

- [54] **METHOD FOR MOUNTING AN ELECTRIC CONDUCTOR IN A DRILL STRING**
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[58] Field of Search..... **166/315, 65, 65 M; 175/57, 175/40, 50, 104; 339/16 R; 174/47; 324/8**

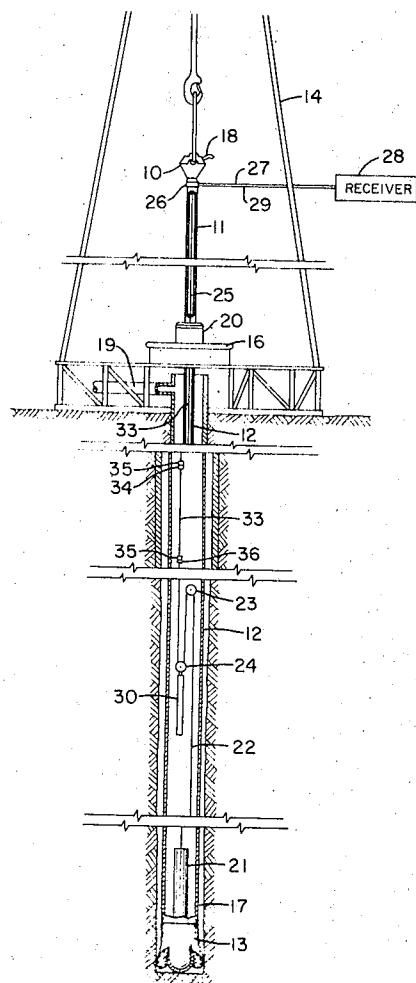
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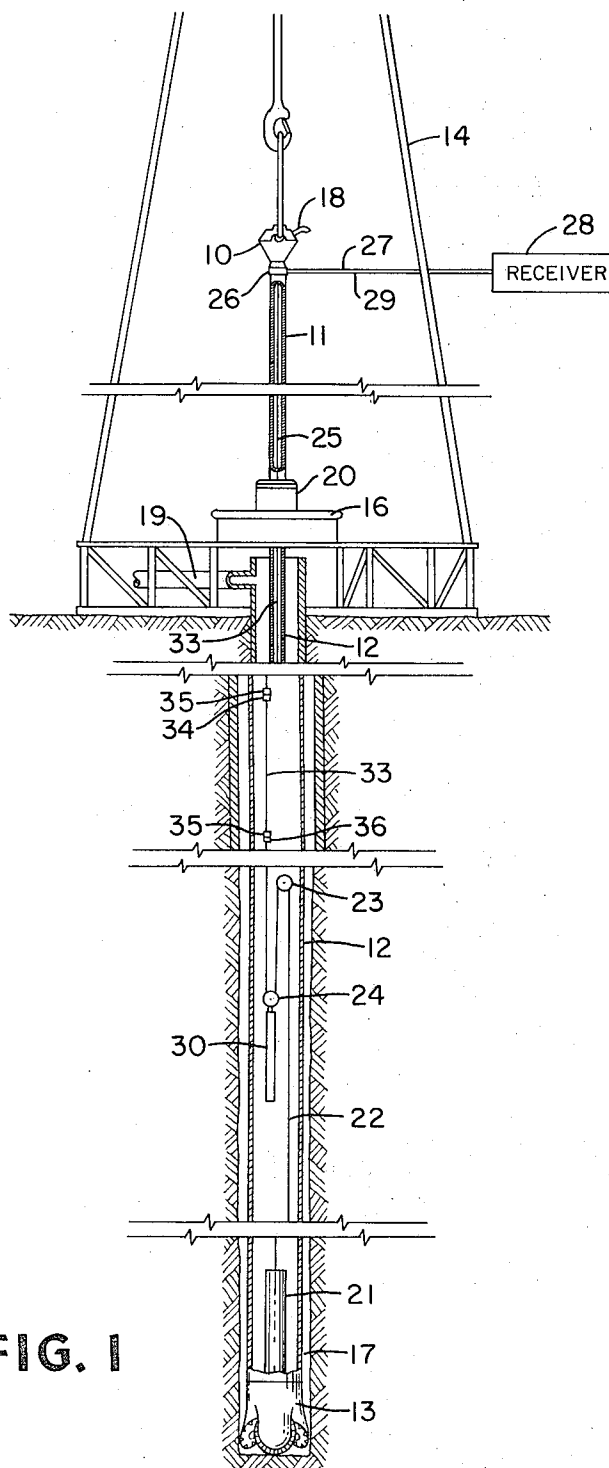
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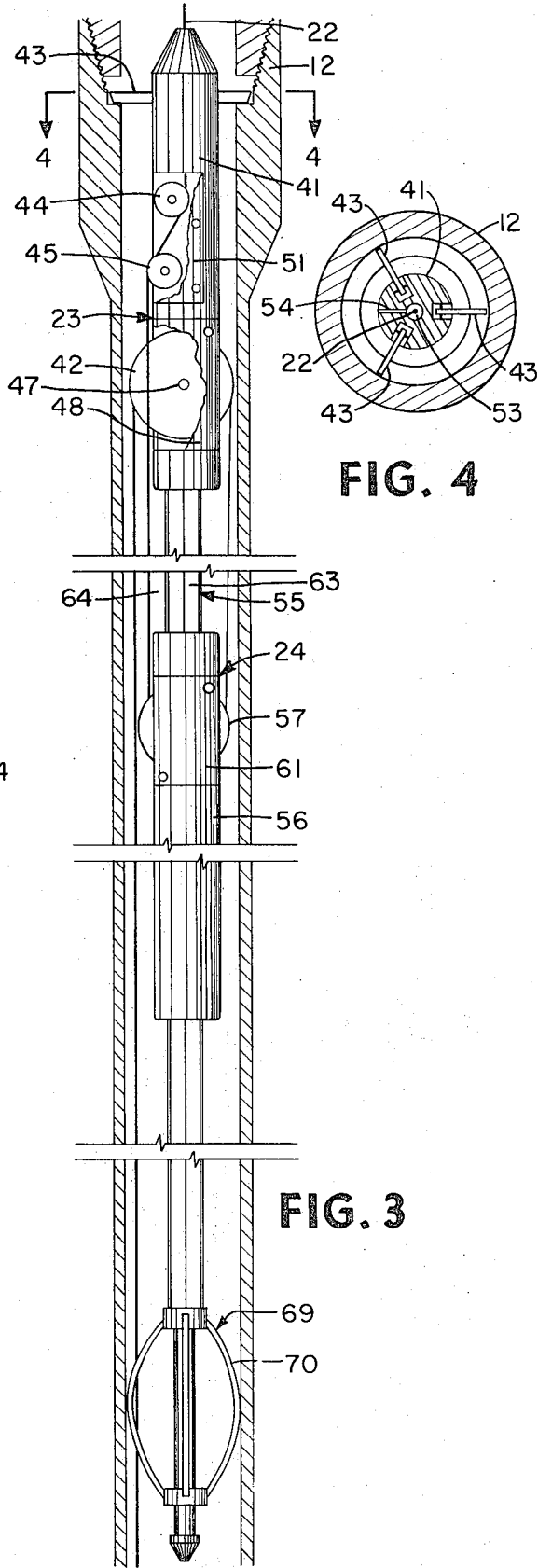
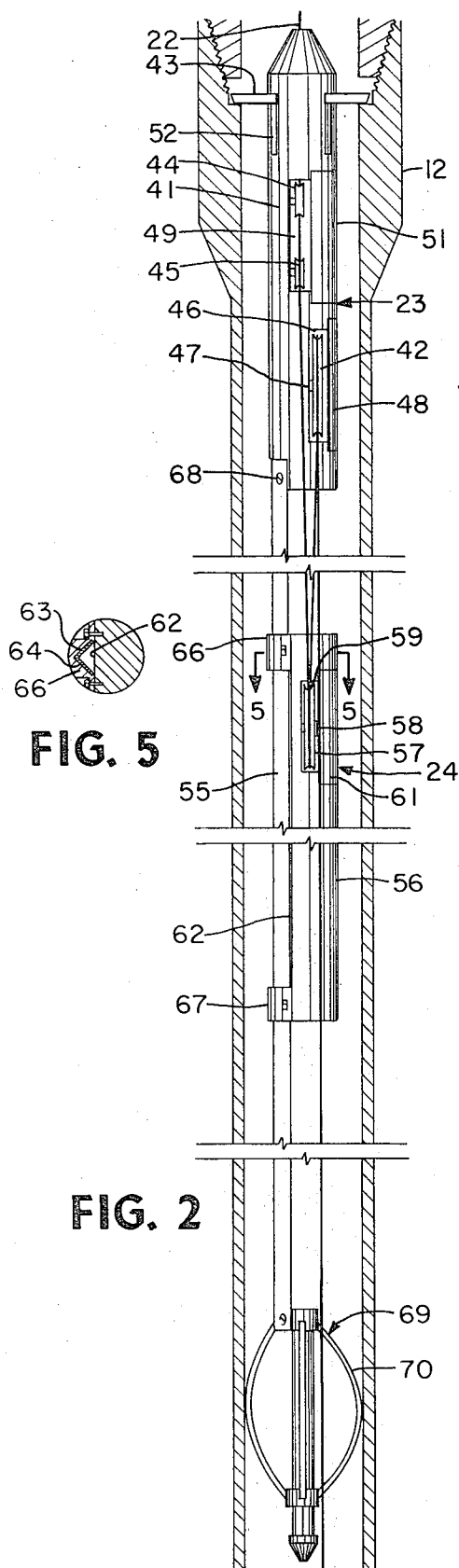
[57] **ABSTRACT**
Method for performing wellbore telemetry operations wherein an electric circuit between a subsurface location in a pipe string and the surface is established and maintained by placing an electric conductor in the pipe string to extend from the subsurface location to the surface, arranging the conductor in an overlapped configuration having an upper loop and a lower loop, biasing the lower loop downwardly to remove slack from the conductor, advancing the wellbore in increments of sufficient length to require lengthening the pipe string and for each such incremental advancement, lengthening the pipe string by adding a length of pipe thereto. The length of pipe added to the drill string has extending therethrough an electrical conductor section for lengthening the conductor in the pipe string.

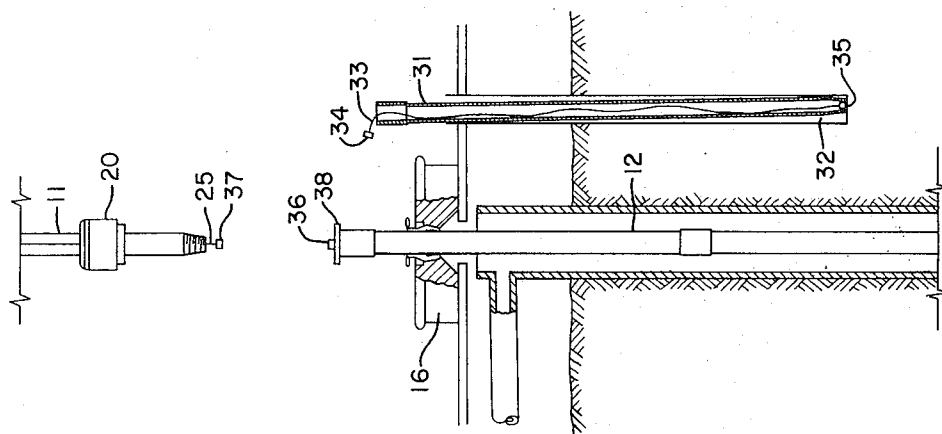
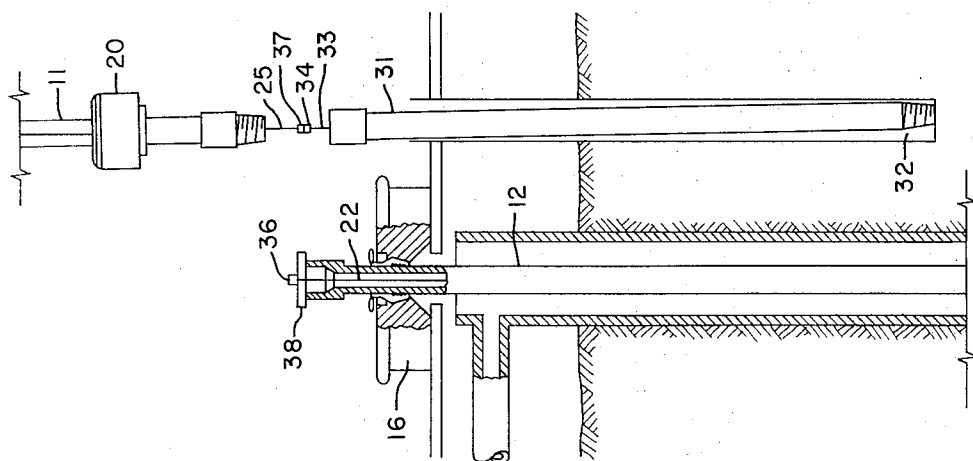
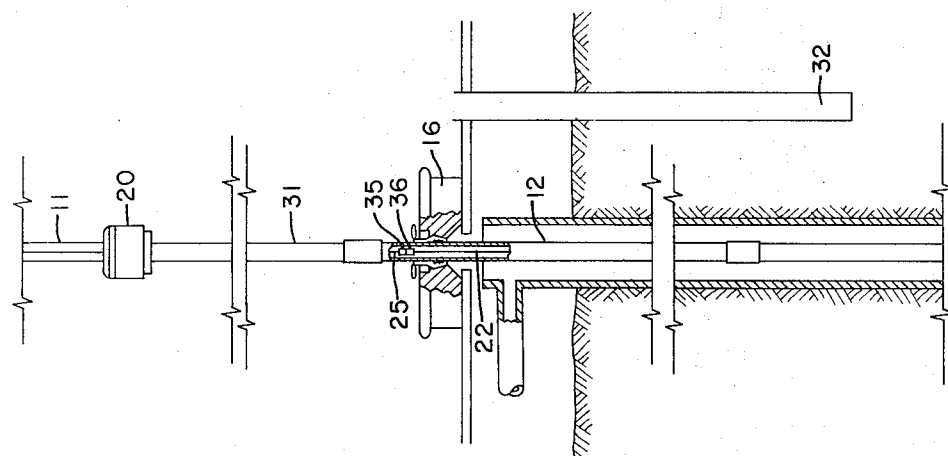
8 Claims, 8 Drawing Figures





SHEET 2 OF 3





METHOD FOR MOUNTING AN ELECTRIC CONDUCTOR IN A DRILL STRING

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an improved method for performing wellbore telemetry operations. In one aspect it relates to a method for establishing and maintaining electric continuity between a subsurface location in a rotary drill string and a surface location.

2. Description of the Prior Art

In the drilling of oil wells, gas wells, and similar boreholes, it frequently is desirable to transmit electric energy between subsurface and surface locations. One application where electrical transmission has received considerable attention in recent years is in wellbore telemetry systems designed to sense, transmit, and receive information indicative of a subsurface condition. This operation has become known in the art as "logging while drilling".

A major problem associated with wellbore telemetry systems has been that of providing reliable means for transmitting an electric signal between the subsurface and surface locations. This problem can best be appreciated by considering the manner in which rotary drilling operations are normally performed. In conventional rotary drilling, a borehole is advanced by rotating a drill string provided with a drill bit at its lower end. Lengths of drill pipe, usually about 30 feet long, are added to the drill string, one-at-a-time, as the borehole is advanced in increments. In adapting an electric telemetry system to rotary drilling equipment, the means for transmitting the electric signal through the drill string must be such to permit the connection of additional pipe lengths to the drill string as the borehole is advanced.

An early approach to the problem involved the use of continuous electric cable which was adapted to be lowered inside the drill string and to make contact with a subsurface terminal. This technique, however, required withdrawing the cable from the drill string each time a pipe length was added to the drill string. A more recent approach involves the use of special drill pipe. Each pipe section of the special pipe is provided with an electric conductor having connectors at its opposite ends. Electric continuity is maintained across the junction of two pipe sections by connectors of one section contacting a connector on the adjacent pipe section (see U.S. Pats. No. 3,518,608 and 3,518,609). Disadvantages of this system include the high cost of the special pipe sections, the need for a large number of electric connections (one at each joint), and the difficulty of maintaining insulation of the electric connectors at each joint.

Still another approach involves the use of cable sections mounted in each pipe section (See U.S. Pat. No. 2,748,358). The cable sections are connected together as pipe sections are added to the drill string. Each cable section is normally made slightly longer than its associated pipe section, with the result that a small amount of slack is present in the conductor string at all times. Drilling fluid flowing through the drill string exerts a fluid drag on the loose cable which tends to damage the connectors or snarl the cable.

SUMMARY OF THE INVENTION

The purpose of the present invention is to provide an electric circuit between a subsurface location in a well and the surface, thereby permitting the monitoring of a subsurface condition during drilling operations. The invention also contemplates that the circuit between the surface and subsurface locations may be used to actuate a subsurface instrument employed in the drill string.

Briefly, the method involves placing within a pipe string used to drill a well an insulated electric conductor string in tension, advancing said well in increments sufficiently long to require additional pipe, and for each incremental advancement inserting into the system a pipe length provided with an electric conductor section to lengthen both the pipe string and the conductor string.

Important advantages of the method of the present invention over prior art techniques are that it permits the use of individual conductor sections without the need for multiple supports within the pipe string; the conductor is maintained in tension during the drilling operation so that the disturbance of fluid flow on the conductor is minimized; and means for maintaining the conductor in tension compensates for variation in lengths of the conductor and removes slack from the conductor string each time a conductor section is added to the conductor string.

Apparatus usable in the method described above include an upper guide supported within the pipe string, a lower guide disposed below the upper guide, an electric conductor extending from a subsurface location within the pipe string around the upper and lower guides and to the surface, and means, preferably a track between the guides, for preventing relative rotary movement of the upper and lower guides but permitting relative axial movement therebetween.

An important feature of the apparatus is that it prevents the overlapped conductor lengths from twisting as a result of the rotary action of the drill pipe. Experience has shown that rotation of the drill pipe containing overlapped cable lengths can sometimes cause the cable to become twisted or snarled. By incorporating a track or guide for preventing relative angular movement of the upper and lower guides, the risk of cable twisting or snarling is minimized.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of well drilling equipment provided with an electric conductor for transmitting an electric signal between subsurface location and the surface.

FIG. 2 is a side elevation view of the apparatus useful in the method of the present invention.

FIG. 3 is a view similar to FIG. 2 showing the apparatus revolved 90° from the position of FIG. 2.

FIG. 4 is a transverse sectional view of apparatus shown in FIG. 3, with the cutting plane taken generally through line 4—4 thereof.

FIG. 5 is a transverse sectional view of the apparatus shown in FIG. 2 with the cutting plane taken generally through the line 5—5 thereof.

FIGS. 6, 7, and 8 are sequence views illustrating a procedure for lengthening the conductor and pipe strings during drilling operations.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Conventional rotary drilling equipment, as schematically illustrated in FIG. 1, includes swivel 10, kelly 11, tubular drill string 12, and bit 13. These components, connected in the manner illustrated, are suspended from the drilling derrick 14 by means of rig hoisting equipment. The kelly 11 passes through rotary table 16 and connects to the upper end of the drill string 12. The term "drill string" as used herein refers to the column of tubular pipe between the bit 13 and the kelly 11; and the term "pipe string" refers to the complete pipe column including the kelly 11. The major portion of the drill string 12 normally is composed of drill pipe with a lower portion being composed of drill collars. The drill string 12 consists of individual pipe sections, either drill pipe or drill collars, connected together in end-to-end relation.

The borehole 17 is advanced by rotating the drill string 12 and bit 13 while at the same time drilling fluid is pumped through the drill string 12 and up the borehole annulus. The drilling fluid is delivered to swivel 10 through a hose (not shown) attached to hose connection 18 and is returned to the surface fluid system through pipe 19. A kelly bushing 20 couples the rotary table 16 to the kelly 11 and provides means for transmitting power from the rotary table 16 to the drill string 12 and bit 13. (The use of a power swivel eliminates the need for the kelly and rotary table. The present invention may also be used in systems which employ a power swivel in lieu of a kelly and rotary table; for purposes of illustration, however, it will be described in connection with the kelly and rotary table arrangement.)

As mentioned previously, it frequently is desirable to monitor a subsurface drilling condition during drilling operations. This requires measuring a physical condition at the subsurface location, transmitting this data as an electric signal to the surface, and reducing the signal to useful form. Typical situations where telemetry is applicable in drilling operations include drilling through abnormal pressure zones, drilling through zones where hole deviation is likely to be a problem, directional drilling, exploratory drilling, and the like.

Although the present invention may be employed in most any drilling operation wherein an electric conductor is used in tubular pipe to transmit electric energy between the subsurface and surface location, it finds particularly advantageous application in a wellbore telemetry system such as that illustrated in FIG. 1 which comprises an instrument 21, conductor string 22, and receiver 28.

The instrument 21 capable of measuring a subsurface condition and generating an electric signal indicative or representative of that condition is mounted or adapted to be mounted in the drill string 12. A variety of devices capable of sensing a physical condition are available. These include transducers for measuring pressure, temperature, strain and the like; surveying instruments for measuring hole deviation; and logging instruments for measuring resistivity or other properties of subsurface formations. The instrument 21 may be powered by batteries or by energy transmitted through conductor 22. Alternatively, a subsurface generator driven by fluid flowing through the drill string 12 may be used to power instrument 21.

The present invention is concerned primarily with a method for maintaining the electric conductor in the pipe string 12 during drilling operations. The energy transmitted through conductor 22 may be a signal generated by the subsurface instrument 21 and transmitted to the receiver 28 at the surface. Alternatively, the energy may be electric power transmitted from the surface to actuate or drive a subsurface instrument or motor. Or, energy may be transmitted down the conductor 22 to power the instrument 21, and simultaneously intelligence may be transmitted up the same conductor.

In telemetry operations, it is preferred that the energy being transmitted be in the form of a pulsating signal. Information can be transmitted by varying the number, amplitude, width or spacing of a train of electric pulses, or it can be transmitted by modulating the frequency or amplitude of the pulsating signal. More than one transducer or other device may be employed in the instrument 21 if desired, in which case a multiplexer may be used for sending the various signals over a single conductor.

In one aspect, the present invention contemplates maintaining the conductor string 22 in tension as drilling operations are in progress. As schematically illustrated in FIG. 1, the conductor string 22 extends from instrument 21 around upper and lower guides 23 and 24 disposed in the drill string 12, and to the surface where it connects to kelly conductor 25. In this embodiment, the kelly conductor 25 extends through the kelly 11 and connects to a terminal located at the upper end of the kelly 11. It should be observed, however, that conductor 25 may be embedded in the kelly 11, in which case the conductor 22 will extend to the upper end of the drill string 12 and connect to conductor 25 at that location. In order to facilitate the addition of pipe sections to the drill string 12, however, it is preferred that conductor 25 extend through the interior of the kelly 11 as illustrated and connect to the upper end of conductor string 22 a short distance (e.g. 1 or 2 feet) below the lower end of kelly 11.

In telemetry operations are to be performed while the kelly 11 and drill string 12 are rotating, the upper end of conductor 25 will be connected to a device 26 capable of transmitting electric energy from a rotating member to a stationary member. Device 26 may be a rotary transformer having a rotor secured to the kelly 11 and a stator secured to the stationary portion of the swivel 10, or it may be a slip-ring and brush assembly. Device 26 and electric conductor 27 provide means for transmitting signals from the conductor string 22 within the pipe string to receiver 28. The return path for the electric circuit may be provided by a variety of grounding circuits but preferably is through the pipe string or conductor armor. Conductor 29, part of the return path, interconnects stationary portion of device 26 and receiver 28. If telemetry operations are to be performed at times when the drill string 12 and kelly 11 are stationary, device 26 will not be needed and the conductors 27 and 29 may be connected directly to conductor 22 and ground through a suitable connector. In this situation, conductors 27 and 29 will be disconnected from conductor string 22 and ground when the kelly 11 and drill string 12 are rotated. Other means for transmitting the signal to the receiver 28 include a wireless transmitter connected to conductors 22 or 25 and located on a rotating member, e.g., kelly 11.

The receiver 28 is an instrument capable of receiving the signal generated by instrument 21 and reducing it to useful form.

In performing the method of the present invention, the conductor string 22 with instrument 21 suspended thereon is first lowered within the drill string 12 until instrument 21 is located at the proper subsurface location. At the surface, conductor 22 is looped over guides 23 and 24 to provide an overlapped configuration.

This guide assembly with conductor looped therearound is then lowered within the drill string 12. In a preferred form, the upper guide 23 is supported within the drill string and the lower guide 24 is suspended on a looped portion of conductor 22. The lower guide 24 which may include a weight 30 maintains tension on the conductor 22 and is free to move toward or away from the upper guide as conductor 22 is retrieved from or fed into the drill string 12. With the guide assembly installed in the drill string 12, the upper terminal end of conductor string 22 is connected to kelly conductor 25. Connection of the kelly 11 to the drill string 12 places the equipment in condition for drilling and for performing telemetry operations if desired.

Under normal drilling, the wellbore is advanced in increments of sufficient length to require lengthening both the drill string 12 and conductor string 22 disposed therein. The procedure for lengthening these strings will be described with reference to FIGS. 6-8 wherein a length of pipe 31 to be added to the drill string 12 is shown disposed in a shallow hole 32 ("mouse hole") below the derrick floor. The length of pipe 31 is provided with a conductor section 33 having electrical connectors 34 and 35 at its opposite ends. Conductor 35 is adapted to mate with connector 36 at the upper terminal end of conductor string 22, and connector 34 is adapted to mate with the lower terminal connector 37 of kelly conductor 25. The connectors of adjacent conductor sections 31 are also adapted to mate; that is, lower connector 35 of one section 31 mates with upper connector 34 of the preceding section in the conductor string 22. As illustrated in FIG. 6, each conductor section 33 is slightly longer than its associated pipe length 31. The longer conductor section facilitates the connecting procedure because it ensures that the lower connector 35 will be exposed below the pipe length 31 with the later suspended from kelly 11.

In inserting each pipe section 31 provided with conductor section 33, the drill string 12 is initially elevated and suspended in the rotary table 16 and the kelly 11 disconnected from drill string 12. The kelly 11 is elevated pulling mated connectors 36 and 37 above the upper end of drill string 12. A support plate 38 or spider is inserted between the upper end of the drill string and connector 36, and serves to support the conductor string 22. Connectors 36 and 37 are then separated. FIG. 6 illustrates the position of the equipment at this juncture in the procedure: The kelly 11 is swung over into alignment with pipe length 31 and the kelly conductor 25 is connected to conductor section 33 by mating connectors 37 and 34. (See FIG. 7.) The kelly 11 is then screwed into the pipe section 31. This assembly is elevated above the drill string 12. Exposed connector 35 is mated with connector 36 inserting conductor section 33 into the conductor string 22. After the support plate 38 is removed, the lower end of pipe length 31 is screwed into the drill string 12 and becomes a part

thereof. (See FIG. 8.) The mated connectors 35 and 36 are pulled downwardly within the drill string 12 by the lower guide 24 until all slack introduced by the conductor section 33 is removed from the conductor string 22.

The equipment is then returned to the drilling position and drilling operations resumed. For each incremental advancement of the borehole of approximately 30 feet, the drill string 12 and conductor string 22 are lengthened by the procedure described above.

It will be seen from FIG. 1 that the lower guide 24 is free to move downwardly relative to the upper guide 23 each time the drill string 12 and conductor string 22 are lengthened. The overlapped lengths of conductor 22 between guides 23 and 24 will normally be short at the beginning of the operation but will become longer as the well is advanced and as pipe lengths 31 and conductor sections 33 are added into the system.

The amount of initial overlap will be determined, in part, by the length of conductor string 22 and the length of drill string 12 at the time the telemetry equipment is introduced into the system. Since the conductor string 22, as delivered to the drilling site, will normally have a fixed length, it will be necessary to adjust the length of the drill string 12 to approximate that of the conductor string 22. This can be done by lowering the drill string 12 in the well until its length is about 15 to 30 feet shorter than the length of conductor string. The excess length of conductor can be used to form the overlapped portions of the conductor string 22. If the excess length is 30 feet, the overlapped portions will each be 15 feet long and the lower guide 24 will initially be 15 feet below the upper guide 23.

It is thus seen that the apparatus for maintaining the conductor within the drill string 12 serves three important functions: (1) it maintains the conductor in tension, preventing it from being excessively disturbed by the drilling fluid being pumped through the drill string; (2) it permits variations in the length of the conductor string as initially installed; and (3) it removes slack from the conductor string as conductor sections are introduced into the conductor string.

Details of a preferred construction of the apparatus useful in the present invention are shown in FIGS. 2-5. As illustrated, the upper guide 23 comprises a cylindrical body member 41, a sheave 42 journaled to body 41, support arms 43, and guide rollers 44 and 45. The sheave 42 is mounted for free-wheel rotation on shaft 47 and is disposed within opening 46 formed in the body 41. The outer side of the opening 46 is closed by the panel 48 (shown cutaway in FIG. 3). The sheave 42 has a grooved outer periphery for retaining conductor 22. Its pitch diameter is sufficiently small to fit within the drill string 12 and yet permit the conductor 22 to be bent therearound. The rollers 44 and 45 are mounted for free-wheel rotation in an opening 49 formed in the body 41 at a location above the sheave opening 46 but laterally offset therefrom. Opening 49 is enclosed on one side by panel 51 (shown cutaway in FIG. 3). Panels 48 and 51 are secured to body 41 by fasteners such as screws but are removable therefrom to permit the conductor 22 to be mounted on the apparatus.

The support arms 43 are pivotally mounted in the upper extremity of the body 41. In the supporting position the arms 43 extend radially outwardly as illustrated and rest on the box end of a drill pipe section. The arms 43, however, are pivotable downwardly into suitable

slots 52 formed in the body member 41 to permit the assembly to be retrieved from the drill string 12 if desired. A central opening 53 extends from opening 49 through the upper nose end of the body 41. A side opening slot 54 (see FIG. 4) provides access to opening 53.

The lower guide 24 which is adapted to be suspended on a looped portion of the conductor 22 is movable in relation to the upper guide 23, preferably, along a stabilizing track 55. The lower guide 24 includes an elongated body member 56, a sheave 57 journaled to body 56, and means for slidably mounting the lower body 56 on track 55. Lower sheave 57 which can be about the same size and structure as the upper sheave 42 is mounted for free-wheel rotation on shaft 58 within opening 59 formed in body member 56. Panel 61 closes one side of opening 59 and serves to prevent conductor 22 from becoming dislodged from the lower guide assembly. In the embodiment illustrated in FIGS. 2 and 3, the lower sheave 57 is slightly smaller in diameter than sheave 42 and is positioned in approximate vertical alignment with rollers 44 and 45.

The lower body member 56 preferably is roughly semicircular in cross section having a flat longitudinal surface 62 (see FIG. 5). The track 55 which serves to maintain the lower guide 24 in the proper attitude in relation to the upper guide 23 may be rectangular, square, or triangular in cross section or any other configuration which prevents relative angular movement of the lower guide 24. Fastening means such as clamps 66 and 67 maintain the body member 56 slidably secured to the track 55 at axially spaced points.

In the embodiment disclosed herein, the track 55 is in the form of an elongate triangular member having diverging legs 63 and 64 (see FIG. 5). The outer edges of the legs 63 and 64 are adapted to engage the flat surface 62 at laterally spaced points and the clamps 66 and 67 have V-shaped interiors conforming to the outer surface of track 55. Clamps 66 and 67 may be bolted to the body as illustrated. The upper end of the track 55 is secured to the upper body member 41 by suitable fasteners such as bolts 68. The lower end of the track 55 may be provided with a centralizer 69 which includes a plurality of bow springs 70.

The overall length of the apparatus including upper guide 23, lower guide 24, track 55, and centralizer 69 need not exceed the length of one or two pipe sections or approximately 30 to 60 feet. However, if desired, it can be made to extend a considerable distance within the drill string 12 by employing tracks that connect together in end-to-end relation; it is possible for the track 55 to extend several hundred feet. A long track would be required for a system such as that disclosed in assignee's copending application Ser. No. 350,459 which stores conductor within the drill string using upper and lower guides and supplies lengths of conductor as the drill string is lengthened. In such a system the guides normally are initially disposed far apart and move toward one another as the excess length of conductor is used up. For purposes of the present invention, however, the track 55 may be considered as being approximately equal to one 30-foot pipe section.

The upper and lower body members 41 and 56 may be machined from steel or other strong metal. The track 55, sheaves 42, 57, and rollers 44 and 45 are of conventional construction and are commercially available. The lower body member 56 should be sufficiently

long to provide sufficient weight to impart a downward tensioning force on the conductor looped thereon. A weight of about forty pounds should be sufficient for most applications.

The conductor 22 usable in the preferred embodiment of the present invention should have the following properties. It should have a breaking strength sufficiently high to support the guides 23 and 24 and instrument 21; it should have an operating temperature at least equal to the maximum subsurface temperature encountered; and it should be sufficiently flexible to permit it to be arranged in the proper convoluted configuration. A particularly suitable conductor is a single conductor 3/16-inch armored cable manufactured by Vector Cable Company and sold as Type 1-18P. Tests have shown that this cable can be bent around sheaves having a pitch diameter of two inches.

Both the upper and lower assemblies with conductor wound thereon should have a sufficiently small diameter to pass through the interior of a drill string. For a 4½ inch drill pipe with internal upset I. D. of 2.81 inches, 2 inch sheaves and somewhat smaller body diameters provide adequate clearance.

The installation of the apparatus and performance of the method of the present invention is described below. After drilling has progressed to the point that it is desired to commence wellbore telemetry operations, drilling operations are interrupted and an instrument 21 is lowered into the pipe string on the conductor 22 using conventional techniques. For this operation, a sheave disposed above the derrick floor is normally employed to guide the conductor string 22 into the wellbore as it is unreeled from a drum. With the instrument 21 properly seated in the lower end of the pipe string 12, preferably in a locking sub immediately above bit 13, the conductor 22 is manually looped around the upper and lower sheaves 42 and 57, threaded between the guide rollers 44 and 45 and positioned in the nose opening 53. With the conductor string 22 properly mounted on the apparatus, the panels 48, 51, and 61 are installed and, by use of rig drawworks, the assembly is elevated above the derrick floor and lowered into the drill string 12. This may be achieved by connecting the conductor connector 36 to the kelly connector 37 and elevating the kelly 11. The lower guide 24, following track 55, is drawn up into abutting engagement with the upper guide 23; the entire assembly is raised by elevating the kelly 11. The assembly is lowered through the upper end of the pipe string until the support arms 43 engage the box end of the top pipe section.

Since connector 36 cannot pass through opening 53 in body member 41, conductor 22 should extend a short distance above the upper guide 23. To provide a length of conductor above the upper guide 23, conductor 22 is fed into the drill string 12 lowering guide 24 along track 55 to its lowermost position. This also places the connector 36 near the upper guide 23. A length of pipe is then added to the upper end of the drill string 12 and the conductor 22 threaded upwardly through the added pipe length. This moves the lower guide to about the mid point of track 55.

As drilling operations proceed, pipe lengths and conductor sections are added to lengthen both the pipe string and the conductor in the manner described previously with reference to FIGS. 6-8. This condition is schematically illustrated in FIG. 1 which shows the conductor string as comprising the original long con-

ductor trained about the guides 23 and 24 and a plurality of conductor sections 33 extending from connector 36 to the surface.

Since the conductor sections are normally longer than the pipe length, the lower guide moves downwardly a short distance away from the upper guide 23 for each lengthening of the pipe string and conductor string 22. The lower guide 24 is sufficiently heavy to remove slack from the conductor string 22. If the excess length of conductor averages one foot, about 30 pipe lengths may be added as the drilling progresses. This should place the lower guide 24 near the lower end of the track 55 and the connector 36 near the upper guide assembly. The apparatus may be returned to its original condition merely by pulling the conductor string 22 upwardly and removing one of the conductor sections 33 from the conductor string 22. This moves the lower guide 24 along track 55 about 15 feet and moves the connector 36 about 30 feet above the upper guide 23.

Although the present invention has been described with reference to conventional rotary drilling operations, it can also be used with other types of drilling equipment including turbodrills and positive displacement hydraulic motors. These devices normally include a motor or turbine mounted on the lower end of the drill string and adapted to connect to and drive a bit. The motor or turbine powered by the drilling fluid drives the drill bit while the drill string remains stationary. When this type subsurface drilling device is used in directional drilling operations, the present invention provides a highly useful means for transmitting directional data to the surface.

I claim:

1. A method of establishing and maintaining electric continuity between a subsurface location within a pipe string used to drill a well and a location substantially at the surface which comprises placing an electric conductor string in said pipe string to extend between said locations; overlapping a portion of said conductor string to form an upper loop and a lower loop; biasing said lower loop downwardly while maintaining said upper loop in said pipe string to remove slack from the said conductor string; advancing said well in increments of sufficient length to require lengthening said pipe string; and for each of said incremented advancements lengthening both said pipe string and said conductor string by inserting a length of pipe into the pipe string and a conductor section into the conductor string, said conductor section having a length different from said pipe length.

2. A method as defined in claim 1 wherein each conductor section is slightly longer than its associated pipe length and wherein the biasing step moves the lower loop downwardly from the upper loop to remove slack

from the conductor string introduced by each addition of a pipe length and a conductor section.

3. A method as defined in claim 1 and further comprising the step of preventing the upper and lower loops from twisting relative to one another.

4. A method of establishing and maintaining electric continuity between a subsurface location within a pipe string used to drill a well and a location substantially at the surface which comprises lowering an electric conductor string in said pipe string to extend between said locations; overlapping a portion of said conductor string to form an upper loop and a lower loop; biasing said upper loop and lower loops apart; and preventing said upper loop and lower loops from twisting relative to one another.

5. A method as defined in claim 4 and further comprising the steps of advancing said well sufficiently to require the addition of a length of pipe; adding a conductor section into said conductor string to lengthen said conductor string by an amount slightly longer than said length of pipe and adding said length of pipe to said pipe string to lengthen said pipe string, said step of biasing said loops apart being operative to remove slack from said conductor string introduced by the addition of said conductor section.

6. A method for establishing and maintaining electric continuity between a subsurface location within a pipe string used to drill a well and a location substantially at the surface which comprises lowering an electric conductor string in said pipe string to extend between said locations; looping said conductor string around upper and lower guides to form overlapped conductor portions; supporting the upper guide within said drill string; and mounting said lower guide on a track connected to said upper guide to maintain the lower guides in substantial vertical alignment with the upper guide, said lower guide being suspended on a looped portion of said conductor string and being movable along said track.

7. A method for installing an electric conductor string within a rotatable pipe string used to drill a well which comprises lowering an electric conductor string in said pipe string; looping said conductor string around upper and lower guides to form overlapped conductor portions; supporting the upper guide within said drill string; and maintaining said lower guide in substantial vertical alignment with said upper guide as said pipe string is rotated to prevent said overlapped conductor portions from twisting while enabling said lower guide to move vertically in relation to said upper guide.

8. A method as defined in claim 7 wherein said upper and lower guides are maintained in substantial vertical alignment by a rigid track secured to said upper guide, said lower guide being slidably mounted on said track.

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