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(54) **Title:** DOWNHOLE WIRELINE TOOL

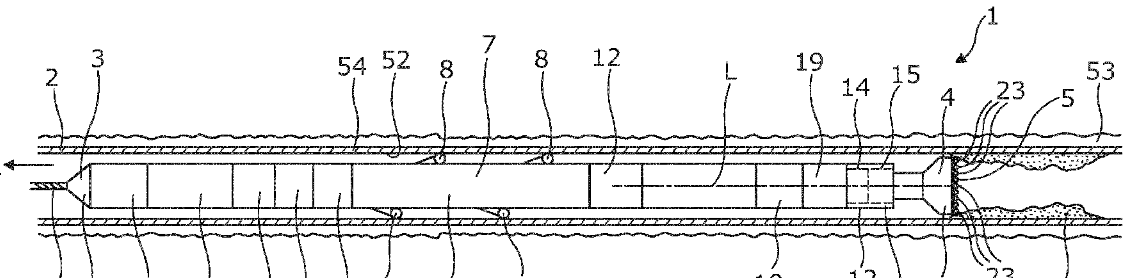

Fig. 1

(57) **Abstract:** The present invention relates to a downhole wireline tool (1) for performing a machining operation, such as milling, in a well having a top, the downhole wireline tool having a longitudinal axis, a first end configured to be connected to a wireline and a second end forming a front of the tool facing away from the wireline along the longitudinal axis, the downhole wireline tool comprising a tool housing (12), a holding section (7) having projectable parts configured to prevent a part of the downhole wireline tool from moving in a direction towards the top, a machining tool (9) arranged in the front of the tool, and a rotation unit (10) for rotating the machining tool, wherein the downhole wireline tool further comprises an oscillation device (11) having a rotational stationary part (14) being connected with the rotation unit and a rotational part (15) being connected to the machining tool, the oscillation device being configured to provide an oscillating movement of the machining tool by oscillating the rotational part in relation to the rotational stationary part.

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DOWNHOLE WIRELINE TOOL

Description

The present invention relates to a downhole wireline tool for performing a machining operation, such as milling, in a well having a top, the downhole wireline tool having a longitudinal axis, a first end configured to be connected to a wireline and a second end forming a front of the tool facing away from the wireline along the longitudinal axis.

When performing wireline operations, power for performing the operation is very limited compared to coiled tubing and drill pipe operations; however, the total time spent on the operation is at least reduced by half compared to coiled tubing and drill pipe operations. Wireline tools are therefore not able to drill through formations for drilling boreholes, but some less power-demanding operations may, after completing the well, be performed by intervening the well on wireline. However, some interventions may take too much time as higher operating speed is too power-demanding to be performed on wireline. One of such operations may be removing a cement plug or very hard scale inside the well tubular metal structure.

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 downhole wireline tool which is able to also perform removal of cement or hard scale blocking the well tubular metal structure in a well.

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 downhole wireline tool for performing a machining operation, such as milling, in a well having a top, the downhole wireline tool having a longitudinal axis, a first end configured to be connected to a wireline and a second end forming a front of the tool facing away from the wireline along the longitudinal axis, the downhole wireline tool comprising:

- a tool housing,
- a holding section having projectable parts configured to prevent a part of the downhole wireline tool from moving in a direction towards the top,
- a machining tool arranged in the front of the tool, and
- a rotation unit for rotating the machining tool,

wherein the downhole wireline tool further comprises an oscillation device having a rotational stationary part being connected with the rotation unit and a rotational part being connected to the machining tool, the oscillation device being configured to provide an oscillating movement of the machining tool by oscillating the rotational part in relation to the rotational stationary part.

By "rotational stationary part" is meant a part which is at least rotational stationary. The rotational stationary part provides rotation of the rotational part, and the oscillating movement of the machining tool is occurring by a movement of either the rotational stationary part or the rotational part along the longitudinal axis. Thus, the rotational stationary part is stationary in relation to rotation, but may be moving in the axial direction along the longitudinal axis of the downhole wireline tool.

Another solution is a downhole wireline tool for performing a machining operation, such as milling, in a well having a top, the downhole wireline tool having a longitudinal axis, a first end configured to be connected to a wireline and a second end forming a front of the tool facing away from the wireline along the longitudinal axis, the downhole wireline tool comprising:

- a tool housing,
- a holding section having projectable parts configured to prevent a part of the downhole wireline tool from moving in a direction towards the top,
- a machining tool arranged in the front of the tool, and
- a rotation unit for rotating the machining tool,

wherein the downhole wireline tool further comprises an oscillation device having a rotational stationary part being connected with the rotation unit and a rotational part being connected to the machining tool, the oscillation device being configured to provide an oscillating movement of the machining tool by oscillating the rotational part in relation to the rotational stationary part, and wherein the rotational stationary part and the rotational part of the oscillation device have serrations providing the oscillating movement.

Moreover, the oscillation device may be a mechanical oscillation device.

In addition, the rotational stationary part and/or the rotational part of the oscillation device may have serrations providing the oscillating movement.

The rotational stationary part and the rotational part of the oscillation device may both have serrations providing the oscillating movement, and this provides the technical effect that the protruding parts of the hammer (rotational part) surface are less prone to breakage since the force is evenly spread out across the inclined surface of the serrations. Along with this, there is also a reduced risk of the central axis of the anvil part and the central axis of the hammer part being dislocated relative to each other due to the hammer punches jumping out of place. Thus, the fact that both the rotational stationary part and the rotational part of the oscillation device have serrations providing the oscillating movement results in an ability to rotate the machining tool at a higher operating speed and thereby an ability to drill more efficiently.

In one embodiment, the rotational stationary part is arranged closest to the holding section, and the rotational part is arranged closest to the machining tool.

In another embodiment, the rotational stationary part is arranged closest to the machining tool, and the rotational part is arranged closest to the holding section.

Furthermore, the rotational stationary part has a first end face abutting a second end face of the rotational part of the oscillation device, the first end face and/or the second end face having serrations.

Also, the first end face or the second end face may have serrations, the other of the first end face and the second end face having a cooperating part.

Additionally, the cooperating part(s) may be spike(s), projection(s) or the like.

Further, the serrations may have a serration height of less than 5 mm along the longitudinal axis, preferably less than 2.5 mm.

Moreover, the serration height may extend along a longitudinal axis.

In addition, the serrations may have a triangular shape with an inclining face and a right face extending along the longitudinal axis.

Also, the serrations may have a round point or end in a flat face forming a trapezoid shape, i.e. Isosceles Trapezium, which is a triangular shape without the point.

Further, the oscillation device may be arranged in the tool housing.

Also, the machining tool may comprise bits for cutting or milling through scale or cement at least partly blocking the well.

Additionally, the present invention may further comprise a rotational member or shaft driven by the rotation unit, the rotational member extending at least through the rotational stationary part of the oscillation device.

Moreover, the present invention may further comprise a rotational member or shaft driven by the rotation unit, the rotational member extending at least through the rotational part and/or the rotational stationary part of the oscillation device.

Furthermore, the rotational member may comprise cooperating shafts transferring rotation from the rotation unit to rotation of the machining part.

In addition, the rotational member may comprise a first shaft part and a second shaft part connected via a coupling.

Furthermore, the coupling may transfer rotation from the first shaft part to the second shaft part and may allow an axial slidable movement of the shaft parts.

The present invention may also further comprise the gearing unit arranged between the rotation unit and the machining tool.

In addition, the holding section may be configured to provide an axial force along the longitudinal axis away from the top.

Additionally, the downhole wireline tool may further comprise the holding section being a rolling anchor.

Also, the downhole wireline tool may further comprise a stroking tool providing an axial force along the longitudinal axis in relation to the holding section.

Finally, the holding section may be a stationary anchor configured to anchor the downhole wireline tool along the longitudinal axis when the projectable parts are in a projected state engaging a wall of a borehole or a well tubular metal structure.

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 side view of a downhole wireline tool having a machining tool and an oscillation device for removing scale partly blocking the inside of the well tubular metal structure,

Fig. 2 shows a side view of another downhole wireline tool having a machining tool and an oscillation device for removing cement fully blocking the inside of the well tubular metal structure,

Fig. 3 shows a perspective of part of a downhole wireline tool having a machining tool and an oscillation device,

Fig. 4 shows an illustration of part of an oscillation device having a rotational part in relation to a rotational stationary part of the oscillation device, and

Fig. 5 shows an illustration of part of another oscillation device having a rotational part in relation to a rotational stationary part of the oscillation device.

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.

Fig. 1 shows a downhole wireline tool 1 for performing a machining operation in a well 2 having a top 51. The machining operation is milling or a similar low-power machining operation for milling or cutting into scale 38 or cement 39 (shown in Fig. 2) fastened in a well tubular metal structure 54 in the well. The downhole wireline tool 1 has a longitudinal axis L, a first end 3 configured to be connected to a wireline 6 and a second end 4 forming a front 5 of the tool facing away from the wireline 6 along the longitudinal axis. The downhole wireline tool 1 comprises a tool housing 12 and a holding section 7 having projectable parts 8 configured to prevent a part of the downhole wireline tool from moving in a direction towards the top 51 and prevent the holding section from rotating. The downhole wireline tool 1 comprises a machining tool 9 arranged in the front of the tool and a rotation unit 10 for rotating the machining tool. The downhole wireline tool 1 further comprises an oscillation device 11 having a rotational stationary part 14 being connected with the rotation unit 10 and a rotational part 15 being connected to the machining tool 9, and the oscillation device 11 is configured to provide an oscillating movement of the machining tool 9 by oscillating the rotational part 15 in relation to the rotational stationary part 14.

By having the downhole wireline tool 1 with the holding section 7 for preventing the downhole wireline tool from moving upwards while the machining tool 9 performs the operation, the oscillating movement generated in the oscillation device 11 is transferred fully to the machining tool 9. In that way, the oscillating movement is not scattered to the entire downhole wireline tool 1 and thereby partly wasted, but instead focussed on the machining process only. Known tools use vibration for releasing a tool string in the well, where the purpose is for the vibration to be distributed to the whole tool string, which is the opposite purpose of the present invention, where the oscillating movement is to be fully transferred to the machining tool.

The downhole wireline tool 1 comprises a cable head 31 for connection to the wireline 6, an electric control unit 32, a compensator 33 for maintaining a predetermined overpressure inside the tool 1, an electric motor 34 driving a pump 35 and a hydraulic section 36 for distribution of the pressurised fluid from the pump. In Fig. 1, the holding section 7 comprises a rolling anchor 27 in the form of a downhole self-propelling unit, such as a downhole tractor, having the projectable parts 8 being wheels on projectable wheel arms. The downhole self-propelling unit may be a hydraulic-driven downhole self-propelling unit. The holding section 7 comprising the rolling anchor 27 is configured to provide an axial force, also called weight on bit 23 of the machining tool 9, along the longitudinal axis away from the top 51, while preventing the downhole wireline tool 1 from moving towards the top during the oscillating movement and thus preventing the oscillating movement from being scattered to the other parts of the downhole wireline tool 1. The hydraulic pump 35 generates fluid for projecting the arms and a separate fluid for rotating the wheels. The wheels may also be rotated by an electric motor in each wheel. The downhole wireline tool 1 further comprises a gearing unit 19 arranged between the rotation unit 10 and the machining tool 9 and being pressure-compensated by a second compensator 33b.

The oscillation device 11 is a mechanical oscillation device arranged inside the tool housing 12 so that it is protected from the well fluid. The oscillation device 11 may be operated close to a natural frequency of the tool 1 so that when the oscillating force is applied at a resonant frequency of the tool, the machining tool 9 will oscillate at a higher amplitude than when the same force is applied at other, non-resonant frequencies. The machining tool 9 comprises the bits 23 for cutting or milling through non-metallic material, such as the scale 38 or the cement 39, at least partly blocking the well. The machining tool 9 may also comprise abrasive inserts instead of bits. The machining tool 9 comprises a rotational member 18, such as one or more shaft(s), driven by the rotation unit 10, and the rotational member 18 extends at least through the rotational stationary part 14 of the oscillation device 11. The rotational member 18 comprises cooperating shafts transferring rotation from the rotation unit 10 to rotation of the machining tool 9 via the gearing unit 19. By having the rotational member 18 extending through the rotational stationary part 14 of the oscillation device 11, the oscillation device can easily be arranged inside the tool housing 12 and be protected from the "dirty" well fluid. Furthermore, the oscillation device 11 can be made in a very simple design which is easily integrated into the tool 1.

In Fig. 2, the downhole wireline tool 1 further comprises a stroking tool 28 providing an axial force along the longitudinal axis L in relation to the holding section 7 and thus being configured to provide an axial force, also called weight on bit 23 of the machining tool 9, along the longitudinal axis L away from the top 51. The holding section 7 is a stationary anchor 29 configured to anchor the main part of the downhole wireline tool 1 along the longitudinal axis L when the projectable parts 8 are in a projected state, engaging a wall 52 of a borehole 53 or a well tubular metal structure 54. The machining tool 9 is still free to oscillate along the longitudinal axis L in relation to the holding section 7, enhancing the machining operation. In Fig. 2, the machining tool 9 is oscillated during cutting into a cement plug 39 fully blocking the well tubular metal structure 54.

In Fig. 3, part of the downhole wireline tool 1 is shown disclosing the rotational stationary part 14, the rotational part 15 of the oscillation device 11 having serrations 16 providing the oscillating movement when the rotational part 15 is rotated with the rotation of the machining tool 9. In Fig. 3, both the rotational stationary part 14 and the rotational part 15 of the oscillation device 11 have the serrations 16, which provides the technical effect that the protruding parts of the surface of the hammer, i.e. the rotational part in cooperation with the rotational stationary part, are less prone to breakage since the force is evenly spread out across the inclined surface of the serrations. Along with this, there is also a reduced risk of the central axis of the anvil part, i.e. the rotational stationary part 14, and the central axis of the hammer part, i.e. the rotational part 15, being dislocated relative to each other despite the hammering punches being off-centre. Thus, the fact that both the stationary part 14 and the rotational part 15 of the oscillation device 11 have the serrations 16 providing the oscillating movement results in an ability to rotate the machining tool 9 at a higher operating speed and thereby an ability to machine more efficiently. The rotational stationary part 14 is held stationary by the holding section 7. As indicated by dotted lines, the rotational member 18, such as a shaft, driven by the rotation unit 10 extends through the rotational stationary part 14 of the oscillation device 11 and is connected with the rotational part 15 for rotating itself and the machining tool 9. The rotational stationary part 14 has a first end face 21 abutting a second end face 22 of the rotational part 15 of the oscillation device 11, and the first end face and the second end face have the serrations 16. The serrations 16 have a serration height h of less than 5 mm along the longitudinal axis L, preferably less than 2.5 mm, and the serration height extends along the longitudinal axis L. The oscillating movement will thus correspond to the serration height h, which will thus preferably be less than 5 mm. As shown in Fig. 4, the serrations 16 have a triangular shape 24 with an inclining face 25 and a right face 26 extending along the longitudinal axis L.

The rotational member 18, such as a shaft, driven by the rotation unit 10 extends through the rotational stationary part 14 of the oscillation device 11 and is connected with the rotational part 15 for rotating itself and the machining tool 9 via a coupling (not shown). The rotational member 18, such as a shaft, is thus a two-part shaft, where a first shaft part 41 and a second shaft part 42 are connected via a coupling 43 so that one of the parts of the shaft is able to move in relation to the other part along the longitudinal axis L of the wireline tool 1 as a result of which the first shaft part 41 connected to the machining tool 9 can move in relation to the second shaft part 42 along the longitudinal axis L of the wireline tool. In this way, the rotational part 15 is connected to the first shaft part 41 and can move along the longitudinal axis L of the wireline tool 1 as the rotational part 15 is rotated in relation to the rotational stationary part 14, resulting in the oscillating movement of the machining tool 9. Thereby, the rotational member 18 in the form of a shaft is able to rotate the oscillating machining tool 9 in a very reliable way.

The rotational stationary part 14 may be connected to the tool housing 12 by means of pins, screws or the like in order to fixedly fasten the rotational stationary part to the tool housing. Even though not shown, the serrations 16 may have a round point or end in a flat face appearing as if the top has been cut off; thus the flat faces of the serrations of the rotational part 15 face the flat faces of the serrations of the rotational stationary part 14.

In Figs. 1-3, the rotational stationary part 14 is arranged closest to the holding section 7, and the rotational part 15 is arranged closest to the machining tool 9. However, the rotational stationary part 14 may also be arranged closest to the machining tool 9, and the rotational part 15 may be arranged closest to the holding section 7; a bearing is arranged between the rotational stationary part and the rotational member, where the rotational member is connected to the machining tool.

The oscillation device 11 is fully comprised inside the tool housing 12, indicated by a dotted line, and the tool housing provides a seal around a shaft 37 of the machining tool 9. Thus, the oscillation device 11 can also be pressure-compensated by means of the second compensator 33b. Even though not shown, the machining tool 9 may have a centre bore extending from the front face at least partly into the machining tool, and inside the bore a fastening element may be arranged for fastening the cut-out part of the cement plug and bringing it to surface.

In Fig. 5, the second end face 22 of the rotational part 15 has the serrations 16, and the end of the rotational stationary part 14 has cooperating parts 17 in the form of radially extending spike(s), projection(s) or similar extensions. In another embodiment, the first end face 21 has the serrations 16, and the second end face 22 or the second end of the rotational part 15 has cooperating parts 17 in the form of radially extending spike(s), projection(s) or similar extensions. The radially extending cooperating parts 17 can be used to control the oscillating movement by engaging a groove in the tool housing 12.

A stroking tool is a tool providing an axial force. The stroking tool comprises an electric motor for driving a pump. The pump pumps fluid into a piston housing to move a piston acting therein. The piston is arranged on the stroker shaft. The pump may pump fluid out of the piston housing on one side and simultaneously suck fluid in on the other side of the piston.

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.

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.

In the event that the tool is not submergible all the way into the casing, a downhole self-propelling unit, such as 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®.

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 downhole wireline tool (1) for performing a machining operation, such as milling, in a well (2) having a top (51), the downhole wireline tool having a longitudinal axis (L), a first end (3) configured to be connected to a wireline (6) and a second end (4) forming a front (5) of the tool facing away from the wireline along the longitudinal axis, the downhole wireline tool comprising:
- a tool housing (12),
- a holding section (7) having projectable parts (8) configured to prevent a part of the downhole wireline tool from moving in a direction towards the top,
- a machining tool (9) arranged in the front of the tool, and
- a rotation unit (10) for rotating the machining tool,
wherein the downhole wireline tool further comprises an oscillation device (11) having a rotational stationary part (14) being connected with the rotation unit and a rotational part (15) being connected to the machining tool, the oscillation device being configured to provide an oscillating movement of the machining tool by oscillating the rotational part in relation to the rotational stationary part, and wherein the rotational stationary part and the rotational part of the oscillation device have serrations (16) providing the oscillating movement.

2. A downhole wireline tool according to claim 1, wherein the oscillation device is a mechanical oscillation device.

3. A downhole wireline tool according to claim 1 or 2, wherein the rotational stationary part has a first end face (21) abutting a second end face (22) of the rotational part of the oscillation device, the first end face and/or the second end face having the serrations.

4. A downhole wireline tool according to claim 3, wherein the first end face or the second end face has serrations, and the other of the first end face and the second end face has a cooperating part (17).

5. A downhole wireline tool according to any of the preceding claims, wherein the serrations have a serration height (h) of less than 5 mm along the longitudinal axis, preferably less than 2.5 mm.

6. A downhole wireline tool according to any of the preceding claims, wherein the serrations have a triangular shape (24) with an inclining face (25) and a right face (26) extending along the longitudinal axis.

7. A downhole wireline tool according to any of the preceding claims, wherein the oscillation device is arranged in the tool housing.

8. A downhole wireline tool according to any of the preceding claims, wherein the machining tool comprises bits (23) for cutting or milling through scale or cement at least partly blocking the well.

9. A downhole wireline tool according to any of the preceding claims, further comprising a rotational member (18) driven by the rotation unit, the rotational member extending at least through the rotational stationary part of the oscillation device.

10. A downhole wireline tool according to claim 9, wherein the rotational member comprises a first shaft part (41) and a second shaft part (42) connected via a coupling (43).

11. A downhole wireline tool according to any of the preceding claims, further comprising a gearing unit (19) arranged between the rotation unit and the machining tool.

12. A downhole wireline tool according to any of the preceding claims, the holding section being configured to provide an axial force along the longitudinal axis away from the top.

13. A downhole wireline tool according to any of the preceding claims, further comprising the holding section being a rolling anchor (27).

14. A downhole wireline tool according to any of the preceding claims, further comprising a stroking tool (28) providing an axial force along the longitudinal axis in relation to the holding section.

15. A downhole wireline tool according to any of the preceding claims, wherein the holding section is a stationary anchor (29) configured to anchor the downhole

wireline tool along the longitudinal axis when the projectable parts are in a projected state engaging a wall (52) of a borehole (53) or a well tubular metal structure (54).

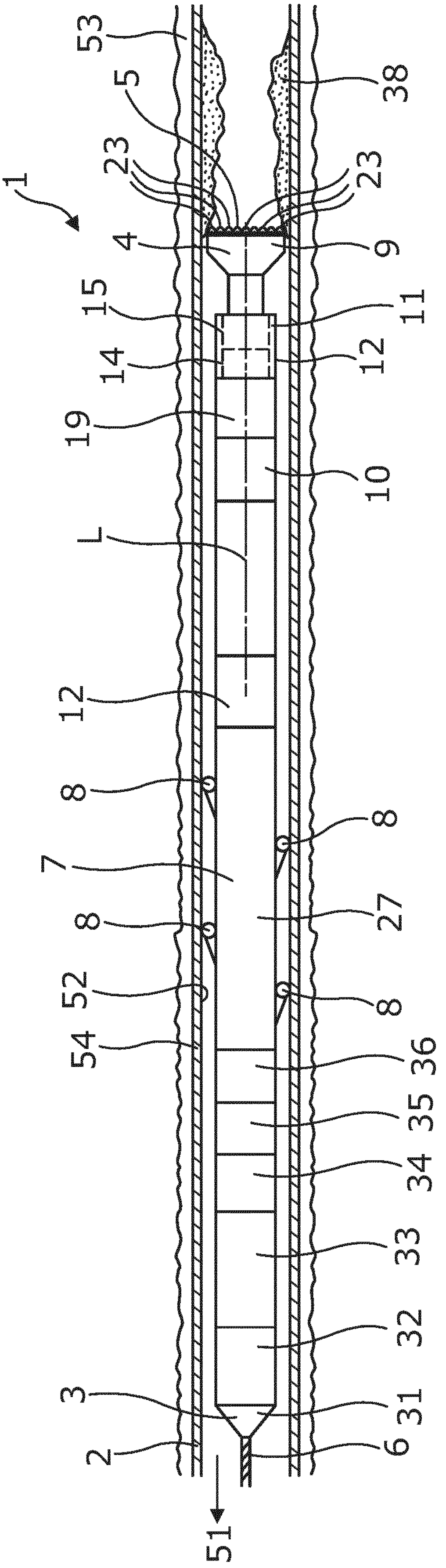
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Fig. 1

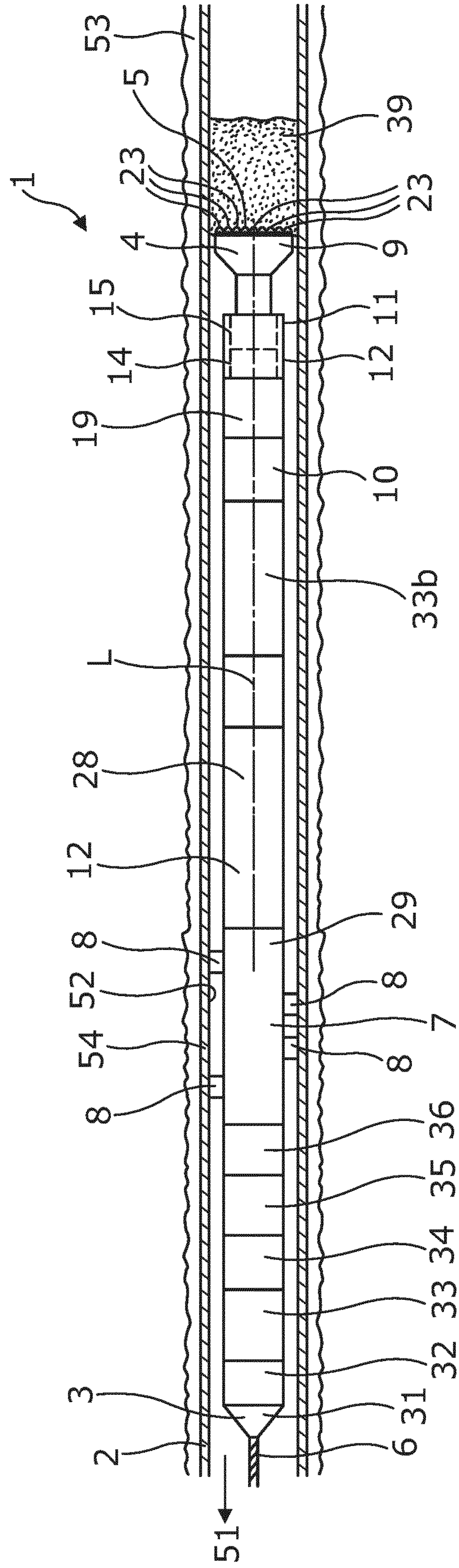
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Fig. 2

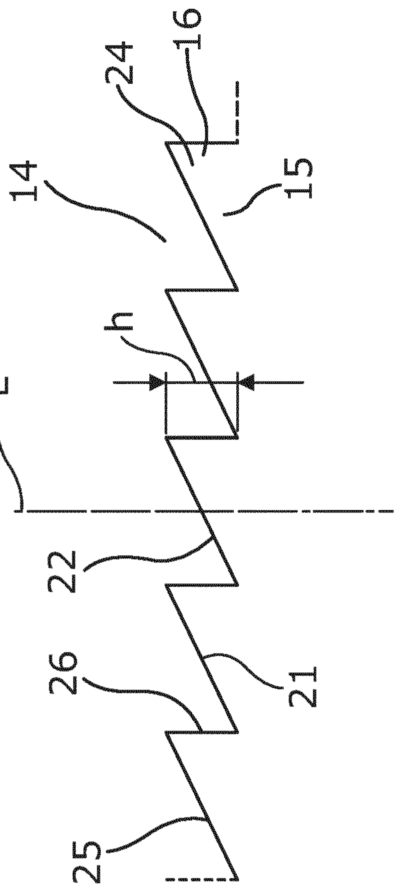

Fig. 4

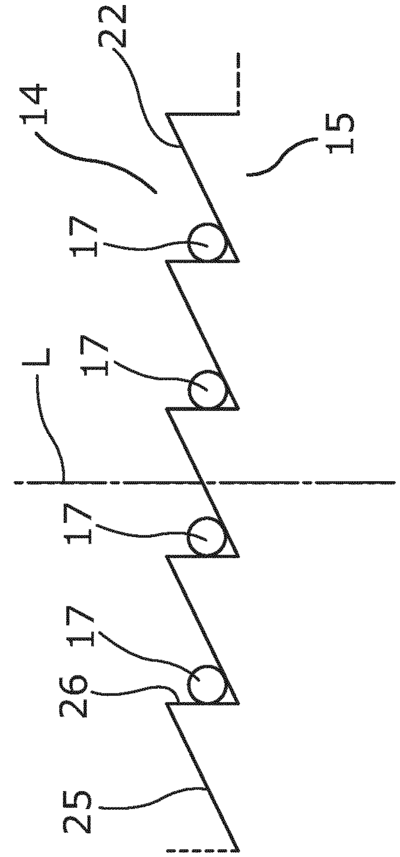

Fig. 5

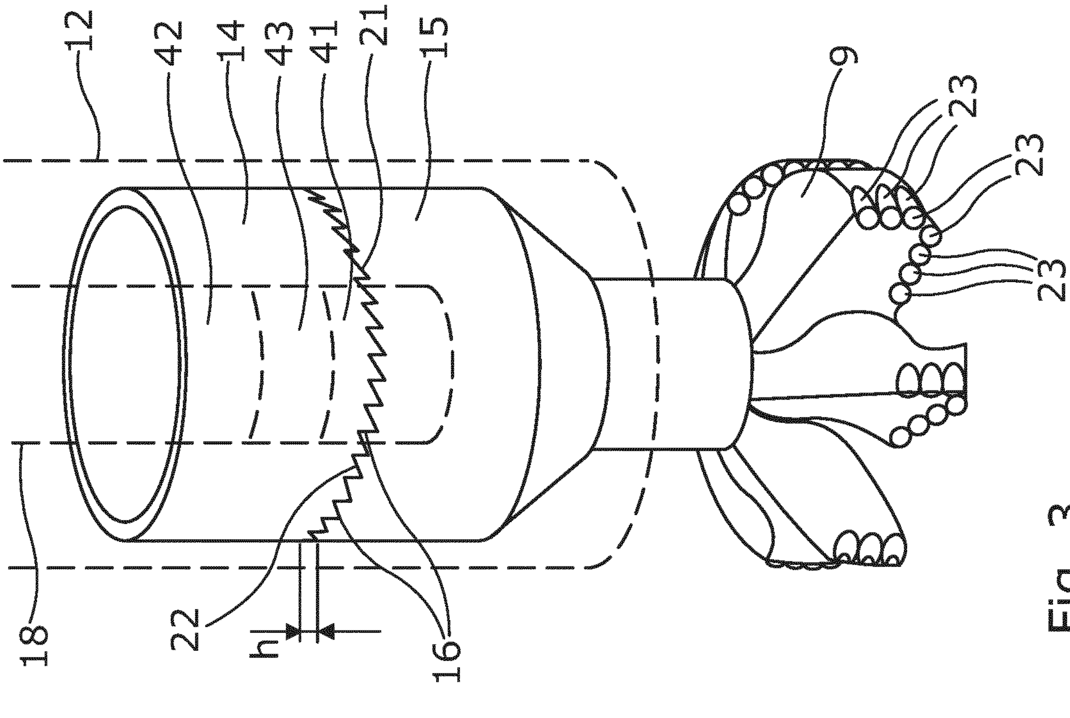

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2022/084825

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B4/10 E21B23/00 E21B23/01 E21B23/04 E21B23/14
E21B29/00 E21B37/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 10 415 314 B2 (HALLIBURTON ENERGY SERVICES INC [US]) 17 September 2019 (2019-09-17)	1-13,15
Y	figure 8	14
Y	US 3 180 437 A (KELLNER JACKSON M ET AL) 27 April 1965 (1965-04-27) figure 1b	14
A	US 2 120 240 A (CHAPPELL JAMES F) 14 June 1938 (1938-06-14) column 3, line 60 - line 64	1-15
A	WO 00/75476 A1 (SHELL INT RESEARCH [NL]; SHELL CANADA LTD [CA]) 14 December 2000 (2000-12-14) the whole document	1-15
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[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
30 January 2023	09/02/2023

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