ABSTRACT

A device for measuring inclination is suspended to a cable passing through a duct formed in the rods of the drill string. A mechanism for winding and unwinding the cable allows to raise and drop the measuring device within the lowermost rod, engaging it with or disengaging from a mule shoe. This is performed without the need to unscrew the rods and open the string. A valve element may close the duct through which the cable passes. In one embodiment, directional drilling is performed supplying low pressure fluid through tubular rods having a single duct. In another embodiment, high pressure fluids are supplied through rods having two or more coaxial ducts.
FIG. 8

FIG. 9
DRILL RIG AND METHODS FOR DIRECTIONAL DRILLING

TECHNICAL FIELD

[0001] The present invention pertains to the field of civil engineering and relates to a drill rig and methods for performing directional drilling in the ground. The drilling operations are aimed, particularly but not exclusively, at executing jet grouting consolidations.

BACKGROUND ART

[0002] With soil perforations known as “directional drillings”, deviations are checked at certain phases of the drilling. Corrections are consequently made either to keep the axis of the drilling within certain limits of deviation from the desired theoretical axis, or to keep a given trajectory of the drilling according to design requirements.

[0003] In order to detect the inclination during a drilling step, a known method provides for mounting a device for detecting inclination fixedly secured to the bottom of the drill string. A number of electrical connections have to be made as new drill pipes are added, to extend a conductor line from the pipe to a power supply on ground surface. Unless special shock absorbers are used, this method does not preserve the device from shocks and vibrations transmitted from the drill.

[0004] Another known system (FIG. 1) provides that a tool 40 for measuring inclination is periodically introduced and lowered through the hollow rods of a drill string 14. Inclination is typically measured every 2-3 meters as the drilling proceeds. According to established practice in oilfield applications, the device for measuring inclination may be of the gyroscopic type, or of the electromagnetic accelerometer, usually including a compass associated with an inclinometer. A known method of this type uses a winch to lower the inclination measuring device 40 within the rods. The measuring device is suspended by a steel cable 22 containing an insulated electrical conductor. Whenever the inclination is to be measured, the drilling must be stopped, the drill string must be opened by unscrewing the rods, and the measuring device must be introduced through the inner cavity of the rods. A device known in the field as a “mule shoe” allows to orient the measuring device according to a known direction, which coincides with the direction of the lowermost element of the drill string (usually built in non-magnetic steel) and the drilling bit integral with it.

[0005] In other instances, where real-time inclination data are not required, the device may be lowered by means of a standard cable without an electrical conductor, and the inclination data may be downloaded from a buffer of the device after it has been brought back up to the surface. However, the above method is unsuitable if inclination data are needed in real time, for example, to promptly correct the direction of the drilling.

[0006] A typical conventional method, regardless of the type of instrumentation used, involves a sequence of operating steps comprising:

a) interrupting the supply of the drilling fluid and stopping the drilling;

b) opening of the drill string, by unscrewing the rods;

c) lowering the measuring device until the “mule shoe” is engaged;

d) measuring the inclination by orienting the string through a clamp, since the rotary in this step is not connected to the string; measurement of the inclination may be performed at 4 different angular positions spaced 90° from each other;

e) retrieving the measuring device back up to surface;

f) closing the drill string by re-screwing the rods.

[0007] For the cases requiring the inclination to be corrected, step f) must be followed by a subsequent step in which a deviated bore section is drilled, thereby correcting the inclination of the borehole. Then, before resuming drilling, it is necessary to repeat the sequence of steps a) to f).

[0008] U.S. Pat. No. 3,718,194 (to Hering et al.) discloses an apparatus for orienting a borehole device in a borehole within the context of drilling oil wells. An orienting tool is positioned in a drill pipe and provided with a conductor cable to the surface. An instrument in the tool provides a measurement for indicating the orientation (the so-called “high side”) of the tool in the wellbore. Instrument measurements are transmitted by the conductor cable to the surface for read-out. A surface indicator provides the readout in a manner which is indicative of degrees of rotation of a reference on the tool to the right or left of the high side of the hole. The tool may then be rotated and subsequent readings taken to determine the position of the tool until the bit is oriented, whereupon drilling proceeds. Such readings can be taken continuously throughout the drilling operation.


SUMMARY OF THE INVENTION

[0010] The present invention aims at speeding up a directional drilling, eliminating some of the steps mentioned herein above. Another object of the invention is to keep the inclination measuring device within the string during the drilling while preserving the device from vibrations and shocks transmitted from the drill string.

[0011] The above and other objects and advantages, which will be better understood from the ensuing description, are achieved according to the invention by methods defined in the appended claims. According to another aspect, the invention provides drill rigs for implementing these methods.

[0012] In brief, a device for measuring inclination is suspended to a cable passing through a duct formed by the cavity of the rods of the drill string. A mechanism for winding and unwinding the cable allows to raise and drop the measuring device within the lowermost rod, engaging it with or disengaging from the mule shoe. This is performed without the need to unscrew the rods and open the string. A valve element may close the duct through which the cable passes. Two embodiments are provided. One embodiment is particularly suitable for the execution of directional drilling with the supply of low pressure fluid with tubular rods having a single duct. A second embodiment is specific for directional drilling with the supply of high pressure fluids and rods having two or more coaxial ducts.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] A few preferred but not limiting embodiments of the methods and drill rig according to the invention will now be described; reference is made to the accompanying drawings, in which:

[0014] FIG. 1 is a schematic view of a step of measuring the inclination of a drilling according to the prior art;
FIG. 2 is a schematic elevation view of a drill rig for executing perforations intended for jet grouting consolidations with detection of the borehole inclination, according to an embodiment of the invention;

FIGS. 3A, 3B and 3C are schematic views in vertical cross section, to an enlarged scale, of part of the drill rig of FIG. 2, in three different operational positions;

FIGS. 4A and 4B are elevation views, as viewed from to two different angles, of a device for measuring inclination with a "male shoe" guide for its angular orientation;

FIG. 5 is a partial view of the vertical section, further enlarged scale, of the lower part of the string of rods shown in FIGS. 3A-3C;

FIG. 6 is a schematic cross-sectional view to enlarged view of a head the supply of fluid in the apparatus of FIGS. 3A-3C;

FIG. 7 is an enlarged view of a detail of FIG. 3A; and

FIGS. 8 and 9 are schematic elevational views, in two different operational conditions, of an apparatus according to a further embodiment of the invention.

DETAILED DESCRIPTION

Referring to FIG. 2, a self-propelled vehicle 10 carries a drilling mast 11, in this example illustrated in an upright or vertical position. Slidably mounted along the mast 11 is a top-drive rotary head 12. The rotary head serves to impart rotation and sliding movement (push-pull) to a string 14 of hollow rods for carrying out soil perforation or drilling. The rotary head may be driven by an associated hydraulic motor gear 125. A boring tool 16 is fixed at the bottom end of the string 14 of rods.

The general structure of a drilling mast and of the actuating means of a rotary head are to be considered generally known. Consequently, the present description will describe in detail only those elements of specific importance and interest for the purposes of implementing of the invention. For the construction of the parts and elements not shown in detail, such as the motor assembly for driving the rotary head and the drive systems of the boring tool, reference may be made to any apparatus of known design. In the description and in the drawings, two different embodiments of the method are illustrated, which differ mainly in the level of pressure of the fluid supplied to the string.

FIGS. 2, 3A-C, 5-7 show an arrangement which is suitable for operation with a boring tool 16 operating with a drilling fluid at low pressure, for example air-powered hammers or non-percussive bits able to work with water pressures not exceeding 50 bars, approximately. FIGS. 8 and 9 depict an apparatus suitable for working with a boring tool operatively associated with a high pressure fluid, for example an in-the-hole hammer powered by high pressure water or rotation bits such as tricone rock bits, three (or four) blade drag bits and the like. As an alternative, asymmetric non-rotating thrust directional bits may be used, or directional active tools, such as "mud motors". The type of boring tool may vary depending on the applications.

For an operational mode with the use of air or low pressure drilling fluid, the string 14 may comprise a set of tubular hollow rods 14a-14c which define a central longitudinal axis x and each have an axially extending inner cavity 15, preferably a cylindrical cavity coaxial to the longitudinal axis x. As understood here, terms and expressions indicating position and orientations, such as "longitudinal", "axial" or "radial" should be interpreted with reference to the longitudinal axis x. In the prevailing mode of use, the x axis is vertical; however, the method is applicable also for perforations inclined with respect to a vertical direction.

When the rods are joined, in a manner known per se, the inner cavities 15 of the rods are axially aligned and interconnected so as to form together a duct through which a drilling fluid can be conveyed, such as water or air or a grout consolidating mixture, according to requirements. The example of FIGS. 3A-3C shows three rods 14a, 14b, 14c. It is understood that the total number of rods used may be greater than three, depending on the depth of the work of consolidation to be carried out.

The lowest or bottom hollow rod 14c has one or more bottom nozzles 18a, in this example, two in number, communicating with the internal cavity 15, for discharge of drilling fluid. The boring tool 16 is integral with the lower end of the lowest hollow rod 14c.

In the illustrated example, just above the bottom nozzle 18a there are provided radially oriented side nozzles 18b, which open on an outer side surface of the bottom rod. Schematically designated 18c is a valve element which, under fluid pressures in excess of a predetermined value, moves so as to occlude the bottom nozzle 18a and simultaneously open the side nozzles 18b to perform the jet grouting injection. In other embodiments, the side nozzles 18b can be made in a cylindrical element called a "monitor" which is mounted immediately above of the boring tool. It should be understood that this specific use is not intended to limiting and that the method may also be implemented with different jet grouting technologies.

In a manner known per se, the inner cavity 15 of the bottom 14c of the rod provides an internal projection 17 (FIG. 5), radially protruding towards the inside of the cavity and defining a predetermined angular position with respect to the central longitudinal axis x of the string 14.

The rotary head 12 has an axially extending through cavity 13 and is lockable to the uppermost or top hollow rod 14a. An upper end 141a of the rod 14a projects above the top of the through cavity 13 of the rotary head and supports a swivel connector 19.

The swivel connector 19 (FIG. 7) comprises two coaxial tubular elements 19a, 19b, rotatable relative to one another by means of a rolling bearing 19c. The outer tubular member 19a of the swivel connector is idly mounted for rotation about the uppermost rod 14a and can be kept rotationally stationary with respect to the x axis. This may be achieved, for example, by means of a bracket or arm or other anti-rotation means 21 which engages an outer, rotationally fixed portion 12a of the rotary head 12 and the swivel connector 19. Designated at 12c is rotational portion of the rotary head 12. The inner tubular member 19b of the swivel connector 19 has an axially extending inner through cavity 20. This cavity is axially aligned and communicating with the inner cavity of the rod 14a and therefore with the duct 15 formed by the communicating cavities of the joined rods of the string.

A cable 22, to which a device (or instrument) 40 for measuring inclination is suspended, passes through the duct formed by the through cavities of the rods 15 and the cavity 20 passing through the swivel connector 19.

The internal cavity 20 passing through the swivel connector 19 may be occluded by an annular valve 30, preferably a pneumatically operated pinch valve mounted on the outer, stationary element 19a of the swivel connector 19. The annular valve 30 is mounted idly mounted for rotation about
the axis x above an upper end of a top rod 14a of the string and above the top-drive rotary head.

[0034] The annular valve 30 may comprise a flexible body, preferably made of rubber, which can be closed by radially tightening or clamping it around the cable 22. The annular valve 30 may be controlled in opening and closing in different ways (for example electrically, pneumatically, hydraulically, or manually), so as to open or seal the passage of the cable 22 and the duct formed by the rods and the swivel connector 19.

[0035] The device or instrument 40 for measuring inclination is mounted on a guiding element 29, per se known in the drilling field as “mule shoe”. The guiding element provides a guide 28 for example in the form of a flared groove, downwardly widening and upwardly tapering. As the device 40 is lowered into the drill string, the lower and wider part of the guiding groove 28 meets the inner projection 17 in the cavity of the lowermost rod and guides the device 40 downwards, at the same time orienting it in a predetermined angular position with respect to the x-axis, the device reaches a stable position in which the inner projection 17 abuts against the upper end 27 of the guiding groove 28.

[0036] According to an embodiment (not shown), the guiding element 29 may be provided with a switch or other switching device (such as a sensor) that closes an electrical circuit (not shown) when the measuring device 40 reaches the correct angular position with respect to the lowermost rod. This way an operator may be sure that the inclination has been detected correctly.

[0037] The device 40 may include a tracking or guiding sensor or probe for measuring inclination, for example a Paratrack® or TrueTrack device. The measuring device 40 may incorporate an inclinometer and a compass, such as a triaxial magnetometer, already used in the field of directional drilling. The selection of the particular device for measuring inclination is not to be considered limiting as regards the implementation of the present method.

[0038] The inner cavities 15 of the rods of the string have an internal diameter sufficient to ensure easy handling of the measuring device 40 within the string. For example, the inner cavities 15 may have an internal diameter between 30 and 100 mm wide.

[0039] The cable 22 may be a steel cable. Optionally, the cable 22 may contain in its interior an insulated electrical cable (e.g. of a Camias cable or the like). Alternatively, the cable 22 may be an electric cable reinforced on its outside.

[0040] Schematically designated 23 in FIG. 6 is a fluid supplying head (or top swivel, or rotary air/water swivel), in this example mounted on an intermediate rod element 14b of the string. The head 23, known per se, supplies a drilling fluid (air, water, polymer additives, bentonite, grout mixtures) that is introduced in the central cavity 15 through one or more lateral inlet openings 24 formed in the rod element 14a. The supplying head 23 is idly mounted for rotation on rod element 14b through one or more rolling bearings 23a.

[0041] A tubular body 26, containing a swivel valve member 30a able to withstand high pressures (e.g. in the order of 300-500 bars), may be mounted in the drill string above the fluid supplying head 23 in order to selectively occlude the central duct 15.

[0042] The drill rig comprises a winch 31 (FIG. 2) or another winding and unwinding mechanism for moving the cable 22 and the measuring device 40. In the illustrated example, the winch 31 is positioned immediately behind the mast 11.

[0043] FIG. 3A shows an arrangement for measuring inclination of the drilled borehole. The measuring device 40 is located in the lowest position reached within the bottom rod 14c. In this position, the device 40 is oriented in an angular position determined by engagement of the guiding element 29 with the internal projection 17.

[0044] During a drilling step (FIG. 3B), the measuring device 40 can be held within the string of rods, either in a condition where the mule shoe is engaged, or suspended from the cable 22 in a raised position above the internal projection 17. When suspended, the measuring device 40 is not integral with the bottom rod 14c, and therefore is not negatively affected by vibrations and shocks transmitted by the boring tool 16 to the bottom rod of the string. It is convenient to perform drilling with the measuring device 40 engaged in the mule shoe because this mode allows to obtain inclination data in real time. It will be understood that this operating mode is only applicable when the boring tool is not a percussive tool.

[0045] The annular valve 30 is kept closed around the cable 22 during the steps of drilling and/or injecting fluid through the drill string, to prevent the escape of fluid from the top of the string, particularly from the top of the duct formed by the communicating cavities of the rods. When the drill string is rotated integrally with the rotary head, the valve 30 is kept rotationally stationary due to the swivel connection 19, which is idly mounted for rotation on the rotary head 12. The measuring device 40, suspended from the cable 22, is rotationally stationary with respect to the rotating string. As a result of the tightening of the annular valve 30 on the cable 22, the measuring device 40 is vertically or axially constrained to the annular valve 30, and follows the movements of axial translation of the rotary head 12 along the mast 11.

[0046] When the inclination of the drilled borehole is to be measured, a sequence of operating steps may be as follows.

[0047] The supply of drilling fluid is interrupted and the drilling is stopped.

[0048] Without needing to unscrew the rods to open the string, the inclination measuring device 40 may be let down to lowest position it may reach inside the bottom rod 14c until the device 40 engages the internal protrusion 17. Advantageously, the device 40 is already present in suspended condition within the string. By engaging the internal projection 17, the guiding element 29 (FIG. 3A) orients the measuring tool 40 in a given angular position.

[0049] The inclination of bottom rod 14c is measured by the device 40. The inclination may be advantageously measured without releasing the rods from the rotary head. The methods of measuring the inclination are not limiting. For example, measurements may be taken in 4 different angular positions spaced 90° from one another, in accordance with the methods disclosed in patent publication US 2013/020129 A1, incorporated herein by reference in its entirety.

[0050] After measuring the inclination, the device 40 may be raised again so as to disengage it from the internal projection 17 release it rotationally from the string 14. The measuring device may be fully recovered, i.e. pulled out of the string without opening it. Alternatively, the device 40 may be kept suspended within the string (FIG. 3B).

[0051] The drilling operations may then be resumed or steps may be followed to correct the inclination of the borehole. To correct the inclination, the measuring device 40 is
preferably suspended within the string to protect it from the vibrations generated by the downhole boring tool. Maneuvers for correcting inclination are known in the art, and therefore will not be described herein. Sufficient to mention that inclination correction usually provides a further sinking or penetration of the boring tool for a short length, of the order of some tens of inches, without setting the string in rotation, so as to deviate appropriately the direction of the drilling, depending on the measured values of inclination. In this step, the device 40 may remain engaged in the mule shoe.

The annular valve 30 may be closed to seal the top of the string when the measuring device has been pulled out of the string. During rotation of the string, if the measuring device 40 has not been completely removed, the annular valve 30 is locked in the closed position around the cable 22, ensuring hydraulic seal.

It will be appreciated that the present method allows to measure the inclination of the drilling without the need to unscrew the rods in order to open the string and introduce the inclination measuring device in the string, and without having to re-screw the rods once the inclination has been measured and the measuring device has been withdrawn from the string.

It will also be appreciated that, due to the above described arrangement, it is possible to supply pressurized fluid in order to perform the drilling without the need to remove the measuring device from the string, and, unless a percussive boring tool is used, without disengaging the mule shoe.

The mechanism 31 for winding and unwinding of the cable 22 may be equipped with automatic devices that facilitate the operator’s work. The rig may be equipped with a control system that stores the depth reached by the measuring device 40.

The control system may be set to automatically slow down the winch before the measuring device reaches a preset depth where it has been programmed to measure the inclination. Advantageously, the control system can be set to cause the measuring device 40 to raise automatically up to a predetermined level just before the drilling restarts, in order to protect the device from the vibrations induced by the boring tool.

FIG. 3C shows the arrangement of the apparatus during a jet grouting step. Once the drilling is completed, and after the measuring device has been extracted out of the string 40, the duct 15 can be occluded or sealed tightly above the fluid supplying head by rotating the rotatable valve element 30a in the closed position (FIG. 3C). Then, the string may begin to raise and perform a jet grouting injection in the lift mode, using the fluid supplying head 23 to pump pressurized grout (for example at 300-500 bars) through the central duct 15. The valve element 18c, which is activated automatically due to the pressure, will occlude the bottom holes 18a and force the fluid to exit from the radially oriented side nozzles 18b.

Referring now to FIGS. 8 and 9, there is illustrated an embodiment of a method of performing directional drilling with a drill rig working with a high pressure fluid. The drill rig comprises a top-drive rotary head 12 similar to that described with reference to FIGS. 2 and 3A-3C, lockable to a drill string 14. The string includes a tubular top rod 14a, in this example with a single passage or through cavity 15, and a number of dual passage rods 14b, 14c (two in number in the illustrated example).

Fixed to the bottom rod 14c is a boring tool 161 capable of operating with a drilling fluid supplied at high pressure. The boring tool 161 may for example be an in-the-hole hammer powered by high pressure water (known as “Wassara™”) or a rotating bit (a tricone, or a three blade drag bit) or an asymmetric directional bit (or “slant face bit”) to be supplied with fluid at high pressure.

The top rod 14a is lockable in the passage 13 of the rotating part 12c of the rotary head in a manner similar to that described in relation to FIGS. 2 and 3A-3C, except for the fact that for the execution of soil consolidation with fluids at high pressure, an annular valve of the type indicated at 30 in FIGS. 3A-3C is not used.

The dual passage rods 14b, 14c each comprise two coaxial pipes: an inner pipe 141b, 141c, with an internal diameter sufficient to ensure the passage of a device 40 for measuring inclination, and an outer pipe 142b, 142c. Each inner pipe has a central cavity 15. The central cavities 15 of the rods are axially aligned and interconnected so as to form together a first central (or more internal) duct through which a fluid can be conveyed, in this example a grout consolidating mixture.

An annular gap forming a second duct 151 is defined between the outer pipes 142b, 142c and inner pipes 141b, 141c is defined the peripheral (or external), through which drilling fluids can be made to pass, typically water or air. These fluids are then injected out of the string through one or more bottom nozzles 18a provided in the boring tool 161. The drilling fluids may be introduced into the peripheral duct 151 through a supplying head 123 idly mounted for rotation about the outer pipe 142b, for example by means of one or more rolling bearings (not shown) similarly to the fluid supplying head 23 shown in FIG. 6. The fluid supplying head 123 is arranged below the rotary head 12, in proximity to and in fluid communication with one or more inlet lateral openings 123a formed in the outer pipe 142b.

A consolidating mixture, such as a grout mixture, can be introduced into the central duct 15 within the inner pipes 141b, 141c by a fluid supplying head 124. The head 124 is idly mounted for rotation about the outer pipe 142a, similarly to the fluid supplying head 123. The fluid supplying head 124 is mounted just below the rotary head 12, and provides fluid communication between an external fluid source (not shown) and the central duct 15 within the inner pipe 151.

In proximity to and in fluid communication with one or more inlet side openings 124a formed in the outer pipe 142b and with inlet side openings 124c formed in the inner pipe 141b. The grout is injected out of the string through one or more side nozzles 18b. The side nozzles 18b can be formed in a monitor mounted immediately above of the boring tool.

The fluid supplying heads 123 and 124 may be conveniently mounted on a same dual passage rod, as in the example illustrated. In other embodiments (not shown), the two fluid supplying heads may be mounted on two distinct rods.

In the embodiment illustrated in FIGS. 8 and 9, the head 124 for supplying the consolidating mixture is located above or upstream of the head 123 for supplying drilling fluids.

According to an alternative embodiment (not shown), the two fluid supplying heads 123 and 124 may be constructed as a single unit.

The swivel connector 19, visible in FIGS. 8 and 9, may be omitted.
A tubular body 26 containing a rotatable valve member 30a, capable of withstanding high pressures (e.g. in the order of 300-500 bars), may be mounted in the drill string above the fluid supplying head 124 to occlude the central duct 15 when this is required.

The device 40 for measuring inclination may be introduced into the string during any operational step, for example even during the drilling. The device 40, suspended from a cable 22 in a manner similar to that described with reference to Figs. 2, 3A-C, may be lowered into the central duct 15 until it reaches an inward projection 17 protruding in the central cavity 15 of the bottom rod 14c to provide angular orientation of the inclination measuring device 40.

FG. 8 illustrates an operating condition in which the measuring device 40 is suspended in the central cavity 15 and detached from the bottom rod, in order to preserve the device 40 from vibrations coming from the boring tool. The central duct 15 has a diameter (for example between 30 and 100 mm wide) sufficient to ensure easy handling of the device 40 within the string. The rotatable valve member 30a is rotated into a position in which it leaves the central duct 15 open and allows the passage of the cable 22.

During a drilling step, the tool 40 may be left inside the string in the suspended and raised condition shown in Fig. 8. In this event, the mule shoe allows a quick connection of the measuring device 40 to the bottom rod in order to immediately achieve inclination data just after a step of correcting the inclination has been completed.

When grout has to be injected as the string moves upwards, after the borehole has been drilled, the measuring device 40 must be completely removed from the string. The central duct 15 must be temporarily occluded to prevent the fluid from reaching the top of the string (Fig. 9). During the injection step, the rotatable valve member 30a is rotated to close the central duct 15 above the fluid supplying head 124. Then, the consolidating mixture is supplied into the central duct 15 through the fluid supplying head 124.

The second, peripheral duct or cavity 151 may be used to inject pressurized air, as typically occurs in a dual-fluid jet process. The central duct 15 may be provided with an automatic valve, shown schematically at 18c, configured for moving under the action of pressures in excess of 200-300 bars and putting the central duct 15 in fluid communication with the side nozzles 18b, typically made in a monitor.

Preferably, the peripheral duct 151 can communicate with both the nozzles of the bottom of the boring tool and the side nozzles in the monitor.

It will be appreciated that the embodiment shown in Figs. 8 and 9 allows to perform, with a single single rig, both the directional drilling and the following jet grouting operations. The central duct 15 is advantageously exploited also for guiding and protecting the inclination measuring device 40 (Fig. 8) while high pressure drilling fluids are injected through the peripheral duct 151.

It will also be appreciated that the cable 22 provides a continuous and perfectly insulated power line which allows power to be supplied and data collected by the device 40 to be transmitted even when considerable depths are reached. This allows to dispose of sealed electrical contacts and quick connection electric contacts between the rods, which usually increase the electric resistance and cause electric dispersion, leading to malfunction of the equipment.

What is claimed is:

1. A drill rig for directional drilling, comprising:
   - a self-propelled vehicle (10);
   - a drilling mast (11) carried by the self-propelled vehicle;
   - a top-drive rotary head (12), translatable along an axis (x) parallel to the mast (11), the head having a rotatable part (12c) rotationally drivable around said axis and defining a through cavity (13), and a rotationally stationary part (12a);
   - a string of threaded coupling tubular rods (14) having respective axially extended communicating cavities (15) and defining altogether at least one duct adapted to convey at least one fluid to at least one bore (18) obtained in a bottom element of the string, wherein the string comprises at least one upper tubular rod (14a) lockable in the through cavity (13) of the rotatable part (12c) of the rotary head;
   - at least one fluid supplying device (23, 123, 124) idly mounted for rotation on a rod (14b) located below the rotary head, for supplying at least one fluid through the duct (15);
   - a boring tool (16) mounted at the bottom of the string (14) of rods;
   - a device (40) for measuring inclination suspended by a cable (22) passing through the duct (15) formed by the rods;
   - a winding and unwinding mechanism (31) for moving the cable (22);
   - a mule shoe assembly (17, 28), comprising a guiding surface (28) integral to the device (40) and a key member (17) within a bottom rod (14c) of the string, adapted to engage the guiding surface (28) and guide the device in a desired orientation with respect to the bottom rod (14c);
   - at least one valve member (30), associated with the duct (15), and mounted on the string above said at least one fluid supplying head and above the top-drive rotary head, the valve member being capable of reaching a closure position closing the duct and an open position opening the duct.

2. The drill rig of claim 1, wherein the valve member (30) is an annular valve idly mounted for rotation about the axis (x) above an upper end of a top rod (14a) of the string.

3. The drill rig of claim 2, wherein the annular valve (30) is mounted on the upper end of the top rod (14a) through the interposition of a swivel connector (19), the swivel connector having an inner tubular element (19b) having a through axially extending cavity (20) which is communicating and aligned axially and rotationally integral with the inner cavity of the upper rod (14a);

4. The drill rig of claim 3, further comprising an anti-rotation element (21) which engages a rotationally stationary part (12a) of the rotary head (12) and the outer tubular element (19c) of the swivel connector to maintain the outer tubular element (19b) rotationally stationary.

5. The drill rig of claim 2, wherein the annular valve (30) is a pneumatically operated pinch valve.

6. The drill rig of claim 1, wherein the rods of the string have a single central duct (15) and wherein the apparatus...
comprises a single fluid supplying device (23), mounted below the rotary head, for supplying a fluid through the single duct (15).

7. The drill rig of claim 1, wherein:
   the upper tubular rod (14a) which is lockable to the rotatable part (12c) of the rotary head has a single, axially extending through cavity;
   the string comprises a plurality of tubular dual-passage rods (14b, 14c), wherein each dual-passage rod comprises two coaxial tubes which have a central, axially extending cavity communicating with the through cavity of the upper tubular rod (14a) so as to define altogether a first central duct (15) capable of conveying a fluid to at least one bore (18) obtained in a bottom element of the string;
   an axially extending annular cavity communicating with the annular cavities of the other dual-passage rods so as to define altogether a second peripheral duct (151) adapted to convey a fluid to at least one bore (18a) obtained in a bottom element of the string;
   two fluid supplying devices idly mounted for rotation on one or two dual-passage rods mounted below the rotary head:
    a first fluid supplying device (123) for supplying a fluid through the peripheral duct (151), and
    a second fluid supplying device (124) for supplying a fluid through the central duct (15),
   and wherein the valve member (30a) is associated with the central duct (15) and is mounted above the second fluid supplying device (124).

8. A method of performing directional drilling, comprising the steps of:
   performing a directional drilling in a soil by means of the drill rig according to claim 1, supplying a drilling fluid in the duct (15) through the fluid supplying device (23);
   interrupting the supply of drilling fluid and stopping the motion of the rotary head and the string of rods;
   bringing the at least one valve member (30, 30a) into open position;
   without unscrewing the rods to open the string, lowering the inclination measuring device (40) into the duct (15), bringing the mule shoe assembly (17, 28) to an engaged condition so as to orient the inclination measuring device (40) in a desired orientation with respect to the bottom rod (14c) of the string;
   measuring the inclination of the bottom rod by means of the device (40);
   lifting the device (40) by means of the cable (22) so as to disengage the mule shoe assembly and rotationally release the device (40) from the string;
   optionally, performing maneuvers to correct the inclination of the string;
   bringing the at least one valve member (30, 30a) into the closed position;
   resuming drilling and supplying drilling fluid through the duct (15).

9. The method of claim 8, wherein the step of bringing the valve member (30, 30a) into the closed position is preceded by the step of completely removing the measuring device (40) from the string of rods, pulling the device (40) upward by rewinding the cable (22), without unscrewing the rods of the string.

10. The method of claim 8, wherein the step of bringing the valve member (30) into the closed position is performed by hermetically closing the valve member (30) around the cable (22), and the subsequent step of resuming the drilling is performed keeping the measuring device (40) suspended to the cable (22) inside the duct (15), simultaneously keeping the valve member element (30) rotationally stationary.

11. A method of performing directional drilling, comprising the steps of:
   performing a directional drilling in a soil by means of the drill rig according to claim 7, supplying a drilling fluid in the second peripheral duct (151) through the second fluid supplying device (124);
   interrupting the supply of drilling fluid and stopping the movements of the rotary head and the rod string;
   bringing the valve member (30a) into the open position;
   without unscrewing the rods to open the string, lowering the inclination measuring tool (40) into the first central duct (15), bringing the mule shoe assembly to an engaged condition so as to orient the measuring device in a desired orientation with respect to the bottom rod (14c) of the string;
   measuring the inclination of the bottom rod by means of the device (40);
   lifting the device (40) via the cable (22) so as to disengage the mule shoe assembly and rotationally release the device from the string;
   optionally, performing maneuvers to correct the inclination of the string;
   resuming the drilling and the supply of drilling fluid in the second duct (151) through the second fluid supplying device (124);
   upon completion of the drilling, completely removing the device (40) from the rod string, pulling the device upward by rewinding the cable (22), without unscrewing the rods of the string;
   bringing the valve member (30a) into the closed position so as to close the first central duct (15);
   lifting the string of rods while supplying a consolidating fluid in the first central duct (15) through the first fluid supplying device (123).

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