably mounted on crawler tracks 12 and hinged to the bottom end 14a of a vertical guide mast 14. The mast 14 serves to guide a carriage 16 in vertical translation

03 MAY 2005

which in turn carries a drilling head 18 or rotary drive head. The drilling head 18 serves firstly to rotate the string of rods 20 constituted by individual rods 20a, and secondly to move the string of rods downwards as the carriage 16 descends. The top end of the string of rods carries in particular a rotary joint 22 enabling air under pressure and jet liquid 24 and 26 to be fed to the rods. The bottom rod 20_i is fitted with a jet tool 28 and with a mechanical drill tool 30.

It will be understood that drilling is performed by setting the string of rods into rotation and by lowering into the ground. It will also be understood that when drilling is carried out to a considerable depth, it becomes necessary to install additional intermediate rods 20_a???.

Figure 2 is a simplified diagram of the string of rods 20 comprising ordinary rods 20_a and the bottom rod 20_i, the jet tool 28, and the mechanical tool 30. At its bottom end, the string of rods also includes a module 32 containing various sensors which are explained below. As can be seen in Figure 2, each rod 20_a is constituted by an outer tube 34 and by a coaxial inner pipe 36. The outer wall 34 and the inner pipe 36 define between them an annular gap 38 which is used for conveying air under pressure to the jet module 28. The coaxial inner pipe 38 is used for conveying liquid under pressure, also to the jet module.

In the invention, in order to enable information to be transmitted from the sensors contained in the bottom module 32 to the surface of the ground, a first electromagnetic coupling coil 40 is mounted in the bottom rod element 20_i, which coil is mounted in the annular gap 38 filled with air under pressure. This coil 40 surrounds the inner pipe 36. To make the coil 40 easier to install, it is possible to provide for the outside wall 34 of the rod to have a larger diameter portion 42 in this zone. As explained in greater detail below, the

03 MAY 2005

coil 40 is connected by electrical conductors such as 44 to the sensors of the module 32. In the top rod element 20_s, a second coil 46 is installed which surrounds the inner pipe 36 and which is placed in the annular space 38. This second coil 46 is connected to electrical conductors 48 via the rotary joint 22.

As is known, the outer walls of the rods 20 and the inner pipes 36 of the same rods are made of a metal or a metal alloy that conducts electricity. It should be understood that the inner pipe 36 and the outer wall 34 when electrically connected at their top and bottom ends by any suitable means constitute a conductor loop that is well suited transmission in current loop mode. The coils 40 and 46 are mounted on one of the conductor elements of this current loop constituted by the inner pipe 36 and the outer wall 34. Thus, if a non-DC electrical signal is applied to the bottom coil 46, induced current is established in the above-defined current loop and is therefore picked up by the top coil 46. As a result, the coil 46 and the conductors 48 associated therewith obtains an electrical signal representative of the electrical signal which was applied to the bottom coil 40. If the signal applied to the coil 40 is representative of measurements performed by the sensors placed in the measurement compartment 32, it will be understood that electrical signals are picked up on the surface of the ground that are representative of said measurements, and that these electrical signals can be processed in real time on the surface.

With reference now to Figure 3, the component elements of the invention placed in the bottom rod element 20_i and in the top rod element 20_s are described in greater detail.

Figure 3 shows in greater detail that the measurement compartment 32 contains a tilt sensor 50 for monitoring how close the drilling tool is to vertical and a sensor 52 enabling the thickness of the column made in

03 MAY 2005

the jet stage to be measured. It would naturally be possible to have other sensors placed in this compartment. There is also shown a self-contained electrical power supply or battery 54. The measurement sensors 50 and 52 are connected to an interface component 56 which enables the electrical signals delivered by the sensors and corresponding to the measurements they performed to be converted into digital measurements and then into AC signals representative of the digital information. By way of example, this can comprise a generator delivering an AC signal of fixed frequency and fixed amplitude in periods when the digital signal has binary value 1, and delivering no AC signal when the digital signal has binary value 0. This is shown in Figure 4. The frequency signals generated by the interface circuit 56 are applied to the bottom inductive coupling coil 40 by the conductors 44. The inductive coupling coils 40 and 46 are preferably constituted by a magnetic core of toroidal shape surrounding the inner pipe 36, with an electrical conductor being coiled around the core so as to constitute a conventional type of electromagnetic coil.

The top receiver coil 46 can be seen in the annular space 38 of the top rod 20_s and this coil is connected via the rotary joint 22 to the output electrical conductor 48. The coil 46 is preferably likewise made using a magnetic core 58 of toroidal shape with an electrical conductor wound on the core 60.

Figure 3 also shows in diagrammatic manner the admission 62 of liquid under pressure, e.g. cement in suspension in water for feeding the inner pipe 36, and the compressed air feed 64 for feeding the annular space 38. In the jet compartment 28 there is also shown diagrammatically an injection nozzle 66 connected to the axial pipe 36.

03 MAY 2005

In the embodiment described above, a transmitting bottom coil 40 connected to the sensors co-operates with a top coil 46 connected to a processing unit. Information therefore flows from the bottom portion of the string of rods to the surface of the ground. In some circumstances, it can be advantageous to transmit information to the sensors from the surface of the ground, i.e. to enable transmission to take place downwards. For this purpose, it is possible to provide two coils in the top rod 20_s, one of which acts as a transmitter and the other as a receiver, and two coils in the bottom rod 20_i, one acting as a transmitter and the other as a receiver. From a practical point of view, it is preferable for both coils to be constituted by a single magnetic torus having both a transmitter winding and a receiver winding wound thereon.

To achieve this result, it is also possible to use only two coils each of which alternate between being used as a transmitter and being used as a receiver. For this purpose, each coil can be associated with a switch member enabling it to be connected either to a receiver circuit or to a transmitter circuit.

The two electromagnetic coils associated with the above-defined current loop also make it possible to transmit electrical power from the surface to the measurement compartment 32 in order to recharge the battery 54. Such power transmission is performed during periods when there is no information to be transmitted.

In addition, in the above description, it is assumed that drilling is performed using the dual jet technique.

For certain structures, a triple jet technique is used. A liquid jet and a compressed air jet serve to destructure the terrain and the third jet serves to deliver the slurry for making the column. Under such circumstances, the rods have two coaxial inner pipes. In such a configuration, the inductive coupling coils should

0 3 MAY 2005

again be located in the annular space used for conveying compressed air.

CLAIMS

1/ A method of transmitting information between the bottom and top ends of a string of rods, each rod comprising an outer conducive wall and a coaxial inner pipe of conductive material for conveying liquid under pressure, the annular space between said pipe and said outer wall being filled with an electrically insulating fluid, the method being characterized in that it comprises the following steps:

placing a first inductive coupling coil in the vicinity of the bottom end of the string of rods in said annular space so that said coil surrounds said pipe;

applying an electrical signal to said coil that is representative of the information to be transmitted;

placing a second inductive coupling coil close to the top end of the string of drilling rods in said annular space so that said second coil surrounds said pipe; and

picking up an electrical signal representative of the transmitted information from said second coil.

2/ A string of drilling rods fitted with information transmission means, each rod comprising a conductive outer wall, a coaxial inner pipe that is likewise conductive for conveying a flow of liquid under pressure, the annular space between the outer wall and the inner pipe being filled with an insulating fluid, the string being characterized in that the information transmission means comprise:

- a first inductive coupling coil placed close to the bottom end of said string of rods in said annular space in such a manner that said coil surrounds said pipe;

- means for applying an electrical signal to said coil that is representative of information to be transmitted;

- a second inductive coupling coil placed close to the top end of said string of rods in the annular space in such a manner that said coil surrounds said pipe; and

- means for picking up the electrical signal created in said second coil.

3/ A string of rods according to claim 2, characterized in that it further comprises, at its bottom end, at least one measurement sensor, and in that said means for applying said electrical signal comprise means for converting the measurement performed by said sensor into an electrical signal and means for causing an electrical signal representative of said measurement to flow through said coil.

4/ A string of rods according to claim 3, characterized in that, at its bottom end, it further comprises a rechargeable battery for powering the sensor(s), said coupling coils also serving to transmit electrical power for recharging said rechargeable battery.

5/ A string of rods according to claim 3 or claim 4, characterized in that said sensor comprises means for generating a digital electrical signal representative of said measurement, and in that the means for applying the electrical signal comprise means for converting said digital signal into an analog signal.

6/ A string of rods according to claim 5, characterized in that the means for converting the digital information comprise means for generating an electrical signal at given frequency and amplitude whenever the digital signal is in a first binary value and no such signal whenever the digital signal is in a second binary value.

7/ A string of rods according to any one of claims 2 to 6, characterized in that each coil further comprises

03 MAY 2005

switching means for applying an electrical signal to said coil in a first binary value and for picking up an electrical signal present on the coil in a second binary value.

8/ A string of rods according to any one of claims 2 to 6, characterized in that it further comprises a third inductive coupling coil placed in said annular space close to said second coil, and means for applying an electrical signal representative of information for transmission to said third coil, and a fourth inductive coupling coil disposed close to said first coil and fitted with means for picking up the electrical signal present on said fourth coil.

9/ A string of rods according to any one of claims 2 to 8, characterized in that each coil comprises a magnetic torus surrounding said inner pipe and an electrical conductor wound on the torus.