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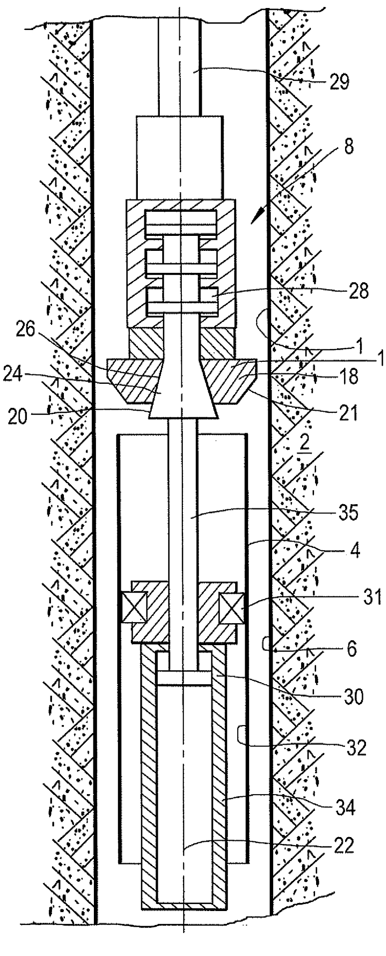
(54) Method of expanding a tubular element in a wellbore

(57) A method is provided of radially expanding a tubular element (4) against a wall (6) in a wellbore (1) using an expansion assembly (8) comprising an expander (10) adapted to expand the tubular element against said wall by movement of the expander from a radially retracted mode to a radially expanded mode, and an anchoring device (30) for anchoring the expansion assembly to the tubular element and to suspend the tubular element in the wellbore. The method comprises the steps of:
(a) anchoring the anchoring device to the tubular element and locating the expander in the tubular element;
(b) suspending the tubular element on the anchoring device and lowering the expansion assembly with the tubular element into the wellbore; and
(c) inducing the expander to move from the radially retracted mode to the radially expanded mode so as to expand at least a portion of the tubular element against said wall in the wellbore.

Fig.1



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Description

[0001] The present invention relates to a method of radially expanding a tubular element against a wall in a wellbore using an expansion assembly comprising an expander adapted to expand the tubular element against said wall by movement of the expander from a radially retracted mode to a radially expanded mode. Expansion of tubular elements finds increasing use in the industry of hydrocarbon fluid production from an earth formation, whereby boreholes are drilled to provide a conduit for hydrocarbon fluid flowing from a reservoir zone to a production facility to surface. Conventionally such borehole is provided with several tubular casing sections during drilling of the borehole. Since each subsequent casing section must pass through a previously installed casing section, the different casing section are of decreasing diameter in downward direction which leads to the well-know nested arrangement of casing sections. Thus the available diameter for the production of hydrocarbon fluid decreases with depth. This can lead to technical and/or economical drawbacks, especially for deep wells where a relatively large number of separate casing sections are to be installed.

[0002] To overcome such drawbacks it has already been practiced to use a casing scheme whereby individual casings are radially expanded after installation in the borehole. Such casing scheme leads to less reduction in available diameter of the lowest casing sections. Generally the expansion process is performed by pulling, pumping or pushing an expander cone through the tubular element (such as a casing section) after the tubular element has been lowered into the borehole. However the expansion force necessary for moving the expander cone through the tubular element may be extremely high since such force not only has to expand the tubular element, but also has to overcome the friction between the expander cone and the tubular element.

[0003] EP 1438483 B1 discloses a method of radially expanding a tubular element in a wellbore, whereby the tubular element is suspended on a drill string extending from a drilling rig at surface into the wellbore. During use, initially an upper portion of the tubular element is expanded using a radially expandable mandrel to anchor the tubular element to an existing casing. Then an expansion cone arranged at the lower end of the tubular element is pulled through the tubular element to fully expand the tubular element.

[0004] Thus, in the known method two expansion devices are required to expand the tubular element. Moreover, a drilling rig at surface is necessary to provide sufficient force to pull the expansion cone through the tubular element.

[0005] It is an object of the invention to provide an improved method of radially expanding a tubular element against a wall in a wellbore, which overcomes the drawbacks of the known method.

[0006] In accordance with the invention there is provided a method of radially expanding a tubular element against a wall in a wellbore using an expansion assembly comprising an expander adapted to expand the tubular element against said wall by movement of the expander from a radially retracted mode to a radially expanded mode, and an anchoring device for anchoring the expansion assembly to the tubular element and to suspend the tubular element in the wellbore, the method comprising the steps of:

(a) anchoring the anchoring device to the tubular element and locating the expander in the tubular element;
(b) suspending the tubular element on the anchoring device and lowering the expansion assembly with the tubular element into the wellbore; and
(c) inducing the expander to move from the radially retracted mode to the radially expanded mode so as to expand at least a portion of the tubular element against said wall in the wellbore.

[0007] By suspending the tubular element on the anchoring device, the tubular element is held in a position to allow the expander to expand the tubular element. Once an initial portion of the tubular element has been expanded against the wall, frictional forces between the expanded portion and the wall are sufficient to suspend the tubular element in the wellbore so that the anchoring device may be released from the tubular element. Further, since the tubular element is expanded by radial expansion of the expander rather than by pulling or pushing the expander through the tubular element, no drilling rig at surface is needed to provide such high pulling of pushing force. The expansion process does not require a significant axial force (push or pull) to be applied to the tubular element. The tubular element can be suspended, for example, on coiled tubing through which hydraulic or electric power is supplied to the expansion assembly to expand the tubular element. This saves on rig mobilization costs. In view of the absence of a high pulling force, there is the additional benefit that the tubular element is not subjected to axial forces that may lead to unintended axial displacement of the tubular element during the initial stage of the expansion process.

[0008] In most applications a plurality of cycles will be required to fully expand the tubular element against the wellbore wall, whereby the method suitably further comprises: (d) inducing the expander to move from the radially expanded mode to the radially retracted mode, moving the expander axially forward in the tubular element, and repeating step (c) so as to expand another portion of the tubular element against said wall.

[0009] Step (d) defines an expansion cycle, and the method suitably comprises a plurality of expansion cycles including a first expansion cycle in which the expander is expanded to a first maximum diameter and a second expansion cycle in which the expander is expanded to a second maximum diameter different from the first maximum diameter. By virtue of this arrangement, the expander is operated in a so-called compliant mode whereby the tubular element is expanded to a variable diameter in order to follow an irregular pattern of the wellbore wall against which the tubular element is expanded. If the wellbore wall is a casing or liner, such irregular pattern may be due to, for example, fabrication tolerances or internal upsets at connections. In case the tubular element is expanded against the rock formation, the irregular pattern may be due to a rugged open-hole profile. As a result there is no gap, or only a minimal gap, between the expanded tubular element and the wellbore wall. Thus, the amount of fluid trapped and the associated pressure loading between the expanded tubular element and the wellbore wall is minimized.

[0010] The compliant expansion process minimizes variations in the sealability and expansion forces associated with the hanger of the expandable tubular element. If, for example, elastomer seals are applied on the outer surface of the hanger joint of the expandable tubular element, the compliant expansion process reduces the degree of deformation imposed on the elastomer seals. In this manner undesired squashing, extrusion or tearing of the elastomers is prevented. Since the expander is compliant to the cross-sectional dimension of the well bore, the expansion method of the invention is more efficient than conventional expansion methods using an expansion cone of fixed diameter. With the method of the invention there is no need to pump or pull an expansion cone at high force through the tubular element when clearances are tight. Neither does the wall against which the tubular element is clad, such as a casing or the rock formation, have to be expanded.

[0011] If on the other hand, the expansion stroke of the expander is set to a fixed magnitude, the expanded tubular element has a substantially constant diameter over its length.

[0012] To ensure that the expander can be lowered into the wellbore unhampered, it is preferred that the expander is collapsible to a largest diameter equal or less than the outer diameter of the tubular element before expansion.

[0013] Preferably, in step (c) the tubular element is fixedly connected to said wall, and the method further comprises releasing the anchoring device from the tubular element after the tubular element has been fixedly connected to said wall.

[0014] A suitable expander for practicing the method of the invention comprises a plurality of segments arranged around an expansion actuator, the segments being movable in radial direction, the expansion actuator being operable to move the segments in radial direction by axial movement of the expansion actuator relative to the segments. In step (c) the expansion actuator is axially moved relative to the segments so as to move the segments radially outward.

[0015] It is preferred that the expansion actuator is hydraulically operated using a hydraulic fluid supply conduit onto which, in an advantageous embodiment, the expansion assembly is suspended in the wellbore.

[0016] The anchoring device suitably comprises an anchor movable between a radially retracted position in which the anchor is free from the inner surface of the tubular element and a radially expanded position in which the anchor is fixedly connected to the inner surface of the tubular element, and a suspension actuator operable to move the anchor in axial direction relative to the expander. In step (a) the anchor is moved to the radially expanded position and the suspension actuator is induced to move the anchor in axial direction so that the expander is located in the tubular element. The suspension actuator is, for example, hydraulically operated and may extend below the expander.

[0017] Suitably the expansion assembly is suspended in the wellbore on a string selected from drill pipe and coiled tubing.

[0018] In order to increase the collapse strength of the expanded tubular element, the expander can have an outer surface shaped to create a corrugation in the tubular element during step (c) so that the tubular element has a corrugated profile after expansion.

[0019] The method of cladding a tubular element against a wellbore wall, in accordance with the invention, allows that multiple clads can be placed in a well. A new clad can be run through, and expanded below, a previously installed clad. This functionality provides a flexible remediation of water or gas break-through during the production phase of a wellbore. Also, multiple clads of the same size can be set in an open hole, for example if a severe fluid loss zone or an unstable formation is encountered during the drilling phase.

[0020] If the tubular element is clad against an existing casing or liner in the wellbore, high collapse strength is achieved since the strength of the combination of the two tubular elements against external pressure (collapse loading) is significantly higher than in case there is a gap between the two tubular elements.

[0021] Further advantages of the method of the invention are as follows.

[0022] There is no need to apply an expensive lubrication coating to the expandable tubular element to prevent abrasive wear/galling since there is no (or only minimal) relative motion between the expander and the tubular element during the expansion stroke, contrary to conventional expansion methods.

[0023] Contrary to conventional expansion methods, the tubular element is not subjected to high internal fluid pressure to push a cone through the tubular element. Therefore, the method of the invention can be applied in cases wherein such high fluid pressure would exceed the pressure level up to which the connections are leak tight.

[0024] In conventional methods, thin-walled launchers or hanger joints are sometimes required to initiate or terminate the expansion process. With the method of the invention such thin-walled sections are obviated, therefore the expandable tubular element can have the full wall thickness, and hence associated strength, over its entire length.

[0025] The expandable tubular element is run open-ended and thereafter expanded over its entire length. Therefore there is no need to drill-out a shoe or launcher after running in, which otherwise would require additional rig time. Further, the expansion method is compatible with well construction applications that do not rely on cement for zonal isolation. In such applications there is no longer a need for a float shoe at the lower end of the tubular element during running in, compatible with the method of the invention.

[0026] The method of the invention will be described hereinafter in more detail and by way of example, with reference to the accompanying drawings, in which:

Fig. 1 schematically shows an embodiment of an expansion assembly for use in the method of the invention, partly in longitudinal section;
Fig. 2 schematically shows the embodiment of Fig. 1 during a first stage of operation;
Fig. 3 schematically shows the embodiment of Fig. 1 during a second stage of operation;
Fig. 4 schematically shows the embodiment of Fig. 1 during a third stage of operation;
Fig. 5 schematically shows the embodiment of Fig. 1 during a fourth stage of operation;
Fig. 6 schematically shows the embodiment of Fig. 1 during a fifth stage of operation; and
Fig. 7 schematically shows the embodiment of Fig. 1 during a sixth stage of operation.

[0027] Referring to Fig. 1 there is shown a wellbore 1 formed in an earth formation 2, wherein an expandable tubular element 4 is located in the wellbore 1 prior to radial expansion of the tubular element 4 against the wall 6 of the wellbore. An expansion assembly 8 extends into the wellbore, comprising an expander 10 having a set of segments 18 circumferentially spaced around an expansion actuator 20. The segments are radially movable relative to a central longitudinal axis 22 of the expansion assembly 8. The expansion actuator 20 is axially movable relative to the segments 18 and has an upwardly tapering outer surface 24. Each segment 18 has an inner surface 26 in contact with the tapering outer surface 24 of the expansion actuator, whereby said inner surface 26 is substantially complementary in shape to said outer surface 24. By virtue of this configuration, the segments 18 move radially outward if the expansion actuator 20 moves axially upward, and the segments 18 move radially inward if the expansion actuator 20 moves axially downward. The expander 10 is in a radially expanded mode when the segments 18 are in the radially outermost position, and in a radially retracted mode when the segments 18 are in the radially innermost position. The size of the expander 10 is such that, when in the radially retracted mode, a lower portion of the set of segments 18 fits inside the unexpanded tubular element 4 while an upper portion of the expander has a larger diameter than the inner diameter of the unexpanded tubular element 4. Further, when the expander is in the radially expanded mode, the tubular element 4 is expanded against the wellbore wall 6 at the level of the expander 10.

[0028] The expansion actuator 20 is connected to a multistage hydraulic piston / cylinder assembly 28 operable to move the expansion actuator 20 axially upward or downward relative to the segments 18. Hydraulic fluid is supplied to the piston / cylinder assembly 28 via a string of coiled tubing 29 extending from surface to the expansion assembly 8. Instead of a string coiled tubing, any other suitable string can be used, such as a string of jointed drill pipe.

[0029] The expansion assembly 8 further comprises an anchoring device 30 located below the expander 10, including an anchor 31 movable between a radially retracted position in which the anchor 31 is free from an inner surface 32 of the tubular element 4 and a radially expanded position in which the anchor 31 is fixedly connected to said inner surface 32. The anchoring device 30 also includes a hydraulic suspension actuator 34 operable to move the anchor 31 in axial direction relative to the expander 10. The suspension actuator 34 is controlled from surface by hydraulic fluid supplied via the string of coiled tubing 29.

[0030] Normal use of the system shown in Fig. 1 is explained hereinafter with reference to Figs. 2 - 8 showing various steps during normal use of the system.

[0031] Referring to Fig. 2, in a first step the anchor 31 is in the radially retracted position, and the anchoring device 30 is positioned inside the tubular element 4 while the expander 10 remains located above the tubular element 4. The anchor 31 is then induced to move to the radially expanded position so as to be fixedly connected to the tubular element 4. The expansion assembly 8 with the tubular element 4 suspended therefrom, is then lowered into the wellbore 1 on the string of coiled tubing 29.

[0032] If the tubular element 4 is to be located below another tubular (not shown) element already present in the wellbore, for example a casing or liner, and with a short overlapping section between the two tubular elements, suitably the tubular element 4 is at its upper end portion provided with a lock spring or similar device that snaps into a corresponding opening or groove provided at the lower end portion of the other tubular element during lowering of the tubular element 4 into the wellbore. In this manner the tubular element 4 becomes accurately positioned relative to the other tubular element before expansion of the tubular element 4. Such lock spring can be an annular lock spring connected to the outer surface of the tubular element 4.

[0033] Referring to Fig. 3, in a second step the expander is in the radially retracted mode, and the suspension actuator 34 is hydraulically controlled from surface to move the anchor 31 with the tubular element 4 connected thereto axially upward relative to the segments 18 until the segments become partially located in the tubular element 4 and the tubular element 4 stops against the segments 18 of the expander. Then the suspension actuator 34 is controlled so that the tubular element 4 remains pressed against the segments 18.

[0034] Referring to Fig. 4, in a third step, the multistage piston / cylinder assembly 28 is hydraulically controlled to move the expansion actuator 20 axially upward and thereby to move the segments 18 radially outward while the tubular element 4 remains pressed against the segments 18 by suspension actuator 34. As a result, a portion of the tubular element 4 is radially expanded against the wellbore wall 6.

[0035] Referring further to Fig. 5, in a fourth step, the piston / cylinder assembly 28 is controlled to move the expansion actuator 20 axially downward so that the segments 18 radially retract. With the segments 18 radially retracted, the expander 10 is moved axially downward until the segments 18 stop against the inner surface of the unexpanded portion of the tubular element 4. Such axial downward movement of the expander 10 occurs by gravity and, if necessary, by operation of the suspension actuator 34 to pull the expander 10 downward.

[0036] The third and fourth steps are repeated a sufficient number of times until the tubular element becomes fixedly connected to the wellbore wall 6 so that the anchoring device is no longer necessary to suspend the tubular element 4.

[0037] Referring further to Figs. 6-7, in a fifth step, the anchor 31 is radially retracted from the inner surface 32 of the tubular element 4.

[0038] Thereafter, the third and fourth steps are repeated until the entire tubular element 4 has been radially expanded against the wellbore wall 6. To retrieve the expansion assembly 8, the expander 10 is brought to the radially retracted mode, and the expansion assembly 8 is retrieved through the expanded tubular element 4 to surface.

Claims

1. A method of radially expanding a tubular element against a wall in a wellbore using an expansion assembly comprising an expander adapted to expand the tubular element against said wall by movement of the expander from a radially retracted mode to a radially expanded mode, and an anchoring device for anchoring the expansion assembly to the tubular element and to suspend the tubular element in the wellbore, the method comprising the steps of:

   (a) anchoring the anchoring device to the tubular element and locating the expander in the tubular element;
   (b) suspending the tubular element on the anchoring device and lowering the expansion assembly with the tubular element into the wellbore; and
   (c) inducing the expander to move from the radially retracted mode to the radially expanded mode so as to expand at least a portion of the tubular element against said wall in the wellbore.

2. The method of claim 1, further comprising:

   (d) inducing the expander to move from the radially expanded mode to the radially retracted mode, moving the expander axially forward in the tubular element, and repeating step (c) so as to expand a further portion of the tubular element against said wall.

3. The method of claim 2, wherein step (d) defines an expansion cycle, the method comprising a plurality of said expansion cycles including a first expansion cycle in which the expander is expanded to a first maximum diameter and a second expansion cycle in which the expander is expanded to a second maximum diameter different from the first maximum diameter.

4. The method of any one of claims 1-3, wherein in step (c) the tubular element is fixedly connected to said wall, and wherein the method further comprises releasing the anchoring device from the tubular element after the tubular element has been fixedly connected to said wall.

5. The method of any one claims 1-4, wherein the expander comprises a plurality of segments arranged around an expansion actuator, the segments being movable in radial direction, the expansion actuator being operable to move the segments in radial direction by axial movement of the expansion actuator relative to the segments, and wherein step (c) comprises axially moving the expansion actuator relative to the segments so as to move the segments radially outward.

6. The method of claim 5, wherein the expansion actuator is hydraulically operated.

7. The method of claim 6, wherein the expansion assembly is suspended in the wellbore on the hydraulic fluid supply conduit.

8. The method of any one claims 1-7, wherein the anchoring device comprises an anchor movable between a radially retracted position in which the anchor is free from the inner surface of the tubular element and a radially expanded position in which the anchor is fixedly connected to the inner surface of the tubular element, and a suspension actuator operable to move the anchor in axial direction relative to the expander, and wherein step (a) comprises

moving the anchor to the radially expanded position and inducing the suspension actuator to move the anchor in axial direction relative to the expander so that the expander is located in the tubular element.

9. The method of claim 8, wherein the suspension actuator is hydraulically operated.

10. The method of claim 8 or 9, wherein the anchoring device extends below the expander.

11. The method of any one of claims 1-10, wherein the expansion assembly is suspended in the wellbore on a string selected from drill pipe and coiled tubing.

12. The method of any one of claims 1-11, wherein the expander has an outer surface shaped to create a corrugated profile in the tubular element during step (c).

13. The method substantially as described hereinbefore with reference to the accompanying drawings.

Fig.1

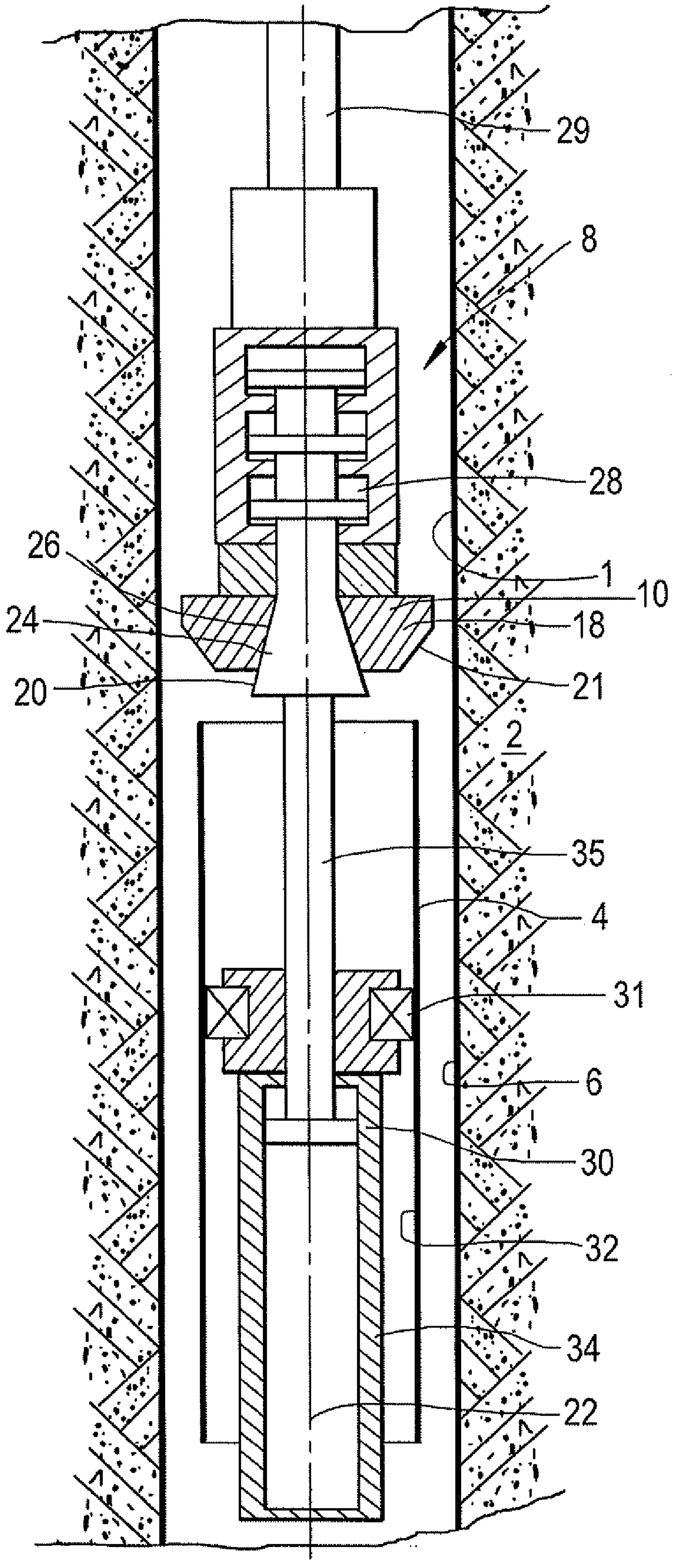


Fig.7

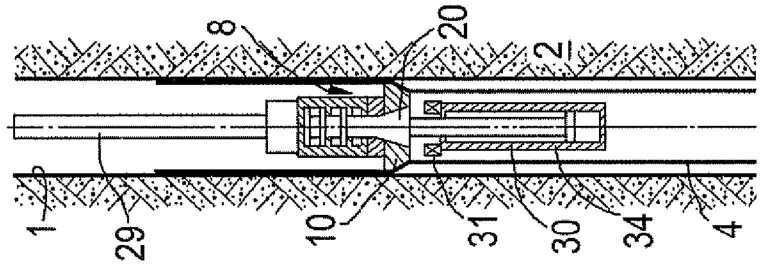


Fig.6

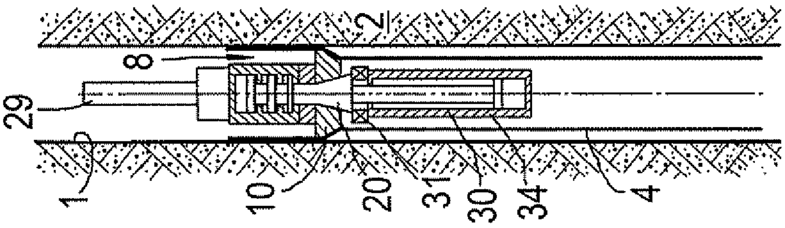


Fig.5

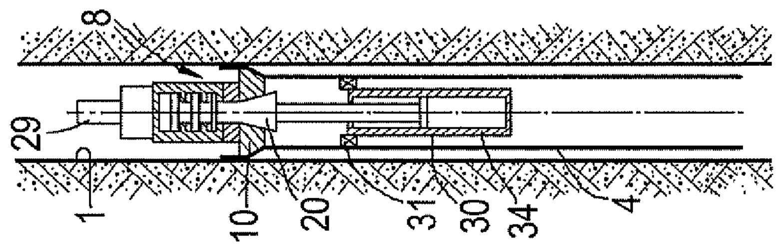


Fig.4

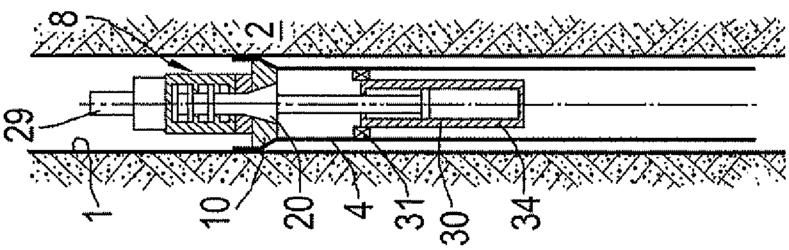


Fig.3

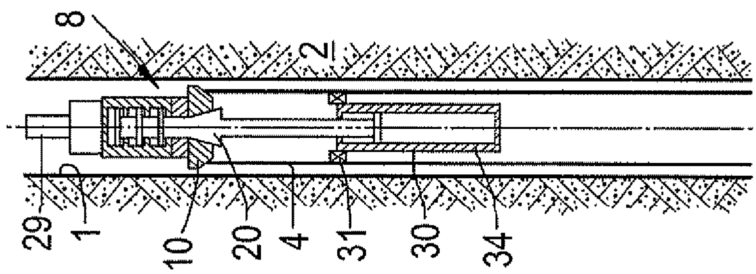
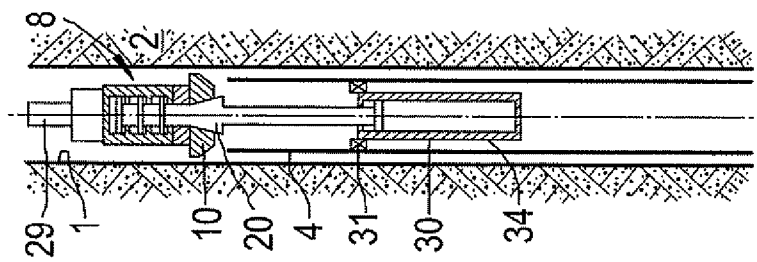


Fig.2



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EUROPEAN SEARCH REPORT

Application Number
EP 08 17 2918

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	14 May 2009	Dantinne, Patrick

CATEGORY OF CITED DOCUMENTS

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