

PATENT SPECIFICATION

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(54) PIPE SECTION FOR USE IN BOREHOLE OPERATIONS

(71) We, SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V., a company organised under the laws of The Netherlands, of 30 Carel van Bylandtlaan, The Hague, The Netherlands, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a pipe section for use in borehole operations, such as in drilling operations in boreholes or in the subsequent production of valuable fluids such as oil and gas from wells that are formed by boreholes penetrating into formations containing such fluids.

The pipe sections according to the invention can be used in strings through which electric signals have to be transmitted. Such signals may be representative for values measured down the hole, such as the inclination of the hole that is being drilled, the knowledge whereof will be of great assistance to the operator for optimizing the drilling operation. The electric signals are then passed on to the surface by means of an electric telemetering system that is carried by the drill pipe sections and the drill collars of the drill string. In oil recovery operations such signals may contain data on the pressure prevailing down the well, which data are often continuously recorded for obtaining information on the behaviour of a well. In these latter operations, the signals are transmitted to the surface through the intermediary of telemetering means carried by the pipe sections of the production tubing that is suspended in the well.

Pipe sections that are adapted for use in pipe strings through which electric signals can be transmitted comprise a length of pipe provided at both ends thereof with screw coupling elements, such as a pin section and a box section of a tool joint. Electrodes are mounted near the coupling elements in a manner such that they are insulated from the metal body of the pipe

section. The electrodes of adjoining pipe sections will be in signal transmitting relationship when two identical pipe sections have been interconnected by their coupling means. The electrodes at both ends of each pipe section are electrically interconnected by means of an insulated electric conductor cable that passes through the length of pipe of the section.

To protect the insulated electric conductor cable, this cable is passed through a metal conduit that extends through the pipe section. The metal conduit should be held mechanically to the inner wall of the pipe section by means that do not interfere with the passage of drilling fluid therethrough, or with the passage of wire-line tools.

When drilling boreholes and/or installing pipe strings within boreholes of wells, the pipe strings may bend by amounts that would move a straight conduit (that is arranged along the inner wall of the pipe) toward the centre of the pipe in a manner that would interfere with the passage of a tool within the pipe. For example, if a 9 meter-length of drill pipe section is flexed at a constant curvature over its length (where the pipe section has an inner diameter of about 10 centimetres and contains an internal conduit that is attached at its ends and has an outer diameter of about 1 centimetre); if the pipe curvature reaches 4.46° per 9 metres (15° per 30 metres), the conduit, even though it is kept in a straight line, will extend across the pipe interior and touch the opposite part of the internal wall of the pipe. Curvatures approaching this magnitude are common, especially in off-shore wells where a large number is drilled from a single platform. In addition, it is obvious that a much smaller amount of curvature could move such a conduit away from the adjacent wall by an amount making it likely to entangle a wire-line run through the pipe.

An object of the present invention is a pipe section comprising electric signal transmission means of the above type, wherein the conduit protecting the insulated electric conductor is

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mounted in the pipe section in a cheap and reliable manner that creates low stress concentrations in the pipe section, and allows the passage of wire line tools.

5 A pipe section according to the invention comprises a length of pipe, provided with screw coupling elements arranged at opposite ends thereof, a bore centrally arranged in each coupling element and having a smaller
10 internal diameter than that of the pipe, a conduit having a helical form with straight end portions, the outer diameter of said helix being sized to firmly engage the inner wall of the length of pipe when said conduit is placed in
15 said length of pipe, a passageway formed in each coupling element, the ends of the conduit being formed to align with said passageways, sealing means disposed in each of the passageways to form fluid-tight seals between the ends
20 of said conduit and the passageways and in addition, mechanically anchor the conduit in the passageways, and electrodes carried by the coupling elements through the intermediary of insulating means, the electrodes at opposite ends
25 of the pipe section being in electric communication by means of an insulated electric conductor that extends through the passageways and the conduit.

30 The invention will be described by way of example in more detail with reference to the drawing which shows by way of example an embodiment of the invention.

Figure 1 of the drawing shows a longitudinal section over a pipe section according to the present invention.

Figure 2 shows detail II of Figure 1 on a larger scale.

35 The pipe section 1 shown in Figure 1 comprises a length of pipe 2 provided with coupling elements at opposite ends thereof, said elements consisting of a pin end 3 and a box end 4. The tool joints are known as X-hole tool joints, but have a reduced internal diameter. For example,
40 in a 4½ inch diameter drill string, 4½ inch X-hole tool joints having a minimum diameter of bore 5 of 2½ inch were used.

45 The tool joints carry electrodes adapted for passing signals to electrodes of pipe sections identical to pipe section 1, when these sections are interconnected by means of their tool joints. In the embodiment shown in Figure 1, these electrodes are formed by contact rings 6 and 7 that are attached to opposite ends of the pipe section 1 in grooves by means of an insulating material such as epoxy resin. Reference is made
50 to Figure 2, which shows a detail of the annular contact element 6 that is for part thereof surrounded by insulating material 8 that fills the groove 9 arranged in the face of the sealing
55 shoulder 10 of the pin end 3 of the tool joint.

60 When interconnecting identical pipe sections 1 as shown in Figures 1 and 2 by means of their tool joints, the contact elements and the insulating materials are isolated from fluid in or around
65 the drill string by the metal-to-metal joining of

the sealing shoulders.

The contacts 6 and 7 are electrically interconnected by an electrical circuit that passes through the passageways 11 and 12, the conduit 13, and the passageways 14 and 15. The circuit consists of a conductor 16 substantially situated
70 in passageway 11, a conductor cable 17 substantially situated in the conduit 13, and a conductor (not shown) substantially situated in the passage 15. The conductor cable 17 is electrically
75 coupled to the two other conductors.

The insulated electrical conductors used in the pipe section according to the present invention can be chosen from the commercially available electrical conductors. Those having a relatively
80 low electrical capacitance between the wire and the outer conduit, and high resistance between the wire and conduit (ground), are preferred. The flexibility and diameter of the insulated electrical conductor 17 is chosen such that the
85 conductor will slide relatively easily within the conduit 13 during its installation.

The conduit 13 consists of end portions 18 and 19 that are anchored in the passageways 12 and 14 formed in the coupling elements 3 and 4,
90 respectively, two substantially straight portions 20, 21, and a mid portion 22. The mid portion 22 is designed to be resiliently maintained against the inner wall of the length of pipe 2. To this end, the mid portion 22 of the conduit 13 is curved into a substantially helical shape that is resiliently biased to expand—when
95 installed in the pipe section—to a diameter at least substantially equalling the inner diameter of the length of pipe 2 of the pipe section 1. Thus, after the mid portion of conduit 13 is resiliently deformed and emplaced within the pipe section 1, substantially all portions of this conduit are resiliently pressed against the
100 inner wall of the pipe section 1. In a pipe section of a length of about 9 metres, the straight portions 20, 21 of the conduit 14 may have lengths of about 30 to 60 centimetres, with the distance between the turns or "the lead" of the helical arrangement being from about 90 to 150 centimetres, with 120 centimetres/turn being especially suitable.

The conduit 13 has the end portions 18, 19 thereof anchored in the passageways 12 and 14 as will be described in more detail herein—after with reference to Figure 2.

The screw coupling elements 3 and 4 are shaped such that the end portions 18, 19 of the conduit 13 can be easily inserted into the passageways 12, 14, respectively. The diameter
120 of the bores 5 in the coupling elements is smaller than the inner diameter of the helically shaped mid portion 22 of the conduit 13. Thus, any wire line tool that passes through the tool joints will also pass through the remainder of the pipe section.

Figure 2 shows in detail the attachment of the end portion 18 of the conduit 13 to the passageway 12 in the pin end 3. End portion 18 carries a small flange member 23, which may be
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a separate ring fastened to portion 18 of the conduit by suitable means, such as welding. The end of portion 18 of the conduit is threaded and carries a nut 24. By tightening the nut 24 on the threaded end of portion 18 of the conduit, portion 18 will be drawn into the passageway 12, and a sealing ring 25 will simultaneously be drawn into a sealing engagement with a conical shoulder formed in the passageway 12.

It will be appreciated that the attachment of the other end of the conduit 13 to the passageway 14 (see Figure 1) of the box end 4 is performed in the same manner as described with reference to the attachment of the end of the conduit to the passageway 12 of the pin end 3.

After both ends of the conduit 13 are securely locked in place by the above-described arrangement, the insulated electrical conductor cable 17 may be led via passageway 12 into the conduit 13 and attached to the conductors arranged in the passageways 11 and 15 arranged in the coupling elements 3 and 4, respectively. The way in which the conductor cable 17 is connected to the conductor 16 arranged in passageway 11 will now be described in more detail with reference to Figure 2.

The electrical conductor of insulated cable 16 is connected at one end thereof to the contact ring 6 situated in the sealing shoulder 10 of the pin end 3, and is provided with a pigtail 26 at its other end. This other end of the conductor is electrically coupled to the conductor 27 of cable 17 by a crimp connector 28, with an insulating cap 29 being placed over the connection.

The end of the passageway 12, formed in the pin end 3, is closed by means of a threaded sealing plug 30. A small radial recess 31 is formed in the passageway 12 of the pin end 3, and serves as a location for the end 26 of the conductor cable 16 when it is necessary to remove the conduit 13 from the pipe section 1 to replace the conduit due to wear or similar problems. In this case, the connection between the conductors 16 and 17 (as well as between the conductor 17 and the conductor in the passageway 15 arranged in the box end 4) can be broken, and the end of conductor 16 placed in the radial recess 31 to permit the nut 24 to be removed from the end portion 18 of the conduit 13 without disturbing the position of the conductor 16. This greatly simplifies the replacement of the cable 17 and/or of the conduit 13 since it does not require the removal of the contact rings 6, 7 from the coupling elements. While the contact rings may be removed, it is a difficult process since they are cemented in place, and thus, would entail a long reinstallation process that requires complete cleaning of the groove in the coupling element before the insulating ring and contact ring can be recemented in place. Normally, epoxy cements are used, which are difficult to remove without remachining the groove. Since the wear is confined to the helical portion 22 of the conduit 13, it is mostly

the conduit that must be renewed and this is a relatively simple operation. Thus, the pipe sections can be reused and will have the same life as a normal drill string.

It will be appreciated that application of the present invention is not limited to the use of the particular annular contact elements 6 and 7 shown in the drawings. Any other type of contact elements or electrodes that are adapted for transmitting electric signals to the contact elements or electrodes of identical pipe sections that are interconnected by their coupling elements to form a pipe string, may be used.

Further, the invention is not limited to the use of the particular metal-to-metal sealing ring 25 shown in Figure 2. Any other type of sealing means, such as compression seals may be applied.

To minimize the pressure drop across the coupling elements of the pipe sections according to the invention, the entrance angle 32 of the pin end 3 and the exit angle 33 of the box end 4 are designed to minimize the pressure drop thereacross. An entrance angle of 30° and an exit angle of 10° may produce excellent results. An entrance angle of 20° and an exit angle of 6° produce minimal pressure drop but their fabrication is somewhat more complex. It is observed that the passageways 12 and 14 intersect the transition sections extending between the bores 5 and the inner wall of the length of pipe 2.

The helix of the conduit may be wound with a left-hand or counterclockwise spiral to minimize pressure loss within the pipe bore and mechanical loading on the conduit anchor points. This assumes a right-hand or clockwise rotating drill string.

The conduit 13 can be easily installed in the pipe section 1 either during the manufacturing process thereof, or in operations for replacing a worn conduit 13.

The conduit 13 is curved by means known per se to obtain a helical shape over the mid portion thereof. The outer diameter of the helix will then be larger than the inner diameter of the pipe 2 of pipe section 1. The conduit 13 further has end portions that conform to the passageways 12 and 14. These latter passageways have been formed in the end portions of the pipe section 1. Subsequently, the pre-formed conduit 13 is introduced into the interior of the pipe section, such that the outer diameter of the mid portion of the conduit is pressed against the inner wall of the pipe section. After emplacing the conduit in the section, the end portions 18, 19 of the conduit are anchored in the passageways 12, 14, respectively. This may be done in the specific manner described with reference to Figure 2.

WHAT WE CLAIM IS:—

1. A pipe section for use in borehole operations, said pipe section comprising a length of pipe, provided with screw coupling elements arranged at opposite ends thereof, a bore centrally arranged in each coupling element and having a smaller internal diameter than that of



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a separate ring fastened to portion 18 of the conduit by suitable means, such as welding. The end of portion 18 of the conduit is threaded and carries a nut 24. By tightening the nut 24 on the threaded end of portion 18 of the conduit, portion 18 will be drawn into the passageway 12, and a sealing ring 25 will simultaneously be drawn into a sealing engagement with a conical shoulder formed in the passageway 12.

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After both ends of the conduit 13 are securely locked in place by the above-described arrangement, the insulated electrical conductor cable 17 may be led via passageway 12 into the conduit 13 and attached to the conductors arranged in the passageways 11 and 15 arranged in the coupling elements 3 and 4, respectively. The way in which the conductor cable 17 is connected to the conductor 16 arranged in passageway 11 will now be described in more detail with reference to Figure 2.

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the conduit that must be renewed and this is a relatively simple operation. Thus, the pipe sections can be reused and will have the same life as a normal drill string.

It will be appreciated that application of the present invention is not limited to the use of the particular annular contact elements 6 and 7 shown in the drawings. Any other type of contact elements or electrodes that are adapted for transmitting electric signals to the contact elements or electrodes of identical pipe sections that are interconnected by their coupling elements to form a pipe string, may be used.

Further, the invention is not limited to the use of the particular metal-to-metal sealing ring 25 shown in Figure 2. Any other type of sealing means, such as compression seals may be applied.

To minimize the pressure drop across the coupling elements of the pipe sections according to the invention, the entrance angle 32 of the pin end 3 and the exit angle 33 of the box end 4 are designed to minimize the pressure drop thereacross. An entrance angle of 30° and an exit angle of 10° may produce excellent results. An entrance angle of 20° and an exit angle of 6° produce minimal pressure drop but their fabrication is somewhat more complex. It is observed that the passageways 12 and 14 intersect the transition sections extending between the bores 5 and the inner wall of the length of pipe 2.

The helix of the conduit may be wound with a left-hand or counterclockwise spiral to minimize pressure loss within the pipe bore and mechanical loading on the conduit anchor points. This assumes a right-hand or clockwise rotating drill string.

The conduit 13 can be easily installed in the pipe section 1 either during the manufacturing process thereof, or in operations for replacing a worn conduit 13.

The conduit 13 is curved by means known per se to obtain a helical shape over the mid portion thereof. The outer diameter of the helix will then be larger than the inner diameter of the pipe 2 of pipe section 1. The conduit 13 further has end portions that conform to the passageways 12 and 14. These latter passageways have been formed in the end portions of the pipe section 1. Subsequently, the pre-formed conduit 13 is introduced into the interior of the pipe section, such that the outer diameter of the mid portion of the conduit is pressed against the inner wall of the pipe section. After emplacing the conduit in the section, the end portions 18, 19 of the conduit are anchored in the passageways 12, 14, respectively. This may be done in the specific manner described with reference to Figure 2.

WHAT WE CLAIM IS:—

1. A pipe section for use in borehole operations, said pipe section comprising a length of pipe, provided with screw coupling elements arranged at opposite ends thereof, a bore centrally arranged in each coupling element and having a smaller internal diameter than that of

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- said length of pipe, a conduit having a helical form with straight end portions, the outer diameter of said helix being sized to firmly engage the inner wall of the length of pipe when
- 5 said conduit is placed in said length of pipe, a passageway formed in each coupling element, the ends of the conduit being formed to align with said passageways, sealing means disposed in each of the passageways to form fluid-tight
- 10 seals between the ends of said conduit and the passageways and in addition, mechanically anchor the conduit in the passageways, and electrodes carried by the coupling elements through the intermediary of insulating means,
- 15 the electrodes at opposite ends of the pipe section being in electric communication by means of an insulated electric conductor that extends through the passageways and the conduit.
- 20 2. A pipe section according to claim 1 wherein the internal diameter of the bores is less than the inner diameter of the helix.
3. A pipe section according to claim 1 or
- 25 of a pin end and a box end arranged at opposite ends of the said length of pipe, and each bore includes a transition section for joining the internal diameter thereof to the internal diameter of the length of pipe, the transition
- 30 angles of the sections in the pin end and the box end being 30° and 10° , respectively.
4. A pipe section according to any one of the claims 1 and 2 wherein the bore of both

coupling elements includes a transition section for joining the internal diameter thereof to the internal diameter of the length of pipe, and the passageways in the coupling elements intersect the interiors thereof in the transition sections.

5. A pipe section according to any one of the claims 1-4 wherein the sealing means in each passageway comprises a shoulder formed in the passageway and a ring disposed on the relevant end of the conduit, a seal disposed between the shoulder and the ring, and means for drawing the conduit into the passageway to compress the seal to sealing position.

6. A pipe section according to claim 1 wherein the insulated electrical conductor comprises two insulated wires attached to the electrodes in each coupling element, and a continuous insulated conductor extending through said conduit, the ends of the wires being joined to the ends of the continuous conductor.

7. A pipe section according to claim 6 wherein the passageway in each coupling element has a recess for storing the end of the relevant wire when the conduit is being installed in the pipe section.

8. A pipe section for use in a borehole operation substantially as described with reference to the accompanying drawings.

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