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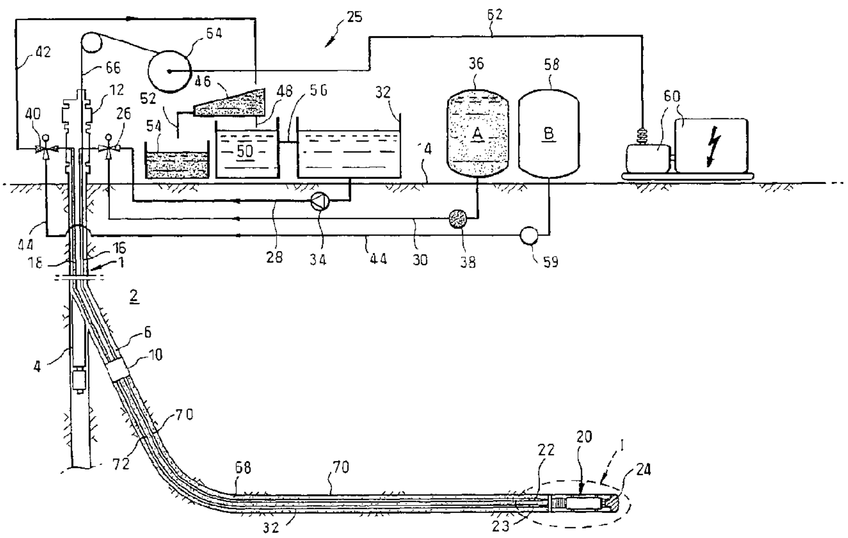
(54) **Title:** SYSTEM FOR CREATING A CONDUIT IN A BOREHOLE FORMED IN AN EARTH FORMATION



(57) Abstract: A system is provided for creating at least one conduit in a borehole formed in an earth formation. The system comprises a device which includes movement means for moving the device in longitudinal direction through the borehole, and injection means for injecting a hardenable substance into the borehole so as to form, for each said conduit, a layer of hardened substance in the borehole behind the device, said layer defining the conduit. The system further comprises control means for controlling the rate of injection of said substance by the injection means so as to correspond with the rate of movement of the device through the borehole by the movement means.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

SYSTEM FOR CREATING A CONDUIT IN A BOREHOLE FORMED IN AN EARTH FORMATION

The present invention relates to a system for creating at least one conduit in a borehole formed in an earth formation. Conventional systems for creating a conduit in a borehole formed in an earth formation involve, for example, the provision of a liner to the borehole wall during drilling of the borehole. Such systems operate on the basis of a rotating drill string, or a stationary drill string provided with a downhole motor for rotating a drill bit. Generally, a relatively large and expensive drilling rig at surface is required to suspend the drill string in the borehole.

International patent application WO 98/59146 discloses a drilling system which includes a drilling device obviating the need for a large drilling rig, which device is powered by an electric cable extending through the borehole to surface. Drill cuttings resulting from the drilling process are deposited into the borehole behind the drilling device. One of the drawbacks of the known drilling system is that there is no possibility of directing a stream of fluid to the drilling device, for example in order to cool the drilling device, to power the drilling device or to transport excess drill cuttings to surface.

It is therefore an object of the invention to provide an improved drilling system, which overcomes the drawbacks of the known drilling system.

In accordance with the invention there is provided a system for creating at least one conduit in a borehole formed in an earth formation, the system comprising a device which includes:

- movement means for moving the device in longitudinal direction through the borehole; and
- injection means for injecting a hardenable substance into the borehole so as to form, for each said conduit, a layer of hardened substance in the borehole behind the device, said layer defining the conduit; the system further comprising
- control means for controlling the rate of injection of said substance by the injection means so as to correspond with the rate of movement of the device through the borehole by the movement means.

It is thereby achieved that each conduit is created and extended continuously in the borehole during movement of the device through the borehole, without the requirement of a large drilling rig. Each conduit thus created with the system allows a stream of fluid to flow to, or from, the device in the borehole. Furthermore, each conduit is available for hydrocarbon fluid production once the device has arrived in a hydrocarbon fluid containing formation.

Suitably the injection means is arranged to inject the hardenable substance into the borehole so as to form a cladding of the borehole wall. The cladding can, for example, be provided at selected sections of the borehole to prevent inflow of water from the earth formation into the borehole or to seal (natural) fractures present in the formation.

Preferably the system further comprises a remote control unit for controlling the device, the remote control unit being in fluid communication with the device via each said conduit.

In case the hardenable substance is formed from a mixture including a first and a second compound, the injection means preferably includes a first container containing the first compound, a second container containing the second compound and a mixing chamber for mixing the first and second compounds.

The invention will be described hereinafter in more detail and by way of example with reference to the accompanying drawings in which

Fig. 1 is a schematic representation of a first embodiment of the system of the invention prior to drilling a new wellbore section;

Fig. 2 schematically shows the embodiment of Fig. 1 during drilling of the new wellbore section;

Fig. 3 schematically shows a drilling device used in the system of Figs. 1 and 2, and indicated as detail I in Fig. 2;

Fig. 4 schematically shows a perspective view of part of the drilling device of Fig. 3; and

Fig. 5 schematically shows a second embodiment of the drilling system of the invention for different steps a)-f) of operation thereof.

In the detailed description like reference numerals relate to like components.

Referring to Fig. 1 there is shown a borehole 1 formed in an earth formation 2, the borehole 1 including a main wellbore 4 and an initial section of a branch wellbore 6 extending from a junction 8 of the main wellbore 4 in deviated direction thereof. A packer 10 is arranged in the branch wellbore 6 a short distance from the junction 8, which packer 10 is provided with a first and a second longitudinal through-bore (not shown). A wellhead 12 is arranged at the earth surface 14, on top of the main wellbore 4. A first and a second fluid passage in the form of respective tubings 16, 18 extend from the wellhead 12 via the main wellbore 4 and the branch wellbore 6 to the packer 10. The tubings 16, 18 are sealingly connected to the packer 10 in a manner that the first through-bore forms a continuation of the first tubing 16 and the second through-bore forms a continuation of the second tubing 18.

A device in the form of drilling device 20 is positioned in the branch wellbore 6 immediately below the packer 10, the drilling device having a first injection tube in the form of tail pipe 22 and a second injection tube in the form of tail pipe 23. Tail pipe 22 extends into the first through-bore of the packer 10, in a sealing relationship therewith, and tail pipe 23 extends into the second through-bore of the packer 10, in a sealing relationship therewith. The drilling device is provided with a rotary drill bit 24 and an electric motor (referred to hereinafter) arranged to drive the drill bit 24.

The first and second tubings 16, 18 are at their respective upper ends connected to a control unit 25 arranged at the earth surface 14. The control unit 25 includes a three-way valve 26 to which the upper end of the first tubing 16 is connected, the valve 26 having a primary position in which the valve 26 provides fluid communication between the first tubing 16 and a primary supply conduit 28, and a secondary position in which the valve 26 provides fluid communication between the first tubing 16 and a secondary supply conduit 30. The primary supply conduit 28 is in fluid communication with a fluid reservoir 32 filled with water, and is provided with a pump 34 for pumping water from fluid reservoir 32 into the first tubing 16. The secondary supply conduit 30 is in fluid communication with a reservoir 36 containing a fluidic compound A, and is provided with a pump 38 for pumping fluidic compound A from reservoir 36 into the first tubing 16. The control unit 25 furthermore includes another three-way valve 40 to which the upper end of the second tubing 18 is connected, the valve 40 having a primary position in which the valve 40 provides fluid communication between the second tubing 18 and a discharge conduit 42, and a secondary position in which the valve 40 provides fluid communication between the second tubing 18 and a tertiary supply conduit 44. The discharge conduit 42 debouches into a shale shaker 46 having a fluid outlet 48 debouching into a tank 50, and a drill cuttings outlet 52 debouching into a container 54. The tank 50 is in fluid communication with the fluid reservoir 32 via a pipe 56. The tertiary supply conduit 44 is in fluid communication with a reservoir 58 containing a fluidic compound B, and is provided with a pump 59 for pumping fluidic compound B from reservoir 58 into the second tubing 18. Compounds A and B are selected such that upon intermixing of A and B a composition C is formed which chemically reacts so as to harden and thereby to form a solid or elastomeric compound.

The control unit 25 furthermore includes an electric power supply 60 arranged to supply electric power to the electric motor of the drilling device 20 via a conductor 62, a reel 64 and an electric cable 66 spooled onto reel 64. The cable 66 extends through the wellhead 12, the first tubing 16, the first through-bore of packer 10 and tail pipe 22, to the electric motor of the drilling device 20.

Reference is further made to Fig. 2 showing the drilling device 20 after drilling a new section 68 of branch wellbore 6. A first conduit 70 and a second conduit 72 extend through the newly drilled wellbore section 68 between the packer 10 and the drilling device 20, whereby the first conduit 70 provides fluid communication between the first through-bore of the packer 10 and tail pipe 22, and the second conduit 72 provides fluid communication between the second through-bore of the packer 10 and tail pipe 23. The space in the newly drilled wellbore section 68 between the conduits 70, 72 on one hand and the borehole wall on the other hand is filled with a body of drill cuttings 74. The cable 66 is partly unreeled from reel 64 and extends further, compared to the situation of Fig. 1, from the first through-bore of packer 10 via the first conduit 70 and tail pipe 22, to the electric motor.

Reference is further made to Figs. 3 and 4 schematically illustrating the drilling device 20 in the newly drilled wellbore section 68. The drilling device 20 has a tubular housing 80 provided with a sleeve 82 arranged around the housing, the housing 80 being axially slideable relative to the sleeve 82 for a selected stroke. The housing 80 and the sleeve 82 are provided with electrically operated thruster means (not shown) for selectively thrusting the housing 80 relative to the sleeve 82 in axially forward or backward direction. The sleeve 82 is provided with a set of radially extendible pads 84 and electrically operated activating means (not shown) for selectively radially extending or retracting the pads 84. A cuttings press in the form of a circular plate 86 is arranged at the end of the housing opposite the drill bit 24 and extends in transverse direction of the housing 80. The cuttings press 86 has a diameter substantially equal to the wellbore diameter and is provided with a plurality of sieve openings 88 arranged in a radially outer portion of the cuttings press. The tail pipes 22, 23 extend from the cuttings press 86 away from the housing 80 and into the respective first and second conduits 70, 72 whereby the far end of the tail pipes 22, 23 are indicated by respective reference signs 90, 92.

The housing 80 is provided with a fluid passage indicated by line 94. The fluid passage 94 passes from tail pipe 22 via a heat-exchanger 96 to tail pipe 23, and is provided with a pump 95 for pumping fluid through the fluid passage 94 in the direction from tail pipe 22 to tail pipe 23. A cooling fluid loop 98 filled with cooling fluid passes through the heat-exchanger 96 and through the drill bit 24, which cooling fluid loop 98 is provided with a pump 100 for pumping cooling fluid through the cooling fluid loop 98.

The housing 80 is furthermore provided with two containers 102, 104 and a mixing chamber 105. Container 102 is internally provided with a bladder 106 dividing container 102 into a primary container portion 108 containing fluidic compound A and a secondary container portion 110 containing water. Container 104 is internally provided with a bladder 112 dividing container 104 into a primary container portion 114 containing compound B and a secondary container portion 116 containing water. Each tail pipe 22, 23 is provided with a set of injection nozzles 118 for injecting composition C into the wellbore section 68, arranged at a distance L from the respective ends 90, 92 of the tail pipes 22, 23, the nozzles of each tail pipe 22, 23 debouching into an annular recess 120, 122 provided in the outer surface of the respective tail pipe 22, 23. Mixing chamber 105 has an inlet 124 in fluid communication with container portions 108, 114 by respective conduits 126, 128, and an outlet 130 in fluid communication with the injection nozzles by conduits 132, 134 (indicated by dotted lines) extending through the respective tail pipes 22, 23.

Conduit 126 is connected to fluid passage 94 via a three-way valve 133 selectively operable between a primary position in which the valve 133 prevents fluid communication between conduit 126 and fluid passage 94, and a secondary position in which the valve 133 directs a stream of fluid entering fluid passage 94 at tail pipe 22 into conduit 126.

Conduit 128 is connected to fluid passage 94 via a valve 135 selectively operable between a closed position in which valve 135 prevents fluid communication between conduit 128 and fluid passage 94, and an open position in which valve 135 allows fluid communication between conduit 128 and fluid passage 94.

Container portion 110 is connected to fluid passage 94 by a conduit 136 provided with a pump 138 for pumping water from fluid passage 94 into container portion 110. Conduit 136 is, at the downstream side of pump 138, connected to fluid passage 94 via a three-way valve 140 selectively operable between a primary position in which the valve 140 prevents fluid communication between conduit 136 and fluid passage 94, and a secondary position in which the valve 140 provides fluid communication between conduit 136 and fluid passage 94.

Container portion 116 is connected to fluid passage 94 by a conduit 142 provided with a pump 144 for pumping water from fluid passage 94 into container portion 116. Conduit 142 is, at the downstream side of pump 144, connected to fluid passage 94 via a three-way valve 146 selectively operable between a primary position in which the valve 146 prevents fluid communication between conduit 142 and fluid passage 94, and a secondary position in which the valve 146 provides fluid communication between conduit 142 and fluid passage 94.

Furthermore, fluid passage 94 is connected to a conduit 148 provided with a valve 150 for selectively providing fluid communication between fluid passage 94 and the exterior of the housing.

A Moineau pump 152 is provided in the housing 80, and is arranged to be driven by the electric motor (indicated by reference sign 153, Fig. 3). The Moineau pump 152 has an inlet (not shown) in fluid communication with the front end of the drill bit 24 by means of an inlet passage 154 extending through the drill bit, and an outlet (not shown) in fluid communication with an outlet passage 156 debouching in wellbore 68 immediately behind the cuttings press 86. Outlet passage 156 is connected to fluid passage 94 by a three-way valve 158 for selectively diverting at least part of a stream pumped by the Moineau pump 152 through the outlet passage 156, into fluid passage 94.

The housing 80 has a hydrocarbon fluid inlet 160 in fluid communication with fluid passage 94 by a conduit 162 provided with a valve 164.

The valves 133, 135, 140, 146, 150, 158, 164, the pumps 95, 100, 138, 144, the thruster means and the activating means all are arranged to be electrically controlled from a control board (not shown) of the control unit 25 by means of suitable electric signals transmitted to the drilling device via cable 66.

Referring to Fig. 5 there is shown the second embodiment of the drilling system of the invention. This embodiment includes a drilling device 200 which is substantially similar to the drilling device 20 of the first embodiment, however with the difference that the drilling device 200 has two sleeves 202, 204 arranged around the housing 80 instead of the sleeve 82 of the first embodiment, and that the cuttings press is attached to the rear end of sleeve 202 instead of to the housing 80. Furthermore, the housing 80 is axially slideable relative to each sleeve 202, 204, and each sleeve 202, 204 is provided with a set of independently controllable pads 84.

During normal operation of the drilling device 20 the main wellbore 4 and the initial section of the branch wellbore 6 have been drilled using a conventional drill string. The packer 10 with the drilling device 20 connected thereto and the first and second tubings 16, 18 have been installed in the borehole 1 in the arrangement indicated above with reference to Fig. 1. Then, in order to further drill the branch wellbore 6, power supply 60 is operated so as to provide electric power via conductor 62, reel 64 and cable 66 to the drilling device 20 so as to induce the electric motor 153 to rotate the drill bit 24, to induce the activating means to radially extend the pads 84 against the borehole wall and to induce the thruster means to thrust the housing 80 axially forward relative to the sleeve 82. By the combined actions of the rotating drill bit 24, the thrusting action of the thruster means, and the anchoring action of the pads 84 against the borehole wall, the branch wellbore 6 is deepened. Additional thrust force is achieved by the cuttings press 86 pushing against the body of drill cuttings 74.

Simultaneously with operating the power supply 60, pump 34 is operated so as to pump a stream of water from the reservoir 32 via the primary supply conduit 28 and the first tubing 16 (whereby valve 26 is in its primary position) into fluid passage 94 of the drilling device 20. The stream of water passes through the fluid passage 94 and flows via the tail pipe 23 and the second tubing 18 to the shale shaker 46. From there the water flows via tank 50 and pipe 56 back into fluid reservoir 32. Simultaneously with operating pump 34, pump 100 is operated so as to pump cooling fluid through the cooling fluid loop 98. It is thereby achieved that heat generated by the drilling action of the drill bit 24 is dissipated by the cooling fluid to the stream of water, whereby the heat transfer to the stream of water takes place in the heat-exchanger 96.

The Moineau pump 152 is driven by the electric motor 153 and thereby pumps a stream of drill cuttings resulting from the drilling action of the drill bit 24, and earth formation fluid via inlet passage 154 into outlet passage 156 and from there into the new wellbore section 68 immediately behind the cuttings press 86. In this manner the body of drill cuttings 74 with formation fluid in the interstitial spaces is formed in the wellbore section 68. If necessary or desired, part of the drill cuttings is discharged into the water stream flowing through fluid passage 94 by controlling three-way valve 158 accordingly. The drill cuttings discharged into fluid passage 94 are removed from the stream of water by the shale shaker 46, and subsequently deposited into container 54.

Furthermore, simultaneously with operating the power supply 60, the pumps 138, 144 are operated so as to pump water into the respective container portions 110, 116. As a result compound A is induced to flow from container portion 108 via conduit 126 into the mixing chamber 105, and compound B is induced to flow from container portion 114 via conduit 128 into the mixing chamber 105. The composition C thus formed in the mixing chamber 105 flows via conduits 132, 134 to the sets of nozzles and from there into the annular recesses 120, 122 of the respective tail pipes 22, 23. For each tail pipe 22, 23, composition C thereby flows around the tail pipe, between the annular recess 120, 122 and the tail pipe end 90, 92, and forms an annular layer of composition C with drill cuttings embedded therein. Composition C slowly hardens and thereby forms the solid or elastomeric compound referred to above. The layers of solid or elastomeric compound thus formed, with drill cuttings embedded therein, form the respective first and second conduits 70, 72. It will be understood that in this manner, during forward movement of the drilling device 20 through the new wellbore section 68 as drilling proceeds, the conduits 70 72 are continuously extended. The hardening time of composition C is selected such that composition C substantially hardens during the time needed to deepen the wellbore section 68 a further length L (cf. Fig. 3).

In order to compact the body of drill cuttings 74, the drilling process is stopped at regular drilling intervals and the thruster means is controlled in a manner that the housing 80 is thrusted axially backward and thereby pushes the cuttings press 86 against the body of drill cuttings 74. Any excess formation fluid present in the body of drill cuttings thereby flows through the sieve openings 88 into the annular space between the drilling device 20 and the wellbore section 68.

After drilling a section of wellbore 68 equal in length to the stroke of the housing 80 relative to the sleeve 82, drilling is stopped, the pads 84 are retracted, and the thruster means is induced to move the sleeve 82 axially forward relative to the housing 80 over said stroke. The pads 84 then are again radially extended so as to become firmly anchored against the wellbore wall, and drilling is resumed for a further stroke of the housing 80. This process is repeatedly continued until the desired depth of the new wellbore section 68 is reached.

When it is desired to refill container portion 108 with compound A, the following steps are taken. Drilling is stopped, pumping of water into tubing 16 is stopped, and the valves 26, 133, 140 are put in their respective secondary positions. A stream of compound A is then pumped into the first tubing 16 by operating pump 38, which stream of compound A thereby flows via conduit 70, tail pipe 22, fluid passage 94, valve 133 and conduit 126 into container portion 108. Part of the water present in container portion 110 is thereby expelled via conduit 136 and valve 140 into fluid passage 94.

When it is desired to refill container portion 114 with compound B, the following steps are taken. Drilling is stopped, pumping of water into tubing 16 is stopped, valves 40, 146 are put in their respective secondary positions, and valve 135 is opened. A stream of compound B is then pumped into the second tubing 18 by operating pump 59, which stream of compound B thereby flows via conduit 72, tail pipe 23, fluid passage 94, valve 135 and conduit 128 into container portion 114. Part of the water present in container portion 116 is thereby expelled via conduit 142 and valve 146 into fluid passage 94.

In case it is desired to supply water, or other drilling fluid, into the lower part of wellbore 68, valve 150 is opened. As a result water, or such other drilling fluid pumped into the first tubing 16, flows via conduit 148 into the space between the housing 80 and the wall of the wellbore 68.

After the drilling device has arrived in the target earth formation zone containing hydrocarbon fluid drilling is stopped and the drilling device 20 is left in the wellbore. Hydrocarbon fluid is then produced from the earth formation to surface by opening valve 164 following which hydrocarbon fluid enters the conduit(s) 70, 72 via inlet 160 and conduit 162. Alternatively hydrocarbon fluid can enter the conduit(s) 70, 72 via perforations (not shown) created in the conduit(s) 70, 72.

Normal operation of the drilling device 200 is similar to normal operation of drilling device 20, except with respect to forward movement thereof which is described below with reference to sequential steps a)-f) (Fig. 5) during normal operation.

In step a) the sleeves 202, 204 are located at opposite sides of the housing 80, with the pads 84 radially extended against the borehole wall.

In step b) the pads 84 of sleeve 202 are retracted and the drill bit 24 is operated to drill a new section of the wellbore 6. During such drilling the sleeve 202 moves forward together with housing 80.

In step c) the sleeve 202 is thrusted axially backwards so as to push the cuttings press 86 against the body of drill cuttings 74 and thereby compact the drill cuttings, while the drill bit 24 remains in contact with the bottom of the wellbore. Excess fluid present in the body of drill cuttings thereby flows through the sieve openings 88 into the annular space between the drilling device 200 and the wellbore wall.

In step d) drilling of the new wellbore section is proceeded by operation of the drill bit, similarly to step b).

In step e) the sleeve 202 is again thrusted axially backwards so as to push the cuttings press 86 against the body of drill cuttings 74 and thereby compact the drill cuttings, while the drill bit 24 remains in contact with the bottom of the wellbore, similarly to step c).

In step f) the pads of sleeve 204 are retracted and the sleeve 204 is induced to axially slide forward until the position of step a) is reached. Thereafter, steps a)-f) are repeated.

Preferred compounds A and B are those available under the trade name SYLGARD 170 fast cure (A&B) from the company Dow Corning, whereby compound A has a Platinum catalyst and compound B contains a retarder. The composition C formed by intermixing A and B is a silicone rubber of which typical curing times are 10 minutes at 21 °C, and 0.3 minutes at 36 °C.

Instead of applying compounds A and B which form a silicone rubber, compounds A and B can be selected to form composition C in the form of a thermosetting resin.

During drilling the drilling device 20, 200 can be steered in a desired direction by extending the pads 84 in manner that the drilling device becomes tilted in the wellbore.

CLAIMS

1. A system for creating at least one conduit in a borehole formed in an earth formation, the system comprising a device which includes:

- movement means for moving the device in longitudinal direction through the borehole; and
- injection means for injecting a hardenable substance into the borehole so as to form, for each said conduit, a layer of hardened substance in the borehole behind the device, said layer defining the conduit; the system further comprising
- control means for controlling the rate of injection of said substance by the injection means so as to correspond with the rate of movement of the device through the borehole by the movement means.

2. The system of claim 1, wherein the injection means is arranged to inject the hardenable substance into the borehole so as to form a cladding of the borehole wall.

3. The system of claim 1 or 2, wherein the injection means includes, for each said conduit, an injection tube extending from the rear end part of the device into the respective conduit in a sealing relationship therewith.

4. The system of claim 3, wherein each injection tube is provided with at least one injection nozzle for injecting said hardenable substance into the borehole, each injection nozzle being arranged a selected distance from the end of the injection tube opposite said rear end part of the device.

5. The system of claim 4, wherein each injection nozzle debouches into an outer annular recess provided at the injection tube.

6. The system of any one of claims 1-5, further comprising a remote control unit for controlling the device, the remote control unit being in fluid communication with the device via each said conduit.

7. The system of claim 6, wherein the system is suitable to create a first said conduit and a second said conduit, and wherein the system further comprises pumping means for pumping a stream of fluid from the control unit via the first conduit to the device and from the device via the second conduit to the control unit.

8. The system of claim 7, wherein the device is provided with drilling means for deepening the borehole and heat transfer means arranged to transfer heat generated by the drilling means to said stream of fluid.

9. The system of claim 8, wherein the device further includes cuttings transport means for transporting a stream containing drill cuttings generated by the drilling means from the front end part of the device to the rear end part thereof and for depositing the stream containing drill cuttings into the borehole behind the said rear end part.

10. The system of claim 9, wherein the device is provided with a cuttings press arranged to press against a body of drill cuttings formed of drill cuttings deposited behind the rear end part of the device.

11. The system of claim 10, wherein the cuttings press includes a sieve for passage of borehole fluid from the body of drill cuttings into an annular space formed between the device and the borehole wall.

12. The system of any one of claims 9-11, wherein the cuttings transport means is arranged to selectively induce at least part of the stream containing drill cuttings to flow into the second conduit.

13. The system of any one of claims 1-12, wherein the injection means includes a first container containing a

first compound, a second container containing a second compound and a mixing chamber for mixing the first and second compounds, the hardenable substance being formed from a mixture including said first and second compounds.

14. The system of claim 13 when dependent on claim 7, wherein the device includes means for selectively transferring the first compound from the first conduit to the first container, and for selectively transferring the second compound from second conduit to the second container.

15. The system of any of claims 1-14, wherein said device comprises a hydrocarbon fluid inlet for transferring hydrocarbon fluid from the earth formation via said at least one conduit to surface.

16. The system substantially as described hereinbefore with reference to the accompanying drawings.

Fig.1.

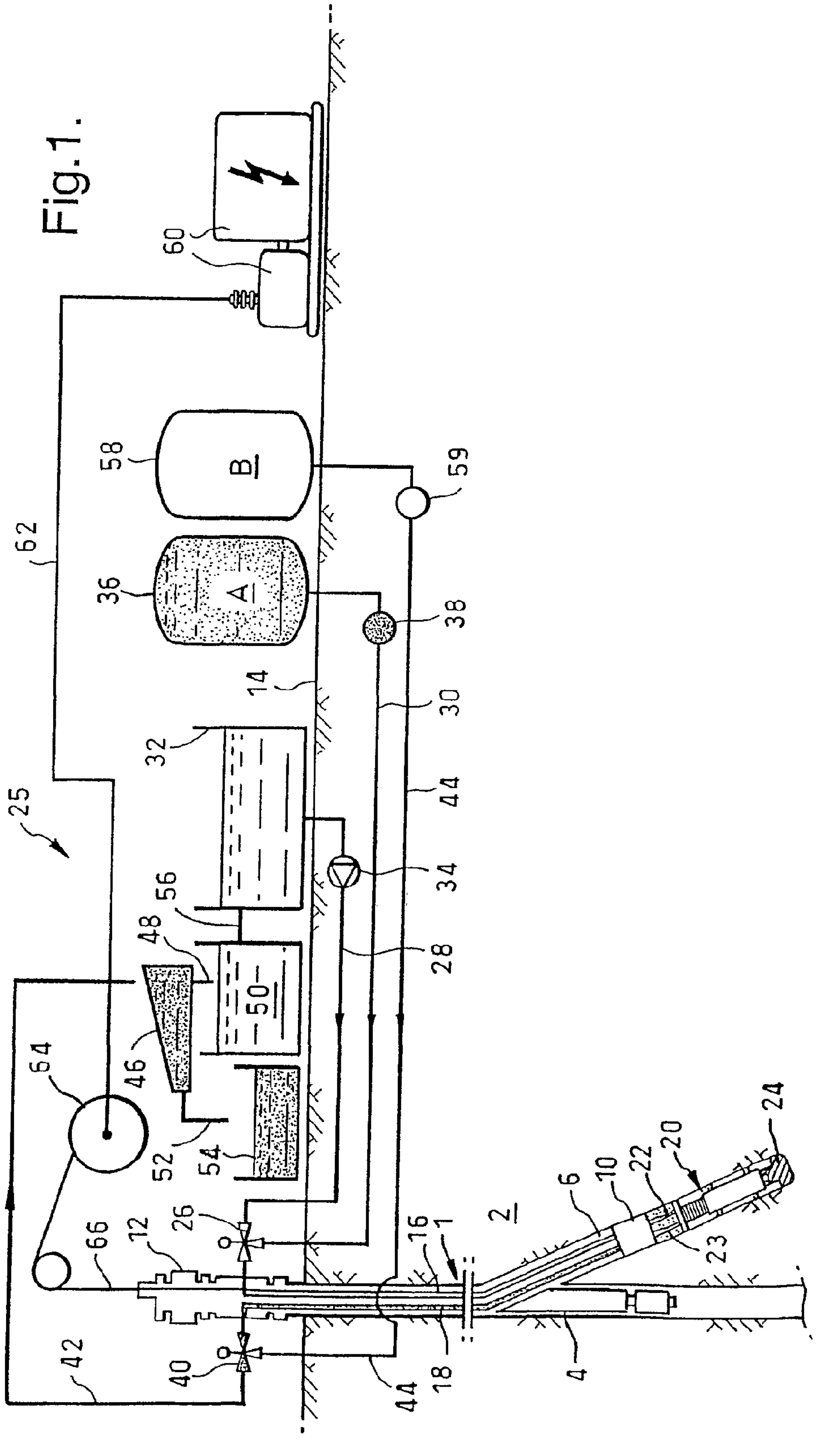
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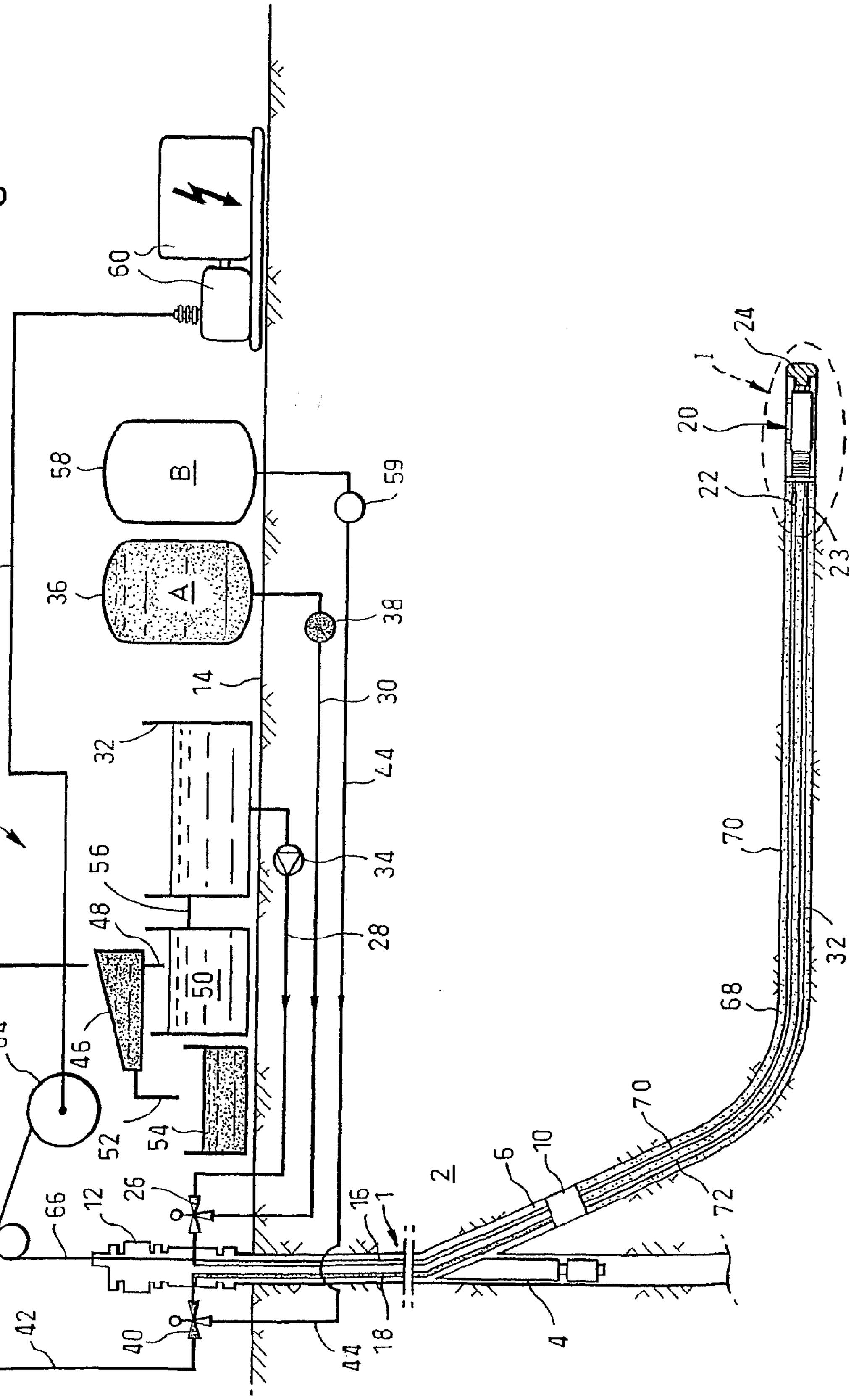
Fig.2.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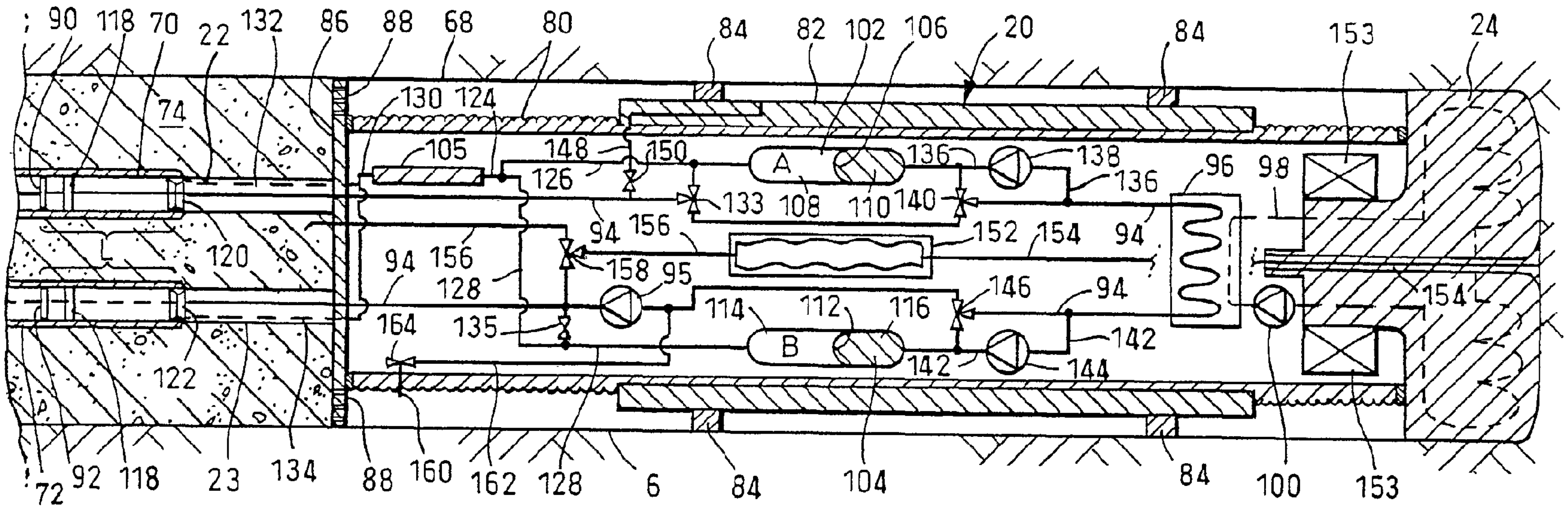
72

Fig.3.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74
130 124 105 148 150 126 A 136 138 136 96 98
133 108 110 140 94
156 152 154 94
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128 146 94 154
114 112 116 3/5
164 135 B 142 142 144
122
72 92 118 23 134 88 160 162 128 6 84 104 84 100 153

Fig.4.

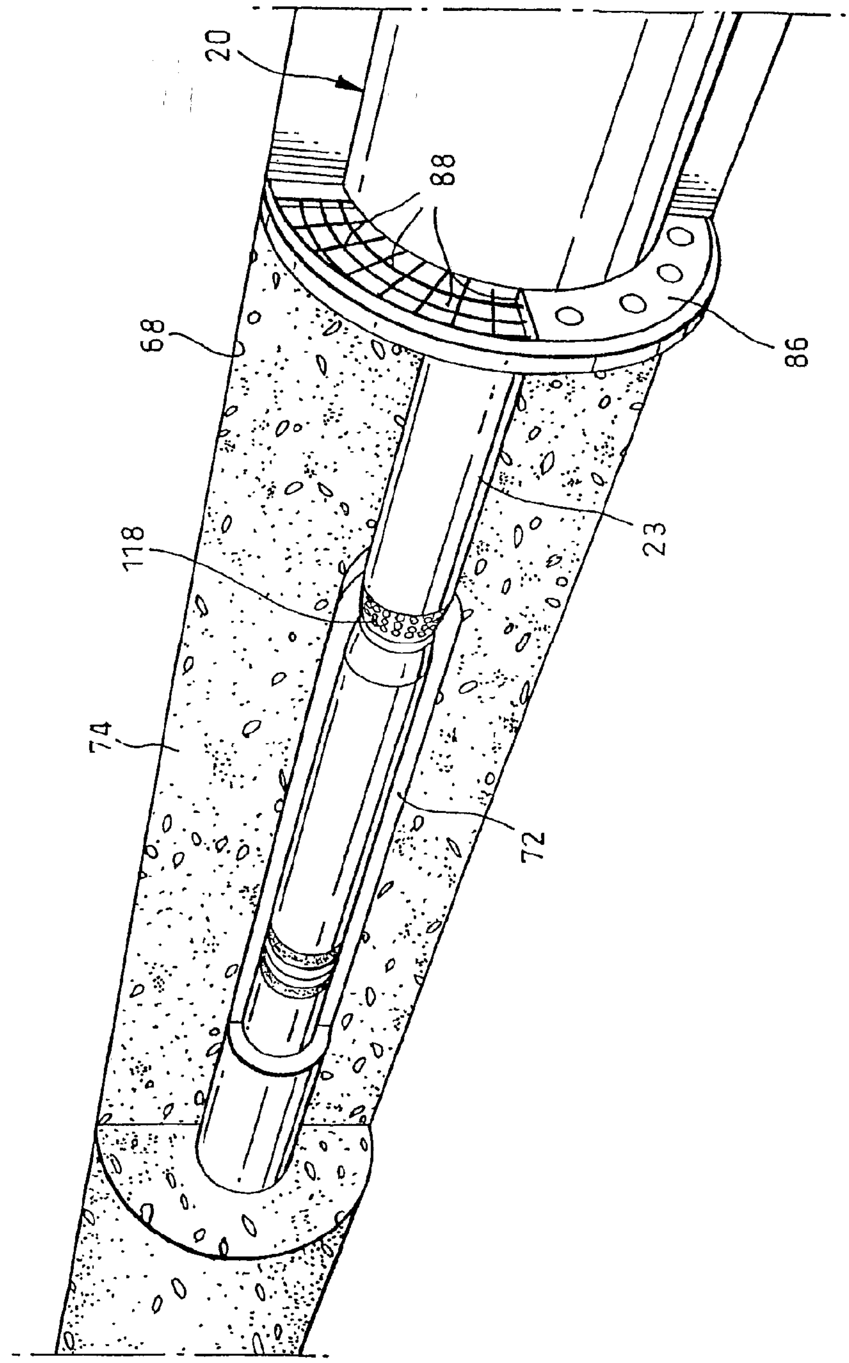

Fig.5a.

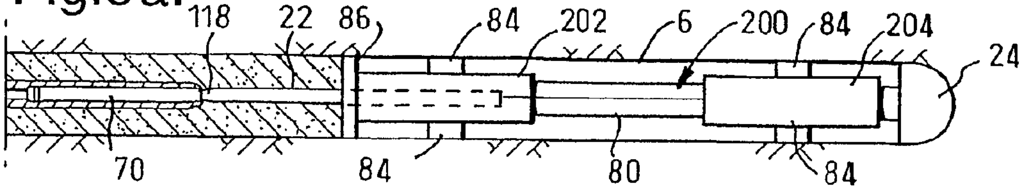

Fig.5 b.

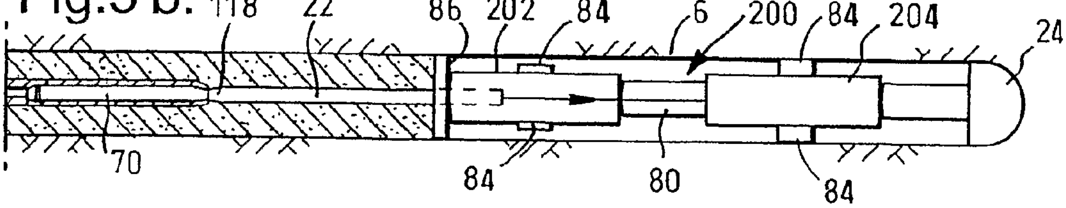

Fig.5c.

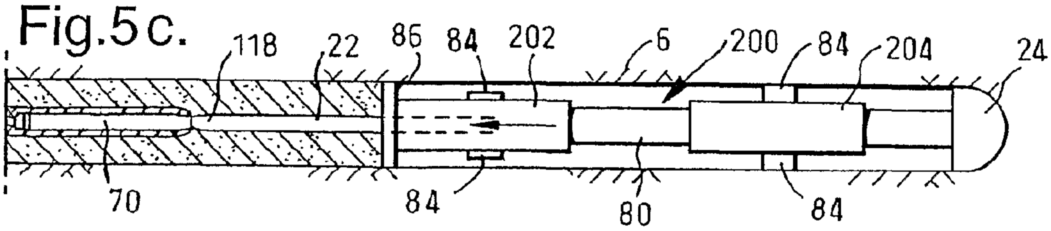

Fig.5d.

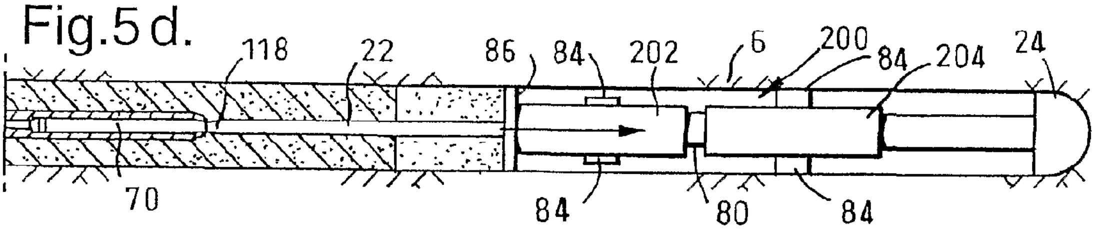

Fig.5e.

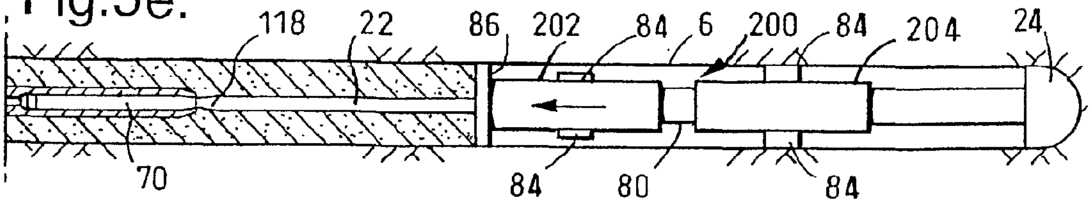

Fig.5f.