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(54) **MECHANICAL PERFORATION TOOL SYSTEM**

MECHANISCHES PERFORATIONSWERKZEUGSYSTEM

SYSTÈME D'OUTIL DE PERFORATION MÉCANIQUE

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Description

[0001] The present invention relates to a perforation tool system for perforating a screen, a sliding sleeve or a casing wall of a casing in a borehole having a top. The invention also relates to a perforation method.

[0002] In a downhole well, a casing or well tubular metal structure is inserted into the drilled hole, and the production zone is isolated from, e.g., water-producing zones. Access to the production zone is normally made by a perforation gun using explosives downhole, which is not always allowed and may imply a dangerous situation downhole. WO 2014/198897 A1 discloses a downhole machining system. US 2008/135226 A1 discloses wireline-run mills, and US 2,998,068 A discloses a perforating apparatus.

[0003] It is an object of the present invention to wholly or partly overcome the above disadvantages and drawbacks of the prior art. More specifically, it is an object to provide an improved perforation tool system which does not use explosives to create openings/perforations in the casing/well tubular metal structure.

[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 perforation tool system for perforating a screen, a sliding sleeve or a casing wall of a casing or another well tubular metal structure in a borehole having a top, comprising:

- a first tool part having an axial extension and an anchoring section,
- a second tool part adapted to rotate and move axially in relation to the first tool part, the second tool part comprising a machining bit which is movable in a direction radial to the axial extension,
- an axial actuator comprised in the first tool part and comprising a shaft for axially moving the second tool part in relation to the first tool part,
- a rotation unit for rotating the second tool part in relation to the first tool part, and
- a first actuator comprising an electric motor for rotating the bit,

wherein the rotation unit comprises a sleeve having a slot engaging a pin of the shaft, the slot comprising a first longitudinal slot part, a second longitudinal slot part and a first guiding slot part connecting the first and second longitudinal slot parts.

[0005] Also, the perforation tool system may be a mechanical perforation tool system, i.e., a system not using explosives.

[0006] Thus, the rotation unit is provided for rotating the second tool part around the axial extension of the perforation tool system in relation to the first tool part.

[0007] Moreover, the perforation tool system may be powered through a wireline, i.e., the perforation tool

system may be a perforation wireline tool system.

[0008] Further, the perforation tool system may comprise an electric motor powered through a wireline and driving a pump.

[0009] In addition, the perforation tool system may further comprise an electronic section for controlling the operation of the perforation tool system.

[0010] Furthermore, the perforation tool system may also comprise a compensator for providing overpressure inside the perforation tool system.

[0011] The pump may drive the axial actuator to move the shaft back and forth along the axial extension.

[0012] Also, the first longitudinal slot part may have a first part and a second part, the guiding slot part being connected to the first longitudinal slot part between the first part and the second part.

[0013] Moreover, the second longitudinal slot part may have a first part and a second part, the guiding slot part being connected to the second longitudinal slot part between the first part and the second part.

[0014] Further, the pin may be in a first position when the pin is arranged in the first part of the first longitudinal slot part, and the pin may be in a second position when the pin is arranged in the first part of the second longitudinal slot part.

[0015] In addition, the first longitudinal slot part may be displaced from the second longitudinal slot part along a circumference of a tool housing.

[0016] Furthermore, the slot may comprise a second guiding slot part connecting the second longitudinal slot part with another first longitudinal slot part.

[0017] Also, the guiding slot part may further comprise a first inclined slot part, a second inclined slot part and an intermediate slot part connecting the first inclined slot part and the second inclined slot part.

[0018] Moreover, the first inclined slot part may be connected to the first longitudinal slot part, and the second inclined slot part may be connected to the second longitudinal slot part.

[0019] Further, the bit may be moved radially in relation to the axial extension by means of an electric motor and/or hydraulics.

[0020] In addition, the bit may be moved radially by means of a hydraulic cylinder.

[0021] Furthermore, the bit may form a piston of the hydraulic cylinder.

[0022] The hydraulic cylinder may comprise a spring arranged between a bottom of the cylinder and the piston so that the piston is retracted when pressurised fluid is not pressing the piston outwards, the spring being squeezed between the piston and a flange of the cylinder housing when the piston and the bit are pressed outwards in the projected position of the bit.

[0023] Also, the piston may form part of a gear that engages another gear of the shaft.

[0024] Moreover, the first tool part may be arranged closer to the top of the well than the second tool part.

[0025] Further, the system may comprise a second

anchoring section, and the anchoring sections may be arranged with a mutual axial distance between them, both anchoring sections being arranged closer to the top of the well than the second tool part and the bit.

[0026] In addition, one anchoring section may be axially movable in relation to the other.

[0027] Furthermore, the first actuator may comprise a gear for changing a rotational speed of the electric motor.

[0028] Also, the gear may be a bevel gear.

[0029] Moreover, the gear may be a planetary gear.

[0030] Further, the perforation tool system may moreover comprise a control unit for controlling the movement of the pin in the slot.

[0031] In addition, the control unit may be connected to the sleeve of the rotation unit for forcing the pin towards one side of the slot or forcing the pin towards the opposing side of the slot.

[0032] Furthermore, the axial actuator may comprise a hydraulic cylinder and a reciprocating piston connected to the shaft.

[0033] Also, the system may further comprise a pinching or cutting tool projectable through an opening in the casing provided by the machining bit.

[0034] Moreover, the bit may be moved radially in a bit housing, the bit having a sharp end facing the casing and a piston end, and the bit being moved radially in relation to the axial extension by means of an electric motor driving a hydraulic cylinder which is in fluid communication with the bit housing, pressing onto the piston end.

[0035] Further, the system may also comprise a fluid cleaner for cleaning up cuttings from the machining process.

[0036] In addition, the system may further comprise a driving unit, such as a downhole tractor.

[0037] Furthermore, the invention relates to a perforation method comprising:

- arranging the perforation tool system into a casing opposite the section to be perforated,
- drilling a first opening in the casing by rotating the machining bit and moving the machining bit in the direction radial to the axial extension for contacting an inner face of the casing,
- retracting the bit,
- activating the axial actuator to move the shaft and the pin in a first direction along the slot from a first position to a second position,
- drilling a second opening in the casing by rotating the machining bit and moving the machining bit in the direction radial to the axial extension for contacting an inner face of the casing, and
- retracting the bit.

[0038] Also, the perforation method may further comprise:

- activating the axial actuator to move the shaft and the pin in a second direction opposite the first direction

along the slot from a second position to a third position,

- drilling a third opening in the casing by rotating the machining bit and moving the machining bit in the direction radial to the axial extension for contacting an inner face of the casing, and
- retracting the bit.

[0039] Moreover, the perforation method may further comprise moving the perforation tool system to a new position along the axial extension.

[0040] Finally, the perforation method may further comprise anchoring the system in the casing.

[0041] 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 perforation tool system in perspective,

Fig. 2 shows another perforation tool system in perspective,

Fig. 3 shows, in perspective, a rotation unit for rotating the second tool part in relation to the first tool part of the perforation tool system,

Fig. 4 shows, in perspective, another rotation unit for rotating the second tool part in relation to the first tool part of the perforation tool system,

Fig. 5A shows another perforation tool system in perspective where the shaft of the axial actuator is in its retracted position,

Fig. 5B shows the perforation tool system of Fig. 5A where the shaft of the axial actuator is in its projected position, and

Fig. 6 is a cross-sectional view of a part of the perforation tool system having the machining bit.

[0042] 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.

[0043] Fig. 1 shows a perforation tool system 1 for perforating a screen, a sliding sleeve or a casing wall of a casing 2 or another well tubular metal structure in a borehole 3. The perforation tool system 1 comprises a first tool part 4 having an axial extension 5, which is also the axial extension of the perforation tool system 1, and at least one anchoring section 6, 6A, 6B, 6C (shown in Figs. 5A and 5B) for anchoring the tool system 1 in the well when perforating, i.e., making openings in the screen, the sliding sleeve or the casing wall of a casing 2. The perforation tool system 1 further comprises a second tool

part 7 adapted to rotate around the axial extension 5 and move axially in relation to the first tool part 4, the second tool part 7 comprising a machining bit 8 which is movable in a direction 9 radial to the axial extension in order to make the opening/perforation. The first tool part 4 is arranged closer to the top of the well than the second tool part 7. The perforation tool system 1 further comprises an axial actuator 10 comprised in the first tool part 4 and comprising a shaft 25 for axially moving the second tool part 7 in relation to the first tool part 4, a rotation unit 12 for rotating the second tool part 7 in relation to the first tool part 4, and a first actuator 11 comprising an electric motor 11A for rotating the bit 8. The rotation unit 12 comprises a tubular sleeve 14 having a slot 18 engaging a pin 19 of the shaft 25, and the slot 18 comprises a first longitudinal slot part 18A, a second longitudinal slot part 18B (shown in Fig. 3) and a first guiding slot part 20 connecting the first and second longitudinal slot parts. The pin is fixedly fastened to the shaft. In the non-activated position of the axial actuator 10, the bit 8 can drill a first opening, e.g. in the casing wall, in a first position P1. As the axial actuator 10 moves the shaft 25 along the axial extension 5 away from the first tool part 4 in a first direction D1, the second tool part 7 is rotated along a rotation direction R as the pin 19 on the shaft 25 moves in the slot 18 and as the sleeve 14 is fixedly fastened to the first tool part 4, and then the shaft 25 is forced to rotate, rotating the second tool part 7 and thus the bit 8. In this second position P2, the bit 8 drills a second opening in the casing wall. When the axial actuator 10 retracts the shaft 25 along the axial extension 5 towards the first tool part 4 in a second direction D2 opposite the first direction, the pin 19 moves along the slot 18, and the shaft 25 is forced to rotate to a third position P3.

[0044] In another embodiment, the sleeve 14 rotates with the second tool part 7 and is fixedly fastened to the second tool part 7, and not to the first tool part. In this embodiment, the shaft 25 does not rotate but merely moves back and forth along the axial extension 5.

[0045] The bit 8 is a drill bit moving along the direction 9 radially and perpendicularly to the axial extension 5 in order to make the openings/perforations. The openings/perforations are drilled in, e.g., the casing wall with a mutual distance in the requested perforation pattern in order to provide a perforated zone without the use of explosives. Thus, the slot is made in a pattern matching the requested perforation pattern. The perforation tool system 1 is thus a mechanical perforation tool system, i.e., a system not using explosives.

[0046] As can be seen in Figs. 5A and 5B, the perforation tool system 1 is powered through a wireline 22, i.e., the perforation tool system 1 is a perforation wireline tool system 1. Thus, the first tool part is arranged closer to the wireline than the second tool part. The perforation tool system 1 comprises an electric motor 24 powered through the wireline 22 for driving a pump 25B. The perforation tool system 1 further comprises an electronic section 21 for controlling the operation of the perforation

tool system. Also, the perforation tool system 1 comprises a compensator 23 for providing overpressure inside the perforation tool system. The pump 25B drives the axial actuator 10 to move the shaft 25 back and forth along the axial extension 5. In Fig. 5A, the shaft 25 of the axial actuator 10 is retracted, and in Fig. 5B the shaft 25 is in its projected position in which the bit 8 has been rotated to a new position to drill a new opening.

[0047] In Fig. 3, the first longitudinal slot part 18A has a first part 51 and a second part 52, and a first guiding slot part 20, 20' is connected to the first longitudinal slot part 18A between the first part and the second part so that the pin 19 moving in the second longitudinal slot part 18B moves past another second guiding slot part 20, 20" into the intended first guiding slot part 20, 20' and further into the first longitudinal slot part 18A. The slot 18 comprises the second guiding slot part 20, 20" connecting the second longitudinal slot part 18B with another first longitudinal slot part 18A. The second longitudinal slot part 18B has a first part 53 and a second part 54, and the second guiding slot part 20, 20" is connected to the second longitudinal slot part 18B between the first part 53 and the second part 54. A corner 56 provided in the transition between the second part 52, 54 and the guiding slot part 20 forces and guides the pin 19 into the intended guiding slot part 20. When moving from the guiding slot part 20 into the longitudinal slot part 18, the pin 19 enters the longitudinal slot part 18 from one side 57 and bumps against the opposing side 58 of the longitudinal slot part 18 and is guided further along the longitudinal slot part to the first part 51, 53. The pin 19 is in a first position P1 when the pin 19 is arranged in the first part 51 of the first longitudinal slot part 18A, and the pin 19 is in a second position P2 when the pin 19 is arranged in the first part 53 of the second longitudinal slot part 18B. The first longitudinal slot part 18A is displaced from the second longitudinal slot part 18B along a circumference of a tool housing 37 (shown in Fig. 1) and slightly overlapping the second longitudinal slot part along the axial extension 5.

[0048] In Fig. 4, the guiding slot part 20 of the slot 18 further comprises a first inclined slot part 20A, a second inclined slot part 20B and an intermediate slot part 20C connecting the first inclined slot part 20A and the second inclined slot part 20B. The first inclined slot part 20A is connected to the first longitudinal slot part 18A, and the second inclined slot part 20B is connected to the second longitudinal slot part 18B. The sleeve 14 of Fig. 4 has more positions than the sleeve 14 of Fig. 3, as the sleeve 14 of Fig. 4 has reverse positions RP1, RP2 as well as the positions of the sleeve 14 of Fig. 3. A control unit 30 for controlling the movement of the pin 19 in the slot 18 is arranged in connection with the sleeve 14 so as to force the sleeve 14 in one rotational direction to move the pin 19 between the "forward" positions and to force the sleeve 14 in the opposing rotational direction to move the pin 19 between the "reverse" positions. The control unit 30 is connected to the sleeve 14 of the rotation unit 12 for

forcing the pin 19 towards one side of the slot 18 or forcing the pin 19 towards the opposing side of the slot 18. In this way, the perforation tool system 1 is able to drill more holes before the perforation tool system has to move position along the axial extension 5.

[0049] In Fig. 1, the rotation unit 12 is disclosed without any cover but may have a cover for covering and protecting the slot 18 from the well fluid. In Fig. 2, the rotation unit 12 is comprised inside the tool housing 37, and the sleeve 14 surrounds the shaft 25 of the axial actuator 10. The axial actuator 10 comprises a hydraulic cylinder 41 and a reciprocating piston 40 connected to the shaft 25 for moving the shaft 25 and the pin 19 back and forth in the slot 18. The bit 8 is moved radially in relation to the axial extension 5 by means of an electric motor and/or hydraulics along the direction 9. The bit 8 is rotated by an electric motor 11A of the first actuator 11 so that the first actuator 11 comprises a gear 15 for changing a rotational speed of the electric motor 11A.

[0050] In Fig. 6, the bit 8 is moved radially in a bit housing/cylinder 31, the bit 8 having a sharp end 32 facing the casing 2 and a piston end of the piston 33, and the bit 8 being moved radially in relation to the axial extension by means of an electric motor driving a hydraulic cylinder which is in fluid communication with the bit housing 31 pressing onto the piston end.

[0051] In Fig. 6, the bit 8 is moved radially by means of a hydraulic cylinder 31, and thereby the weight on bit (WOB) can be held more constant than when using a motor. The bit 8 forms a piston 33 of the hydraulic cylinder 31. The hydraulic cylinder 31 comprises a spring 34 arranged between a bottom of the cylinder 31 and the piston 33 so that the piston is retracted when pressurised fluid is not pressing the piston 33 outwards. The spring 34 is squeezed between the piston 33 and a flange 81 of the cylinder housing 31 when the piston and the bit 8 are pressed outwards in the projected position of the bit. In that way, the spring 34 acts as a failsafe mechanism as the spring 34 retracts the bit 8 when the power to the tool is switched off, and the system can be retracted from the well. The piston 33 forms part of a gear 15 that engages another gear 15 of the shaft 25. The bit 8 is rotated by an electric motor 11A of the first actuator 11 so that the first actuator 11 comprises the gear 15 for changing a rotational speed of the electric motor 11A, which gear engages with the piston housing 31 engaging the bit 8 via a key in a keyway connection. The gear 15 is a bevel gear, but it may also be a planetary gear.

[0052] In Figs. 5A and 5B, the system comprises a first anchoring section 6, 6A and a second anchoring section 6, 6B, and the anchoring sections are arranged with a mutual axial distance between them, both anchoring sections being arranged closer to the top of the well than the second tool part 7 and the bit 8. The system comprises a third anchoring section 6, 6C which is axially movable in relation to the other anchoring sections. By having several anchoring sections, the machining operation when the bit 8 is drilling can be better controlled than

when having only one anchoring section. In Figs. 5A and 5B, the anchoring sections furthermore have the function of displacing the whole tool string/tool system 1 in relation to the casing wall so that the bit 8 is brought into contact with the inner face of the casing 2 before the bit 8 starts drilling and moving radially along the direction 9.

[0053] The system may further comprise a pinching or cutting tool 78 projectable through an opening in the casing 2 provided by the machining bit 8 for cutting a control line outside the casing 2. The perforation tool system 1 may also comprise a fluid cleaner for cleaning up cuttings from the machining process and a driving unit, such as a downhole tractor.

[0054] Perforations are normally made in a predetermined pattern in order to optimise the inflow of well fluid. In order to make such openings/perforations with a predetermined distance without the use of explosives, the perforation tool system 1 is arranged in the casing 2 opposite a section to be perforated, and then a first opening is drilled in the casing 2 by rotating the machining bit 8 and moving the machining bit 8 in the direction 9 radial to the axial extension for contacting an inner face of the casing 2. Subsequently, the bit 8 is retracted, and the axial actuator 10 is activated to move the shaft 25 and the pin 19 in a first direction along the slot 18 from the first position P1 to the second position P2, where a second opening is drilled in the casing 2 by rotating the machining bit 8 and moving the machining bit 8 in the direction 9 radial to the axial extension for contacting an inner face of the casing 2, and then the bit 8 is retracted again. In order to make more than two openings, the axial actuator 10 is activated to move the shaft 25 and the pin 19 in a second direction opposite the first direction along the slot 18 from the second position P2 to the third position P3, a third opening is drilled in the casing 2 by rotating the machining bit 8 and moving the machining bit 8 in the direction 9 radial to the axial extension 5 for contacting an inner face of the casing 2, the bit 8 is retracted, and this process is repeated until the openings are made. In order to make further openings at a distance from the openings that were made first, the perforation tool system 1 is moved to a new position along the axial extension 5, and the process is repeated. In this way, several metres of perforated zone/section can be made in a predetermined pattern without the use of explosives as in the known perforation guns.

[0055] An axial actuator may be called a stroking tool, being a tool providing an axial force. The axial actuator/-stroking tool comprises an electric motor for driving a pump. The pump pumps fluid into a piston housing/cylinder 41 to move a reciprocating piston 40 acting therein. The piston 40 is arranged on the stoker shaft 25. The pump may pump fluid out of the piston housing/cylinder 41 on one side and simultaneously suck fluid in on the other side of the piston 40.

[0056] 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.

[0057] By "casing" or "well tubular metal structure" is meant any kind of pipe, tubing, tubular, liner, string, etc., used downhole in relation to oil or natural gas production.

[0058] In the event that the tool is not submersible all the way into the casing, a downhole tractor can be used to push the tool all the way into position in the well. The downhole tractor may have projectable arms having wheels, wherein the wheels contact the inner surface of the casing for propelling the tractor and the tool forward in the casing. A downhole tractor is any kind of driving tool capable of pushing or pulling tools in a well downhole, such as a Well Tractor®.

[0059] Although the invention has been described above in connection with preferred embodiments of the invention, it will be evident to 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 perforation tool system (1) for perforating a screen, a sliding sleeve or a casing wall of a casing (2) in a borehole (3) having a top, comprising:

- a first tool part (4) having an axial extension (5) and an anchoring section (6, 6A, 6B, 6C),
- a second tool part (7) adapted to rotate and move axially in relation to the first tool part, the second tool part comprising a machining bit (8) which is movable in a direction (9) radial to the axial extension,
- an axial actuator (10) comprised in the first tool part and comprising a shaft (25) for axially moving the second tool part in relation to the first tool part,
- a rotation unit (12) for rotating the second tool part in relation to the first tool part, and
- a first actuator (11) comprising an electric motor (11A) for rotating the bit,

characterised in that

the rotation unit comprises a sleeve (14) having a slot (18) engaging a pin (19) of the shaft, the slot comprising a first longitudinal slot part (18A), a second longitudinal slot part (18B) and a first guiding slot part (20, 20') connecting the first and second longitudinal slot parts.

2. A perforation tool system (1) according to claim 1, wherein the first longitudinal slot part (18A) has a first

part (51) and a second part (52), the first guiding slot part (20, 20') being connected to the first longitudinal slot part (18A) between the first part and the second part.

3. A perforation tool system (1) according to claim 2, wherein the second longitudinal slot part (18B) has a first part (53) and a second part (54), the guiding slot part (20) being connected to the second longitudinal slot part (18B) between the first part (53) and the second part (54).

4. A perforation tool system (1) according to claim 3, wherein the pin (19) is in a first position when the pin is arranged in the first part (51) of the first longitudinal slot part (18A), and the pin is in a second position when the pin is arranged in the first part (53) of the second longitudinal slot part (18B).

5. A perforation tool system (1) according to any of the preceding claims, wherein the first longitudinal slot part (18A) is displaced from the second longitudinal slot part (18B) along a circumference of a tool housing (37).

6. A perforation tool system (1) according to any of the preceding claims, wherein the slot comprises a second guiding slot part (20, 20") connecting the second longitudinal slot part (18B) with another first longitudinal slot part (18A).

7. A perforation tool system (1) according to any of the preceding claims, wherein the guiding slot part further comprises a first inclined slot part (20A), a second inclined slot part (20B) and an intermediate slot part (20C) connecting the first inclined slot part and the second inclined slot part.

8. A perforation tool system (1) according to claim 7, wherein the first inclined slot part (20A) is connected to the first longitudinal slot part (18A), and the second inclined slot part (20B) is connected to the second longitudinal slot part (18B).

9. A perforation tool system (1) according to any of the preceding claims, further comprising a driving unit, such as a downhole tractor.

10. A perforation method comprising:

- arranging the perforation tool system according to any of the preceding claims into a casing opposite the section to be perforated,
- drilling a first opening in the casing by rotating the machining bit (8) and moving the machining bit (8) in the direction (9) radial to the axial extension for contacting an inner face of the casing,

- retracting the bit,
- activating the axial actuator to move the shaft and the pin in a first direction along the slot from a first position (P1) to a second position (P2),
- drilling a second opening in the casing by rotating the machining bit (8) and moving the machining bit (8) in the direction (9) radial to the axial extension for contacting an inner face of the casing, and
- retracting the bit.

Patentansprüche

1. Perforationswerkzeugsystem (1) zum Perforieren eines Screens, einer Schiebehülse oder einer Verrohrungswand eines Bohrrohrs (2) in einem Bohrloch (3) mit einem oberen Ende, aufweisend:

- ein erstes Werkzeugteil (4) mit einer axialen Verlängerung (5) und einem Verankerungsabschnitt (6, 6A, 6B, 6C),
- ein zweites Werkzeugteil (7), das dazu ausgestaltet ist, sich in Bezug auf das erste Werkzeugteil zu rotieren und axial zu bewegen, wobei das zweite Werkzeugteil einen Bearbeitungseinsatz (8) aufweist, der in einer Richtung (9) radial zu der axialen Verlängerung beweglich ist,
- einen axialen Aktor (10), der in dem ersten Werkzeugteil enthalten ist und eine Welle (25) zum axialen Bewegen des zweiten Werkzeugteils in Bezug auf das erste Werkzeugteil aufweist,
- eine Rotationseinheit (12) zum Rotieren des zweiten Werkzeugteils in Bezug auf das erste Werkzeugteil, und
- einen ersten Aktor (11), der einen Elektromotor (11A) zum Rotieren des Einsatzes aufweist,

dadurch gekennzeichnet, dass

die Rotationseinheit eine Hülse (14) mit einem Schlitz (18), der in einen Stift (19) der Welle eingreift, aufweist, wobei der Schlitz einen ersten Längsschlitzteil (18A), einen zweiten Längsschlitzteil (18B) und einen ersten Führungsschlitzteil (20, 20') aufweist, der die ersten und zweiten Längsschlitzteile verbindet.

2. Perforationswerkzeugsystem (1) gemäß Anspruch 1, wobei der erste Längsschlitzteil (18A) einen ersten Teil (51) und einen zweiten Teil (52) hat, wobei der erste Führungsschlitzteil (20, 20') mit dem ersten Längsschlitzteil (18A) zwischen dem ersten Teil und dem zweiten Teil verbunden ist.
3. Perforationswerkzeugsystem (1) gemäß Anspruch 2, wobei der zweite Längsschlitzteil (18B) einen ersten Teil (53) und einen zweiten Teil (54) aufweist,

wobei der Führungsschlitzteil (20) mit dem zweiten Längsschlitzteil (18B) zwischen dem ersten Teil (53) und dem zweiten Teil (54) verbunden ist.

4. Perforationswerkzeugsystem (1) gemäß Anspruch 3, wobei der Stift (19) in einer ersten Position ist, wenn der Stift in dem ersten Teil (51) des ersten Längsschlitzteils (18A) angeordnet ist, und der Stift in einer zweiten Position ist, wenn der Stift in dem ersten Teil (53) des zweiten Längsschlitzteils (18B) angeordnet ist.

5. Perforationswerkzeugsystem (1) gemäß einem der vorstehenden Ansprüche, wobei der erste Längsschlitzteil (18A) gegenüber dem zweiten Längsschlitzteil (18B) entlang eines Umfangs eines Werkzeuggehäuses (37) versetzt ist.

6. Perforationswerkzeugsystem (1) gemäß einem der vorstehenden Ansprüche, wobei der Schlitz einen zweiten Führungsschlitzteil (20, 20") aufweist, der den zweiten Längsschlitzteil (18B) mit einem weiteren ersten Längsschlitzteil (18A) verbindet.

7. Perforationswerkzeugsystem (1) nach einem der vorstehenden Ansprüche, wobei der Führungsschlitzteil ferner einen ersten geneigten Schlitzteil (20A), einen zweiten geneigten Schlitzteil (20B) und einen Zwischenschlitzteil (20C) aufweist, der den ersten geneigten Schlitzteil und den zweiten geneigten Schlitzteil verbindet.

8. Perforationswerkzeugsystem (1) gemäß Anspruch 7, wobei der erste geneigte Schlitzteil (20A) mit dem ersten Längsschlitzteil (18A) verbunden ist und der zweite geneigte Schlitzteil (20B) mit dem zweiten Längsschlitzteil (18B) verbunden ist.

9. Perforationswerkzeugsystem (1) gemäß einem der vorstehenden Ansprüche, das ferner eine Antriebseinheit, wie z. B. einen Downhole-Traktor, aufweist.

10. Perforationsverfahren aufweisend:

- Anordnen des Perforationswerkzeugsystems nach einem der vorstehenden Ansprüche in einer Verrohrungswand gegenüber dem zu perforierenden Abschnitt,
- Bohren einer ersten Öffnung in die Verrohrungswand durch Rotieren des Bearbeitungseinsatzes (8) und Bewegen des Bearbeitungseinsatzes (8) in der Richtung (9) radial zur axialen Verlängerung, um eine Innenfläche der Verrohrungswand zu berühren,
- Zurückziehen des Einsatzes,
- Aktivieren des axialen Aktors, um die Welle und den Stift in einer ersten Richtung entlang des Schlitzes von einer ersten Position (P1) in eine

zweite Position (P2) zu bewegen,
 - Bohren einer zweiten Öffnung in die Verrohrungswand durch Rotieren des Bearbeitungseinsatzes (8) und Bewegen des Bearbeitungseinsatzes (8) in der Richtung (9) radial zur axialen Verlängerung, um eine Innenfläche der Verrohrungswand zu berühren, und
 - Zurückziehen des Einsatzes.

Revendications

1. Système d'outil de perforation (1) pour perforer un écran, un manchon coulissant ou une paroi de tubage d'un tubage (2) dans un trou de forage (3) ayant un sommet, comprenant :

- une première partie d'outil (4) ayant une extension axiale (5) et une section d'ancrage (6, 6A, 6B, 6C),
- une deuxième partie d'outil (7) adaptée pour tourner et se déplacer axialement par rapport à la première partie d'outil, la deuxième partie d'outil comprenant un trépan d'usinage (8) qui est mobile dans une direction (9) radiale par rapport à l'extension axiale,
- un actionneur axial (10) compris dans la première partie d'outil et comprenant un arbre (25) pour déplacer axialement la deuxième partie d'outil par rapport à la première partie d'outil,
- une unité de rotation (12) pour faire tourner la deuxième partie d'outil par rapport à la première partie d'outil, et
- un premier actionneur (11) comprenant un moteur électrique (11A) pour faire tourner le trépan, **caractérisé en ce que**

l'unité de rotation comprend un manchon (14) ayant une fente (18) en prise avec une broche (19) de l'arbre, la fente comprenant une première partie de fente longitudinale (18A), une deuxième partie de fente longitudinale (18B) et une première partie de fente de guidage (20, 20') reliant les première et deuxième parties de fente longitudinale.

2. Système d'outil de perforation (1) selon la revendication 1, dans lequel la première partie de fente longitudinale (18A) a une première partie (51) et une deuxième partie (52), la première partie de fente de guidage (20, 20') étant reliée à la première partie de fente longitudinale (18A) entre la première partie et la deuxième partie.
3. Système d'outil de perforation (1) selon la revendication 2, dans lequel la deuxième partie de fente longitudinale (18B) a une première partie (53) et une deuxième partie (54), la partie de fente de guidage (20) étant reliée à la deuxième partie de fente longi-

tudinale (18B) entre la première partie (53) et la deuxième partie (54).

4. Système d'outil de perforation (1) selon la revendication 3, dans lequel la broche (19) est dans une première position lorsque la broche est disposée dans la première partie (51) de la première partie de fente longitudinale (18A), et la broche est dans une deuxième position lorsque la broche est disposée dans la première partie (53) de la deuxième partie de fente longitudinale (18B).

5. Système d'outil de perforation (1) selon l'une quelconque des revendications précédentes, dans lequel la première partie de fente longitudinale (18A) est déplacée de la deuxième partie de fente longitudinale (18B) le long d'une circonférence d'un boîtier d'outil (37).

6. Système d'outil de perforation (1) selon l'une quelconque des revendications précédentes, dans lequel la fente comprend une deuxième partie de fente de guidage (20, 20") reliant la deuxième partie de fente longitudinale (18B) à une autre première partie de fente longitudinale (18A).

7. Système d'outil de perforation (1) selon l'une quelconque des revendications précédentes, dans lequel la partie de fente de guidage comprend en outre une première partie de fente inclinée (20A), une deuxième partie de fente inclinée (20B) et une partie de fente intermédiaire (20C) reliant la première partie de fente inclinée et la deuxième partie de fente inclinée.

8. Système d'outil de perforation (1) selon la revendication 7, dans lequel la première partie de fente inclinée (20A) est reliée à la première partie de fente longitudinale (18A), et la deuxième partie de fente inclinée (20B) est reliée à la deuxième partie de fente longitudinale (18B).

9. Système d'outil de perforation (1) selon l'une quelconque des revendications précédentes, comprenant en outre une unité d'entraînement, telle qu'un tracteur de fond de trou.

10. Procédé de perforation comprenant les étapes consistant à :

- disposer le système d'outil de perforation selon l'une quelconque des revendications précédentes dans un tubage opposé à la section à perforer,
- percer une première ouverture dans le tubage en faisant tourner le trépan d'usinage (8) et en déplaçant le trépan d'usinage (8) dans la direction (9) radiale à l'extension axiale pour entrer en

contact avec une face intérieure du tubage,

- rétracter le trépan,

- activer l'actionneur axial pour déplacer l'arbre
et la broche dans une première direction le long
de la fente, d'une première position (P1) à une
deuxième position (P2), 5

- percer une deuxième ouverture dans le tubage
en faisant tourner le trépan d'usinage (8) et en
déplaçant le trépan d'usinage (8) dans la direc-
tion (9) radiale à l'extension axiale pour entrer en
contact avec une face intérieure du tubage, et 10
- rétracter le trépan.

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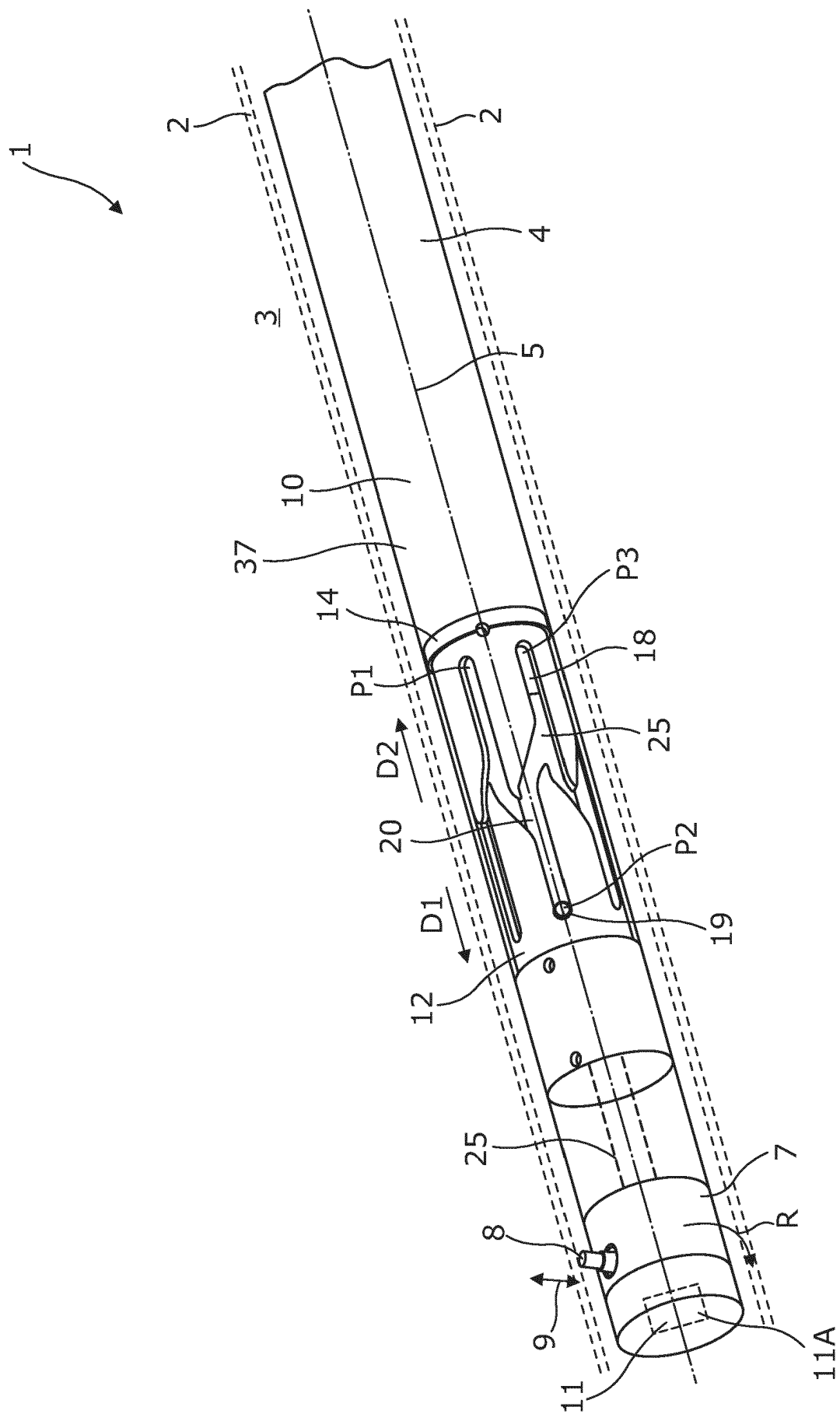


Fig. 1

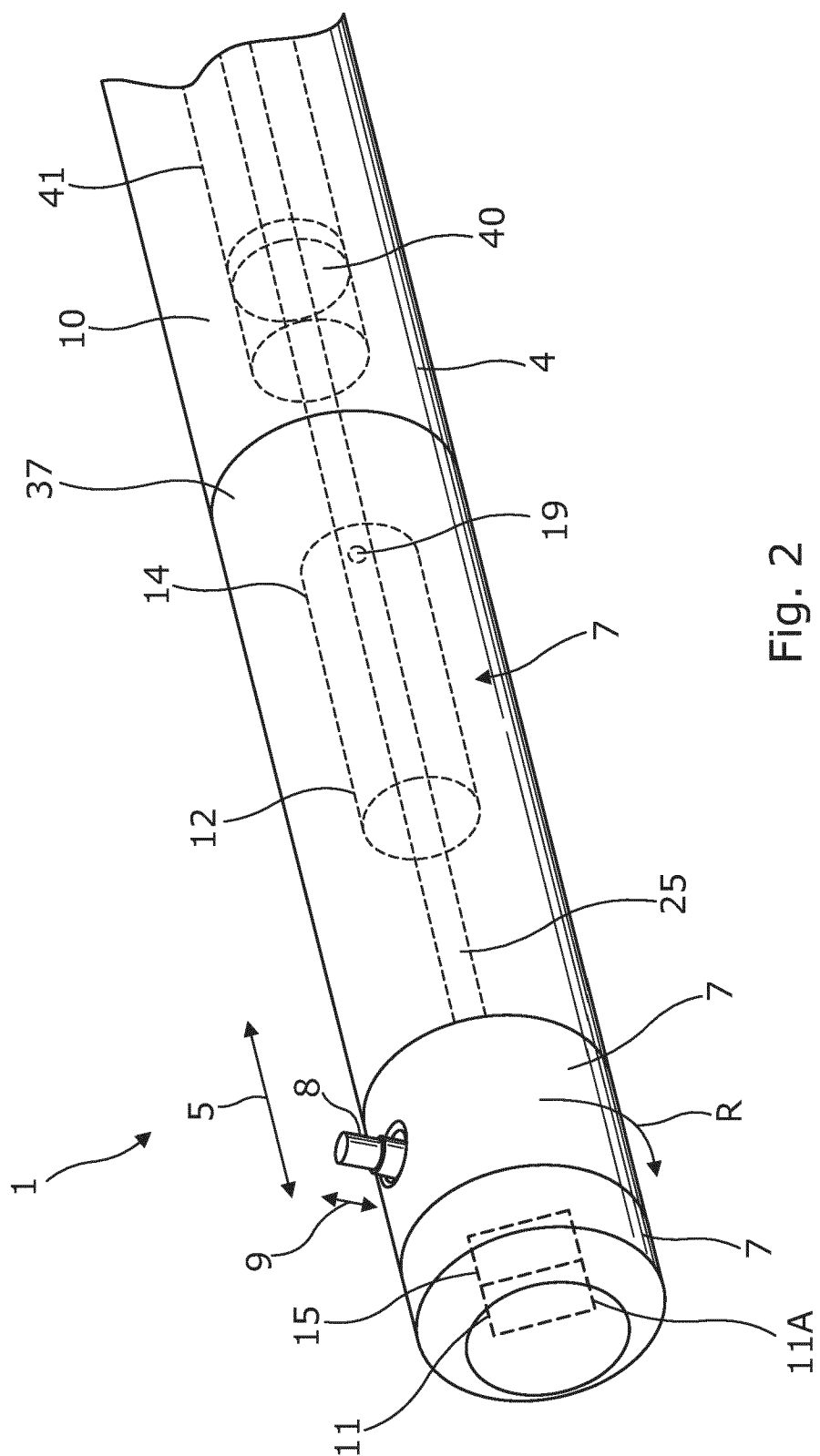


Fig. 2

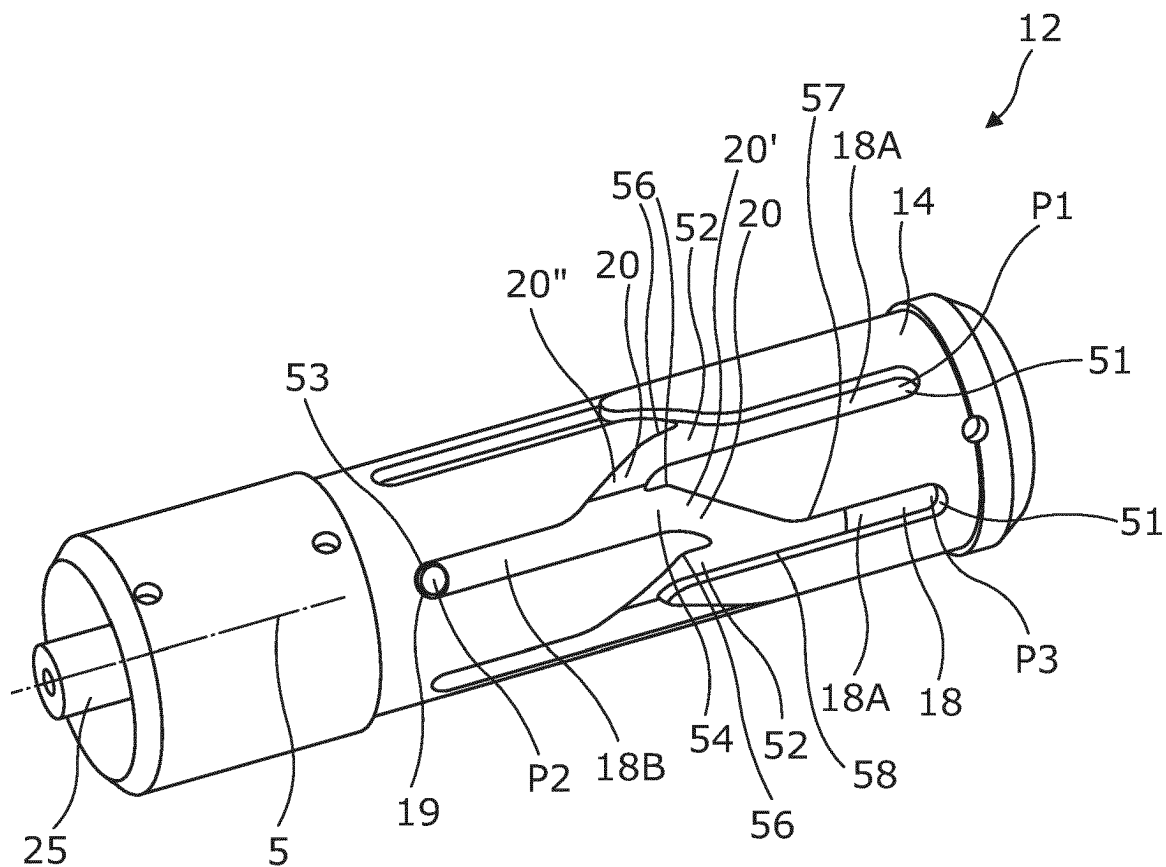


Fig. 3

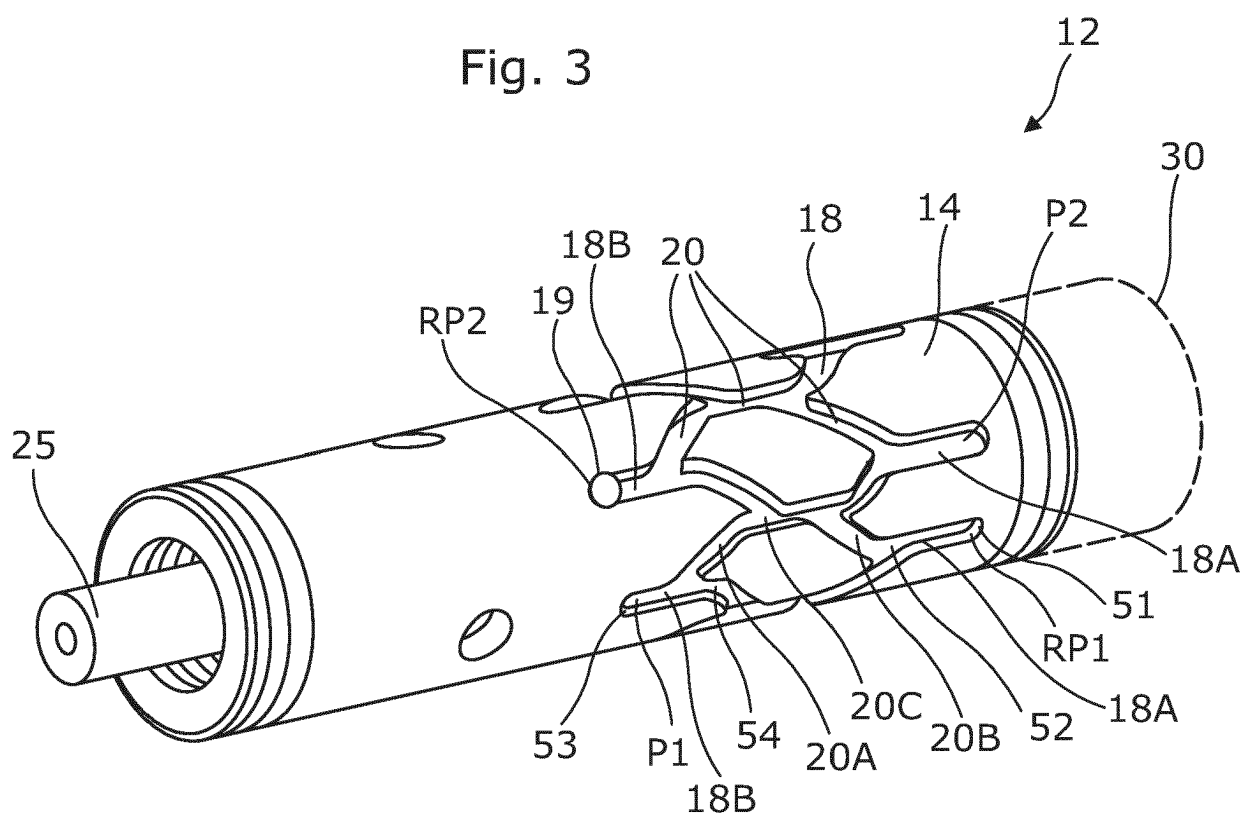
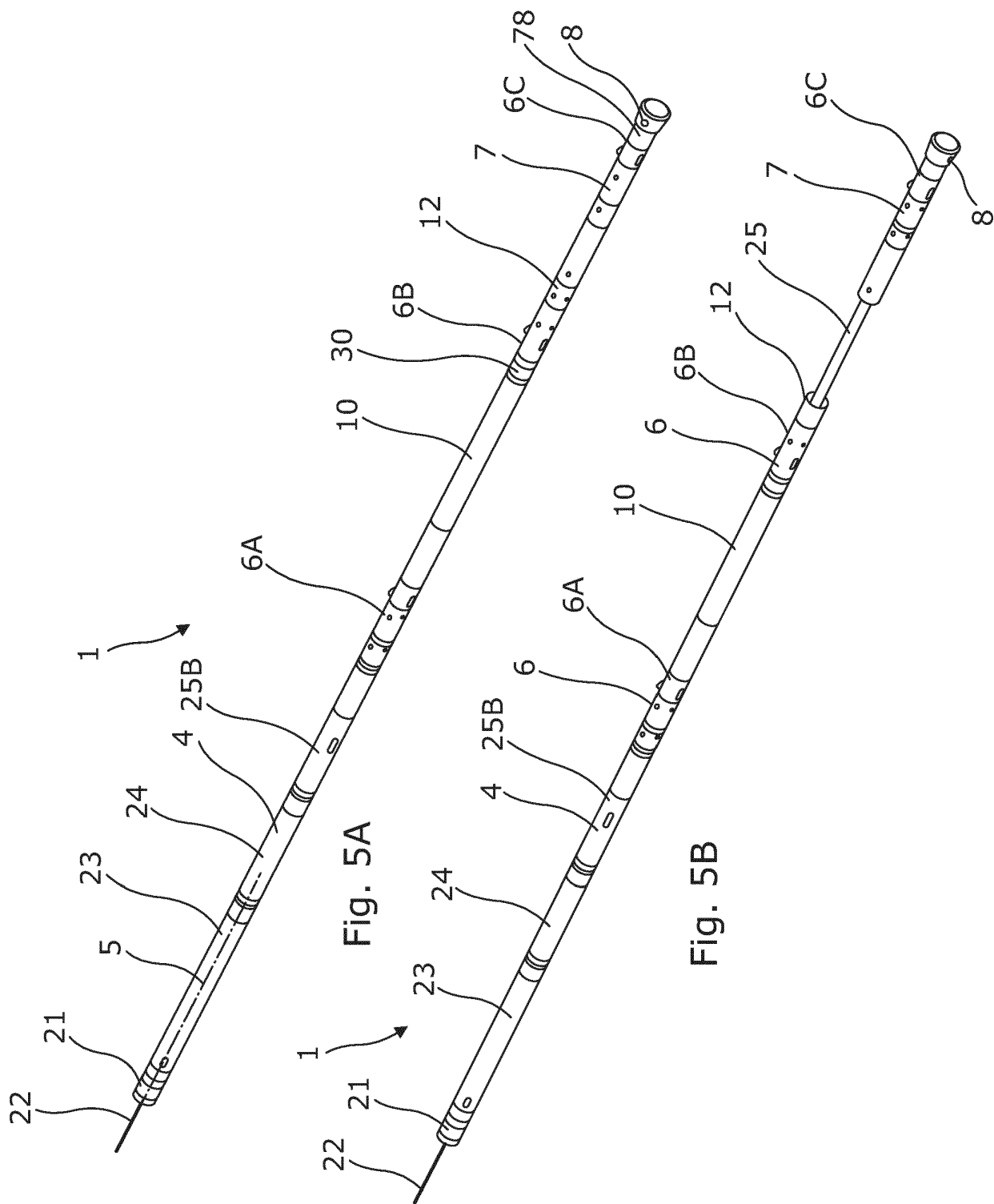


Fig. 4



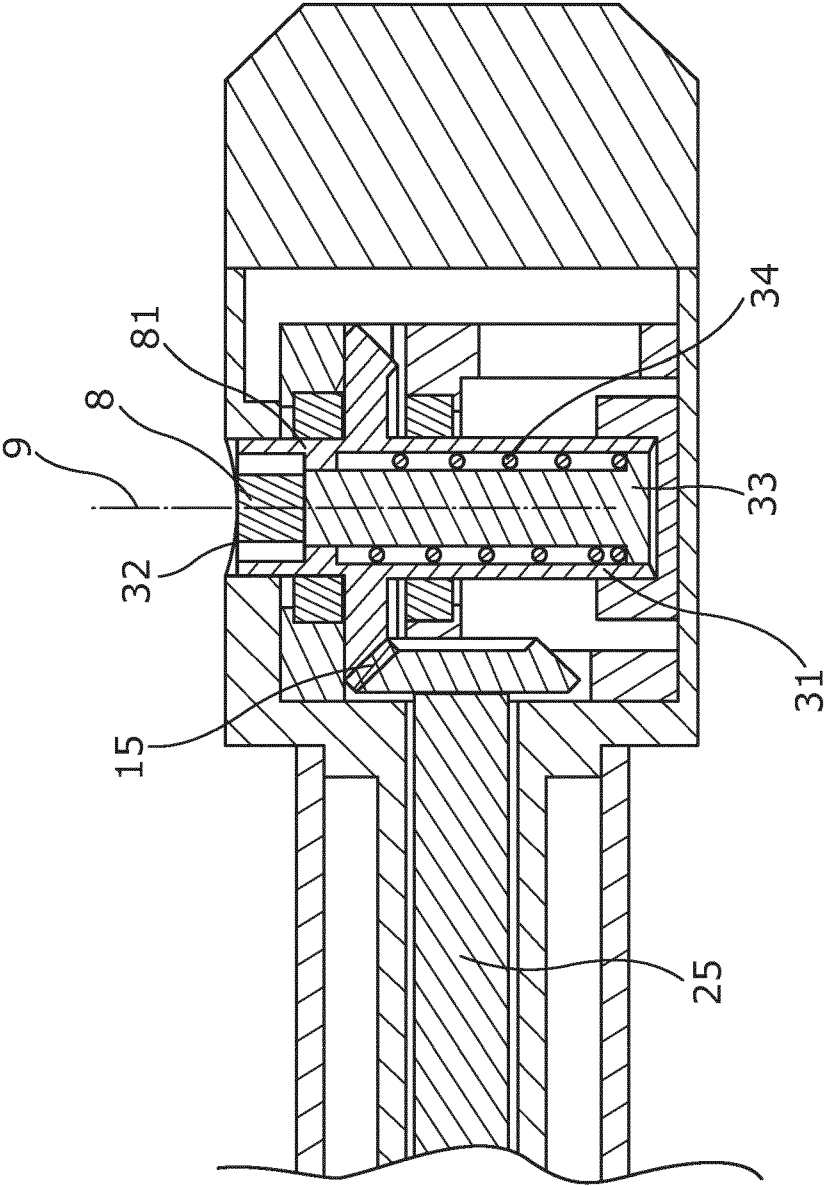


Fig. 6

REFERENCES CITED IN THE DESCRIPTION

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