



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
05.12.2012 Bulletin 2012/49

(51) Int Cl.:
E21B 43/26^(2006.01) E21B 43/114^(2006.01)

(21) Application number: **11168240.7**

(22) Date of filing: **31.05.2011**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(72) Inventors:
• **Mangal, Lars**
2900 Hellerup (DK)
• **Hallundbaek, Jørgen**
3230 Græsted (DK)

(71) Applicant: **Welltec A/S**
3450 Allerød (DK)

(74) Representative: **Hoffmann Dragsted A/S**
Rådhuspladsen 16
1550 Copenhagen V (DK)

(54) **A formation penetrating tool**

(57) The present invention relates to a formation penetrating tool submersible into a casing in a well for hydraulically penetrating a formation comprising a tool housing, a casing penetrating unit adapted to provide a hole in a wall of the casing, a supply hose, slidable in the tool housing, for supplying a high pressurised fluid to a nozzle, and the tool housing has an opening for providing access of the supply hose and the nozzle to the opening in the casing, wherein the downhole tool further comprises a pump in fluid communication with the supply hose for providing a jet of fluid out of the nozzle for penetrating the formation. Furthermore, the invention relates to a downhole system comprising a formation penetrating tool according to the invention and to a method for hydraulically penetrating a formation.

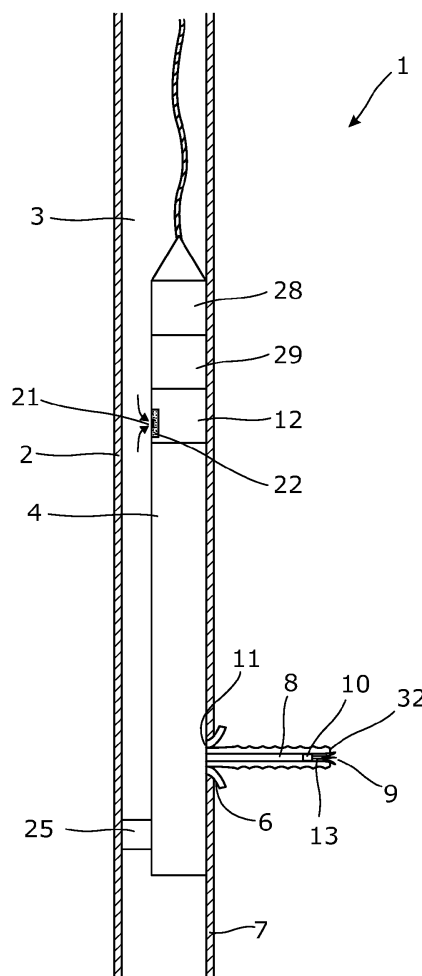


Fig. 1

Description

Field of the invention

[0001] The present invention relates to a formation penetrating tool submersible into a casing in a well for hydraulically penetrating a formation comprising a tool housing, a casing penetrating unit adapted to provide a hole in a wall of the casing, a supply hose, slidable in the tool housing, for supplying a high pressurised fluid to a nozzle, and the tool housing has an opening for providing access of the supply hose and the nozzle to the opening in the casing, wherein the downhole tool further comprises a pump in fluid communication with the supply hose for providing a jet of fluid out of the nozzle for penetrating the formation. Furthermore, the invention relates to a downhole system comprising a formation penetrating tool according to the invention and to a method for hydraulically penetrating a formation.

Background art

[0002] When fracturing the formation in order to provide better access to the hydrocarbon reservoir, the maximum reservoir contact is obtained if the fractures are created perpendicularly or radially from the casing or from the bore hole in a well. When fracturing, there is always a risk that the fractures are not made radially from the casing, as the formation cracks at its weakest spots. In some kinds of formation, the fractures tend to be created in parallel to the casing or the bore hole even though the fracturing fluid or perforating charge is directed radially into the formation.

Summary of the invention

[0003] An object of the present invention is to wholly or partly overcome the above disadvantages and drawbacks of the prior art. More specifically, it is an object to provide a tool enabling a more controlled fracturing process.

[0004] The above objects, together with numerous other objects, advantages and features, which will become evident from the below description, are accomplished by a solution in accordance with the present invention by a formation penetrating tool submersible into a casing in a well for hydraulically penetrating a formation comprising:

- a tool housing,
- a casing penetrating unit adapted to provide a hole in a wall of the casing,
- a supply hose slidable in the tool housing for supplying a high pressurised fluid to a nozzle, and
- the tool housing having an opening for providing access of the supply hose and the nozzle to the opening in the casing,

wherein the downhole tool further comprises a pump in

fluid communication with the supply hose for providing a jet of fluid out of the nozzle for penetrating the formation.

[0005] In one embodiment, a holding unit may be arranged for providing a predetermined pushing force to the supply hose so that the supply hose and thereby the nozzle may be kept in a predetermined position during penetration.

[0006] In another embodiment, the predetermined pushing force may be at least equal to or larger than a pressure of the high pressurised fluid at the nozzle.

[0007] Further, the holding unit may comprise a piston circumferencing the supply hose.

[0008] Additionally, the piston may be arranged in a piston housing in the tool housing.

[0009] In one embodiment, the casing penetrating device may be arranged in or around the nozzle.

[0010] In another embodiment, the nozzle may have an annular opening (orifice) providing a cylindrical jet of fluid.

[0011] In yet another embodiment, the pump may be arranged in or in connection with the tool housing.

[0012] Also, the casing penetrating device may be a punch, a drill bit or a charge of a perforating gun.

[0013] Moreover, the tool housing may comprise a guiding element for guiding the supply hose out of the opening in the tool housing.

[0014] Furthermore, the tool housing may comprise a guiding tube for guiding the supply hose.

[0015] Also, the supply hose may be sliding in a fluid channel being in fluid communication with the pump.

[0016] In one embodiment, the supply hose may be armoured.

[0017] Further, the supply hose may comprise a plastic core such as a Teflon core, or may be coated with Teflon or other friction reducing materials.

[0018] Moreover, the high pressurised fluid may be well fluid.

[0019] In one embodiment, the tool housing may comprise an inlet for the well fluid, the inlet being in fluid communication with the pump.

[0020] In another embodiment, a filter or screen may be arranged in connection with the inlet for filtering the well fluid before it enters the pump.

[0021] The formation penetrating tool according to the invention may further comprise a fluid reservoir.

[0022] Also, the fluid reservoir may contain a supply of fluid.

[0023] Furthermore, the fluid may be the pressurised fluid, an acid, a base, or a mixture of substances.

[0024] In one embodiment, a fluid control device may be arranged in connection with the fluid reservoir. Hereby, it is obtained that a fluid communication to the fluid reservoir may be opened or closed.

[0025] Further, the tool may comprise an anchor section for pressing the penetrating unit against the wall of the casing or anchoring the tool to an inner face of the casing.

[0026] In another embodiment, the pump may be pow-

ered through a wireline or a battery.

[0027] In yet another embodiment, the pump may be a centrifugal pump, a piston pump, or a jet pump.

[0028] Also, the tool may comprise a pressure measuring device.

[0029] Additionally, the tool may comprise an electronic section.

[0030] Further, the tool may comprise a hydraulic motor or an electrical motor for driving the pump.

[0031] Moreover, the tool may comprise a position device, such as a casing collar locator, adapted for positioning the downhole tool in the casing in an axial and/or a radial direction of the casing.

[0032] Furthermore, the formation penetrating tool may comprise an inlet being in fluid communication with the pump, enabling a well fluid to be used as the high pressurised fluid.

[0033] In one embodiment, an additional fluid from a fluid reservoir may be arranged in the formation penetrating tool via the supply hose, and the nozzle may be introduced into the penetrated formation for a subsequent treatment of the penetrated formation.

[0034] In another embodiment, the subsequent treatment may be an acid treatment for creating a larger surface area of the penetrated formation.

[0035] In yet another embodiment, the subsequent treatment may be an enzyme treatment for cleaning the penetrated formation.

[0036] Moreover, the well fluid may be filtered before entering the pump.

[0037] The present invention furthermore relates to a downhole system comprising a formation penetrating tool according to the invention and a driving unit, such as a downhole tractor.

[0038] Finally, the invention relates to a method for hydraulically penetrating a formation comprising the steps of

- submerging a formation penetrating tool in a casing,
- providing an opening in a wall of the casing by means of a casing penetrating unit,
- supplying a high pressurised fluid to a nozzle via a supply hose by means of a pump arranged in the formation penetrating tool,
- positioning the nozzle opposite the opening in the casing, and
- penetrating the formation by means of a jet of fluid out of the nozzle providing a formation bore.

[0039] Additionally, the method according to the invention may comprise at least one of the following steps:

- performing a subsequent treatment of the formation bore by means of acid for creating a larger surface area of the formation bore,
- injecting a fluid comprising enzymes into the formation bore,
- fracturing the formation by injecting high pressurised

fluid into the formation bore, or

- perforating the formation by exploding a charge in connection with the formation bore.

5 Brief description of the drawings

[0040] The invention and its many advantages will be described in more detail below with reference to the accompanying schematic drawings, which for the purpose of illustration show some non-limiting embodiments and in which

Fig. 1 shows a formation penetrating tool in a casing,

Fig. 2 shows a cross-sectional view of the formation penetrating tool,

Fig. 3 shows one embodiment of a holding unit,

Fig. 4 shows a cross-sectional view of another embodiment of the formation penetrating tool,

Fig. 5 shows yet another embodiment of the formation penetrating tool, and

Fig. 6 shows a front view of a nozzle,

[0041] All the figures are highly schematic and not necessarily to scale, and they show only those parts which are necessary in order to elucidate the invention, other parts being omitted or merely suggested.

Detailed description of the invention

[0042] Fig. 1 shows a formation penetrating tool 1 submerged in a casing 2 in a well 3. In order to penetrate the formation, the tool 1 has a tool housing 4 in which a casing penetrating unit 5 adapted to provide a hole 6 in a wall 7 of the casing 2 is arranged. Subsequently, a nozzle 10 is arranged in an end of a supply hose 8, slidable within the tool housing 4. The supply hose 8 supplies a high pressurised fluid 9 to the nozzle 10 which is jetted as a jet stream out through the hole 6 in order to penetrate the formation, thereby providing a formation micro-bore substantially radially from the formation penetrating tool 1. The formation penetrating tool 1 comprises a pump 12 which is in fluid communication with the supply hose 8 for providing a jet 13 of fluid out of the nozzle 10 to penetrate the formation creating the micro-bore or formation bore 32.

[0043] When fracturing the formation to provide better access to the hydrocarbon reservoir, there is a risk that the fractures are not made radially from the casing. Thus, by providing a micro-bore by means of the formation penetrating tool 1, the fracturing process can be controlled better since a micro-bore acts as a notch. The fracturing process may be performed by means of high pressurised fluid pumped down into the casing or by a perforating

gun. In addition, the micro-bore may be used before performing an acidifying process.

[0044] The tool housing has an opening 11 for providing access of the supply hose 8 and the nozzle 10 to the opening 11 in the casing 2. To penetrate the formation, the supply hose 8 is led out through the opening, and fluid 9 is jetted out through the nozzle 10. The high pressurised fluid jetted into the formation is pressurised in the pump 12. The pump 12 pumps well fluid in through an inlet 21 and a filter 22 arranged in the inlet 21 and pumps the well fluid via the supply hose out through the nozzle. By using well fluid to penetrate the formation creating the micro-bore 32, the reservoir is not further contaminated. In addition, the power needed for the jetting process is less than if the pump was arranged at the top of the well and the fluid was pumped down to the supply hose 8 through a drill pipe or coiled tubing. The pump is arranged in the tool and is driven by an electrical motor 29 which is powered by a wireline through an electronic section 28. The formation penetrating tool 1 is thus a wireline tool.

[0045] The formation penetrating tool 1 comprises an anchoring section 25 to force the casing penetrating unit 5 against the casing wall. The tool may have several anchoring sections 25.

[0046] When the jet of fluid 9 hits the formation, the formation crunches but the force of the jet will also force the supply hose backwards. Therefore, the tool comprises a holding unit 14 which holds the supply hose and thus the nozzle close to the formation. The holding unit 14 provides a predetermined pushing force to the supply hose so that the supply hose and thereby the nozzle may be kept in a predetermined position during penetration so that the jet does not lose its jetting power before reaching the formation. The predetermined pushing force is substantially equal to or up to 5% smaller than the pressure of the high pressurised fluid at the nozzle.

[0047] As can be seen in Fig. 2, the holding unit 14 comprises a piston 15 arranged around the supply hose so that the hose penetrates the piston at its center. The piston 15 is slidably arranged in a piston housing 16 in the tool housing so that the hose can extend into the formation bore as the formation bore is created. The pressurised fluid 9 from the pump is pumped into a fluid channel 20 which in Fig. 2 functions as the piston housing 16. The fluid acts upon the piston, forcing the hose out into the formation bore as it is created by the jet. In Fig. 2, the holding unit 14 is the piston sliding in the piston housing. The supply hose is guided in the formation penetrating tool 1 by a guiding tube 19 and a guiding element 18 in order to slide without creating substantial friction.

[0048] In Fig. 2, the casing penetrating device is arranged around the nozzle, and the guiding element 18 is part of the casing penetrating unit 5. In another embodiment, the casing penetrating unit 5 is arranged in the second part of the formation penetrating tool 1 and is slid away from opening when the opening has been made so that the nozzle and the supply hose can enter the formation.

[0049] The casing penetrating device is a punch in Fig. 2, but may also be a drill bit or a charge 33 of a perforating gun forming part of the tool as shown in Fig. 4. The punch shown in Fig. 2 is forced outward towards the casing in order to penetrate the casing wall, creating a hole in the wall by means of a sliding element 42 slidable arranged in a space 43 in the tool housing 4. The sliding element 42 comprises an inclined surface 44, and when the sliding element 42 is forced away from the pump 12 by means of pressurised fluid in a fluid channel 45 indicated by a dotted line, the punch is forced out of the opening in the tool housing 4 and punches a hole in the casing wall.

[0050] In Fig. 4, the charge 33 is activated by a contact 34 arranged in the piston housing and when the piston slides past the contact, the side of the piston presses on the contact and the charge is initiated by the wiring 35, and the charge explodes, creating an opening in the casing wall.

[0051] The supply hose is armoured by a threading embedded in the wall of the hose so that the hose is self-supporting and that the holding unit can exert pressure from one end in order to provide a holding pressure in the other end of the hose countering the pressure from the formation when the jet hits the formation. The supply hose may also comprise a plastic core, such as a Teflon core, or be coated with Teflon or other friction-reducing materials in order to supply the pressurised fluid 9 without losing too much pressure.

[0052] In Fig. 3, the holding unit comprises a first 40 and a second 41 piston arranged around the supply hose at a distance from each other, creating a chamber 37 therebetween. The first piston is arranged closest to the nozzle. The holding unit 14 also comprises a fluid channel 38 in fluid communication with the pump 12 or an additional pump providing a pressure on the first piston 40, forcing the hose outward towards the formation and thus holds the nozzle sufficiently close to the formation in order to crunch the formation by means of the jet of pressurised fluid 9. The second piston and the aforementioned piston 15 may be the same piston.

[0053] As shown in Fig. 5, the formation penetrating tool 1 may comprise a fluid reservoir 23 containing the fluid 9 if the pump does not take in well fluid or the reservoir 23 may contain an additional fluid. The fluid may be any kind of fluid, such as water, an acid, a base, a mixture of substances. The additional fluid from the fluid reservoir may also be introduced into the penetrated formation for a subsequent treatment of the penetrated formation, so that a second run in order to fracture the formation using the micro-bore 32 is no longer needed.

[0054] The formation penetrating tool 1 also comprises a fluid control device 24 arranged in connection with the fluid reservoir 23 so that a fluid communication between the pump 12 and the fluid reservoir may be open or closed. By having the fluid control device 24, the additional fluid in the fluid reservoir can be mixed with the well fluid pumped in by means of the pump, and thus the fluid control device 24 can control the amount of fluid

from the reservoir which is mixed with the well fluid.

[0055] In fig. 6, the nozzle has an annular orifice providing a cylindrical jet of fluid. In this way, the fluid creates an annular micro-bore around a formation centre part which may be brought up with the tool with a view to analysing the formation so that an optimal fracturing process can be initiated.

[0056] The formation penetrating tool 1 is powered by wireline 26 or a battery arranged inside the tool. When the formation penetrating tool 1 comprises a battery, the line 26 can be any line strong enough to pull the tool out of the well after the penetrating operation.

[0057] In Fig. 5, the formation penetrating tool 1 comprises a pressure measuring device 27 for measuring the pressure of the fluid 9 supplied through the supply hose. The formation penetrating tool 1 also comprises a position device 30, such as a casing collar locator, adapted to position the formation penetrating tool 1 in the casing in an axial and/or a radial direction of the casing 2. Furthermore, the position is used for finding the formation micro-bore in the following fracturing process.

[0058] The pump may be a centrifugal pump, a piston pump or a jet pump.

[0059] Fig. 5 shows a downhole system 100. The downhole system comprises the formation penetrating tool 1 and a driving unit 31, such as a downhole tractor. The driving unit is mainly used to drive the formation penetrating tool 1 and itself forward in a horizontal part of the well but may also be used as an anchoring section or a positioning device.

[0060] By fluid or well fluid is meant any kind of fluid that may be present in oil or gas wells downhole, such as natural gas, oil, oil mud, crude oil, water, etc. By gas is meant any kind of gas composition present in a well, completion, or open hole, and by oil is meant any kind of oil composition, such as crude oil, an oil-containing fluid, etc. Gas, oil, and water fluids may thus all comprise other elements or substances than gas, oil, and/or water, respectively.

[0061] By a casing is meant any kind of pipe, tubing, tubular, liner, string etc. used downhole in relation to oil or natural gas production.

[0062] Although the invention has been described in the above in connection with preferred embodiments of the invention, it will be evident for a person skilled in the art that several modifications are conceivable without departing from the invention as defined by the following claims.

Claims

1. A formation penetrating tool (1) submersible into a casing (2) in a well (3) for hydraulically penetrating a formation comprising:
 - a tool housing (4),
 - a casing penetrating unit (5) adapted to provide

a hole (6) in a wall (7) of the casing,

- a supply hose (8), slidable in the tool housing, for supplying a high pressurised fluid (9) to a nozzle (10), and

- the tool housing having an opening (11) for providing access of the supply hose and the nozzle to the opening in the casing,

wherein the downhole tool further comprises a pump (12) in fluid communication with the supply hose for providing a jet (13) of fluid out of the nozzle for penetrating the formation.

2. A formation penetrating tool according to claim 1, wherein a holding unit (14) is arranged for providing a predetermined pushing force to the supply hose
3. A formation penetrating tool according to claim 2, wherein the holding unit comprises a piston (15) circumferencing the supply hose.
4. A formation penetrating tool according to claim 3, wherein the piston is arranged in a piston housing (16) in the tool housing.
5. A formation penetrating tool according to any of the preceding claims, wherein the casing penetrating device is arranged in or around the nozzle.
6. A formation penetrating tool according to any of the preceding claims, wherein the casing penetrating device is a punch, a drill bit or a charge of a perforating gun.
7. A formation penetrating tool according to any of the preceding claims, wherein the supply hose is sliding in a fluid channel (20) being in fluid communication with the pump.
8. A formation penetrating tool according to any of the preceding claims, wherein the supply hose is armoured.
9. A formation penetrating tool according to any of the preceding claims, wherein the high pressurised fluid is well fluid.
10. A formation penetrating tool according to any of the preceding claims, wherein the tool housing comprises an inlet (21) for the well fluid, the inlet being in fluid communication with the pump.
11. A formation penetrating tool according to any of the preceding claims, further comprising a fluid reservoir (23).
12. A formation penetrating tool according to any of the preceding claims, wherein a fluid control device (24) is arranged in connection with the fluid reservoir.

13. A downhole system comprising a formation penetrating tool according to any of the preceding claims and a driving unit (31), such as a downhole tractor.
14. A method for hydraulically penetrating a formation 5 comprising the steps of
- submerging a formation penetrating tool in a casing,
 - providing an opening in a wall of the casing by 10 means of a casing penetrating unit,
 - supplying a high pressurised fluid to a nozzle via a supply hose by means of a pump arranged in the formation penetrating tool,
 - positioning the nozzle opposite the opening in 15 the casing, and
 - penetrating the formation by means of a jet of fluid out of the nozzle, providing a formation bore.
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15. A method according to claim 14, further comprising at least one of the following steps:
- performing a subsequent treatment of the formation bore by means of acid for creating a larger 25 surface area of the formation bore,
 - injecting a fluid comprising enzymes into the formation bore,
 - fracturing the formation by injecting high pressurised fluid into the formation bore, or 30
 - perforating the formation by exploding a charge in connection with the formation bore.

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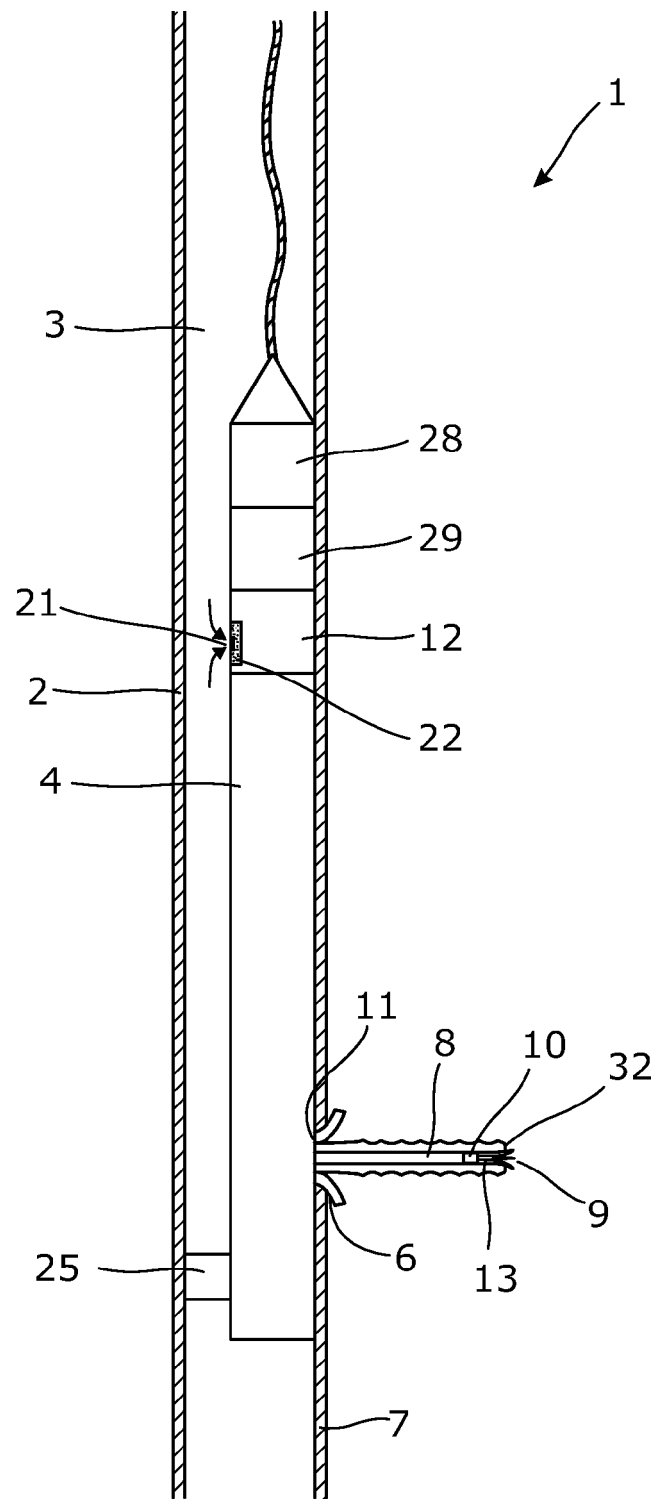


Fig. 1

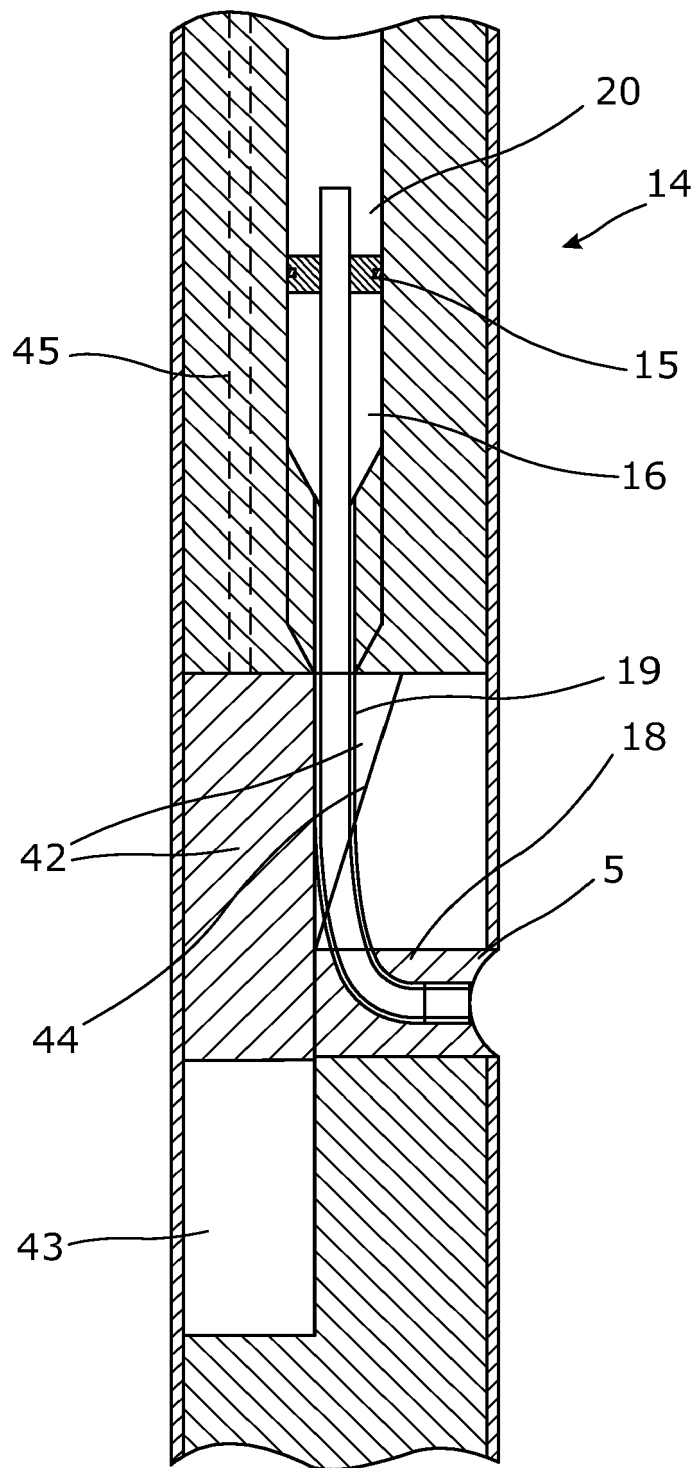


Fig. 2

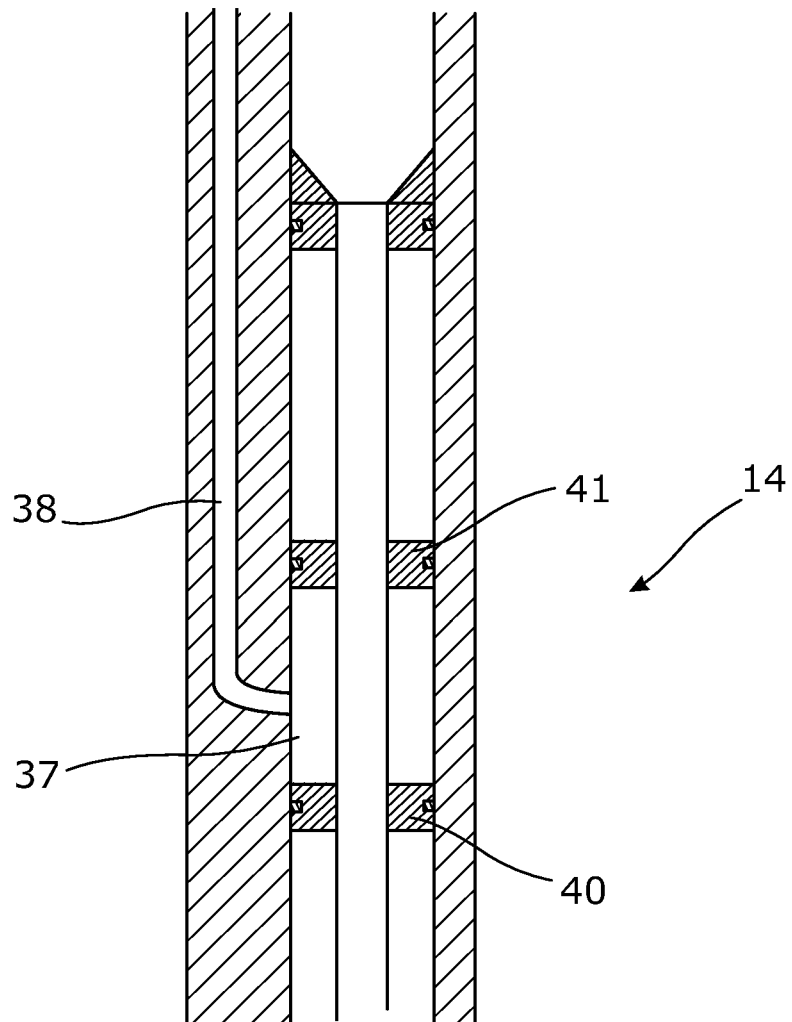


Fig. 3

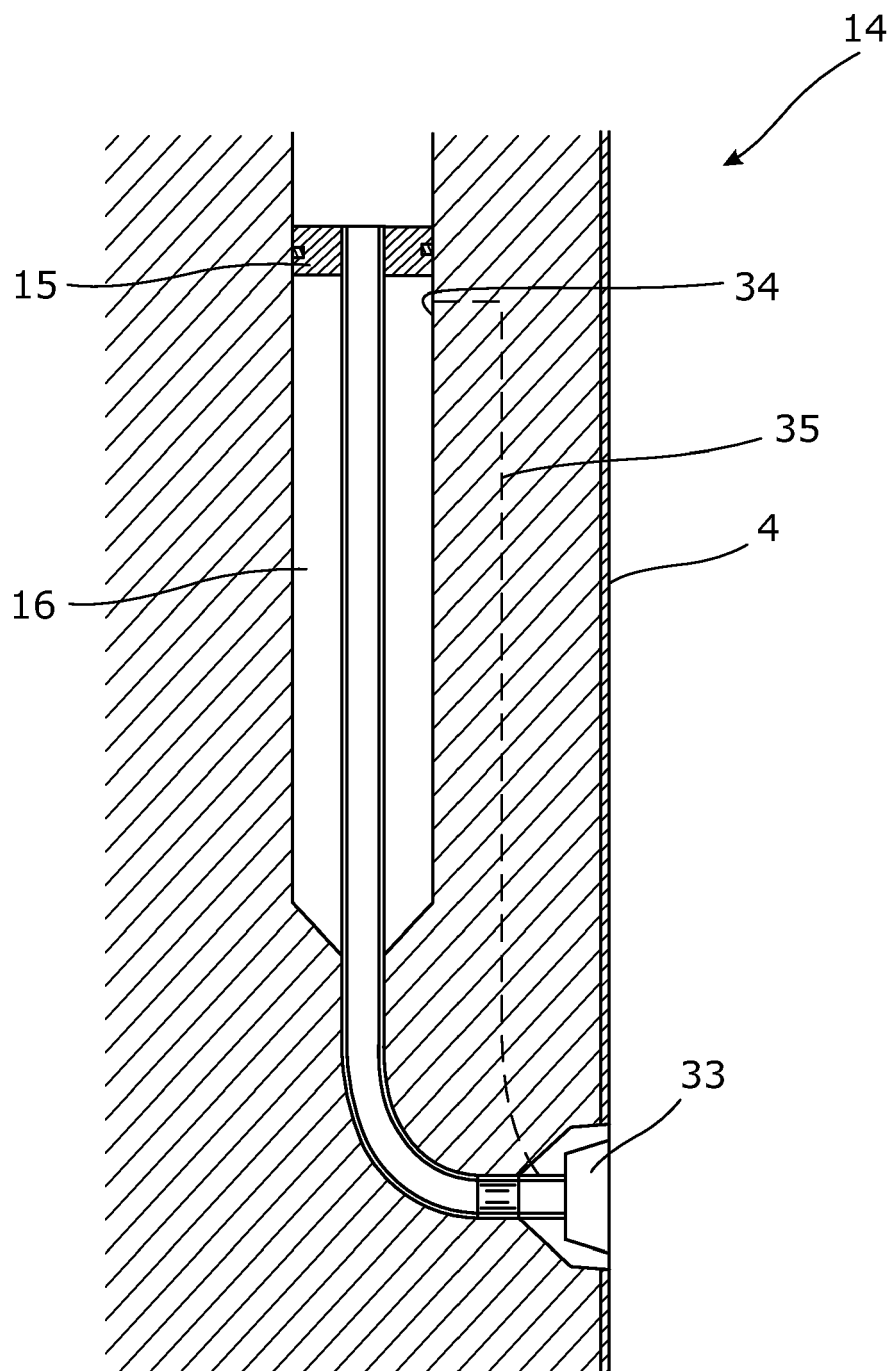
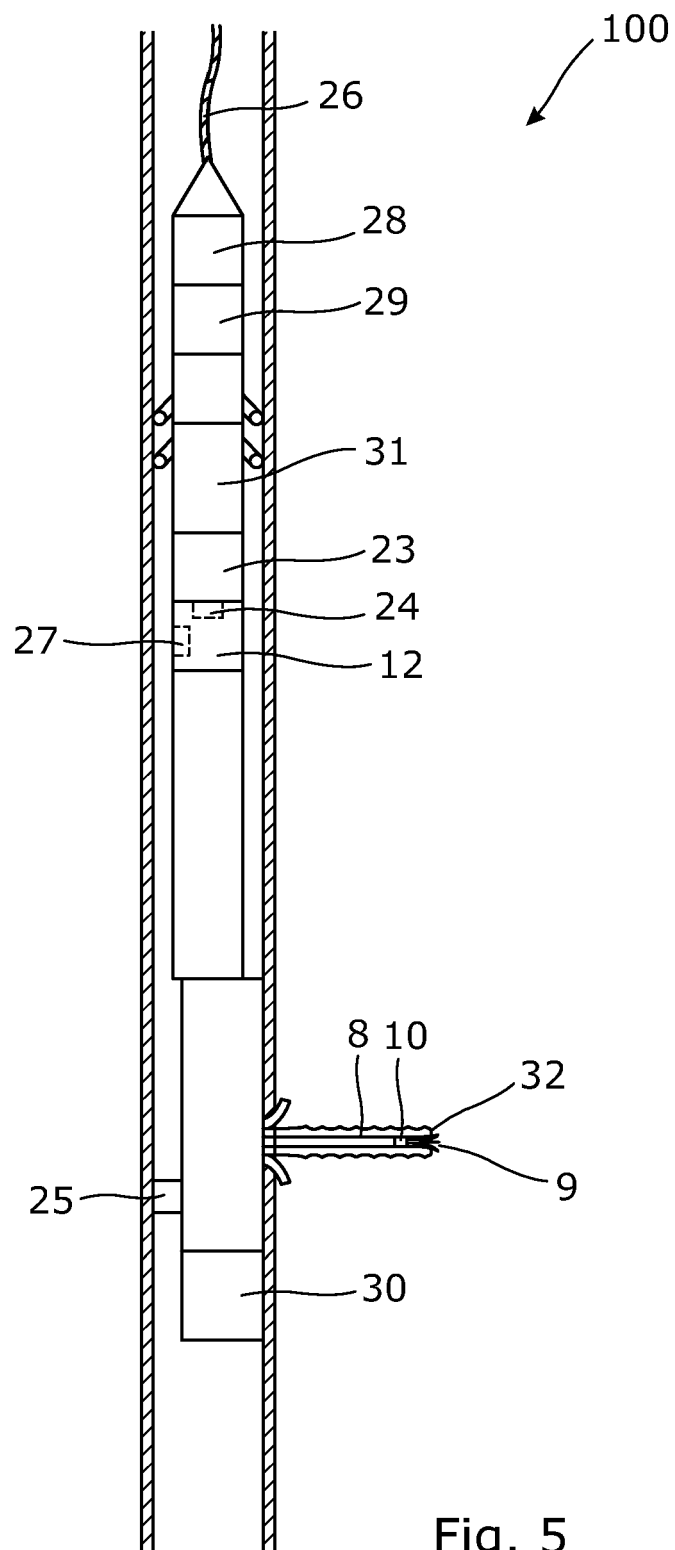


Fig. 4



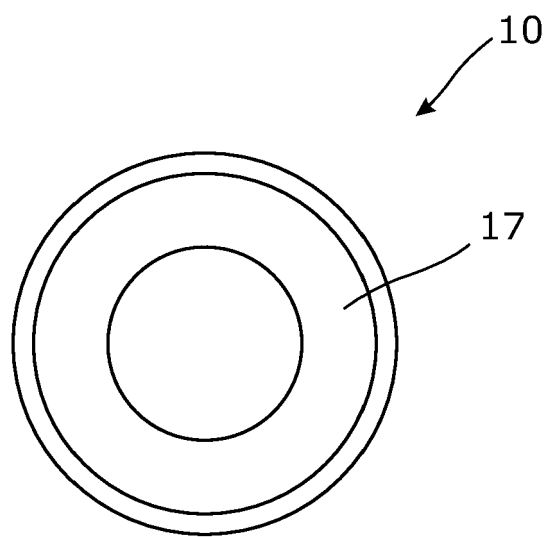


Fig. 6



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EP 11 16 8240

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82