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(54) A DOWNHOLE COMPLETION SYSTEM

(57) The present invention relates to a downhole completion system for charging a device outside a well tubular metal structure. The downhole completion system comprises the well tubular metal structure having an inner and an outer face and a centre axis; a power receiving unit arranged outside the well tubular metal structure, comprising an inductive coil having windings around a coil axis; and a power consuming device arranged outside the well tubular metal structure, configured to receive power from the power receiving unit. The coil axis is parallel or coincident with the centre axis.

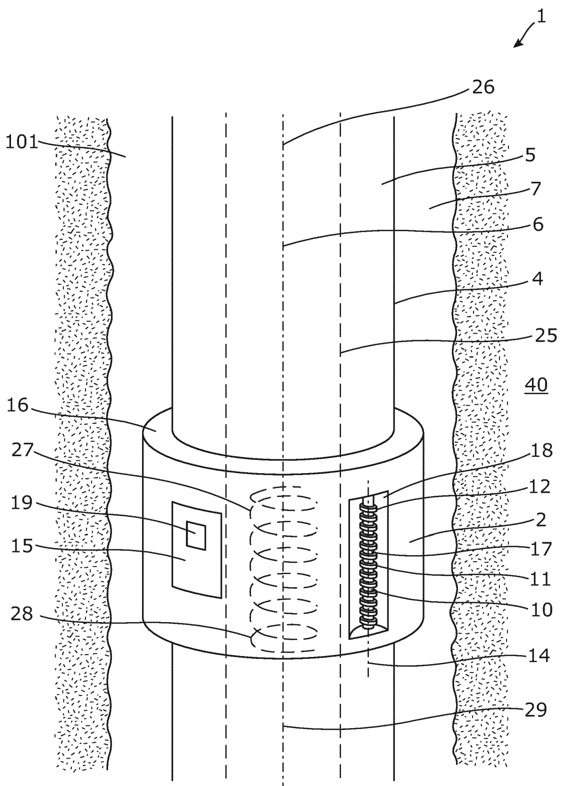

Fig. 1

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Description

Field of the invention

[0001] The present invention relates to a downhole completion system for charging a device outside a well tubular metal structure, comprising the well tubular metal structure having an inner and an outer face and a centre axis, and a power receiving unit arranged exterior of the well tubular metal structure.

Background art

[0002] When having sensors mounted for measuring a condition or property outside a well tubular metal structure downhole, the measured data is very difficult to transmit to surface without having to change the well tubular metal structure significantly to an extent where the completion is substantially weakened or the risk of creating a blow-out or similar uncontrolled occurrences is increased.

[0003] Furthermore, it is very difficult to get these sensors or other instruments to function over time, as the battery power is very limited downhole because the batteries cannot withstand high temperatures and pressures without deteriorating quickly.

Summary of the invention

[0004] 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 completion capable of powering an external device of a well tubular metal structure without jeopardising the safety of the well tubular metal structure and thereby the completion.

[0005] 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 completion system for charging a device outside a well tubular metal structure, comprising:

- the well tubular metal structure having an inner and an outer face and a centre axis,
- a power receiving unit arranged exterior of the well tubular metal structure, comprising:
    - an inductive coil having windings around a coil axis, and
- a power consuming device arranged exterior of the well tubular metal structure, configured to receive power from the power receiving unit,

wherein the coil axis is parallel or coincident with the centre axis.

[0006] By having the coil axis is parallel or coincident with the centre axis, the power receiving unit is prepared to receive power from a coil inside a tool in the well tubular metal structure, and by arranging the coil inside the tool with a tool coil axis parallel or coincident with the coil axis of the power receiving unit, an optimal power transfer can be obtained.

[0007] In an embodiment, the power receiving unit may comprise a metal element abutting the outer face of the well tubular metal structure.

[0008] Furthermore, the windings may be wound around the well tubular metal structure.

[0009] Also, the coil may comprise a metal core which is electrically connected to the metal element.

[0010] By connecting the metal core of the coil of the power receiving unit with the metal element abutting the outer face of the well tubular metal structure, a better transfer of electrical power is obtained between the well tubular metal structure and the coil of the power receiving device.

[0011] In an embodiment, the metal element may be a sleeve.

[0012] By the metal element being a sleeve, the power receiving unit is easily mounted on the outside, and from the outside, of the well tubular metal structure.

[0013] Moreover, the sleeve may comprise two sleeve parts.

[0014] In addition, the two parts may be connected around the well tubular metal structure to obtain metal-to-metal contact to the well tubular metal structure.

[0015] Further, the metal element may comprise a groove in which the coil is arranged.

[0016] Additionally, the power consuming device may be fastened to the metal element.

[0017] Also, the power consuming device may comprise a sensor configured to measure a property of the well, such as a pressure, a temperature, a fluid content or a fluid flow.

[0018] The downhole completion system may further comprise a chargeable battery electrically connected with the power consuming device and the power receiving unit.

[0019] Furthermore, the downhole completion system may further comprise a communication unit arranged on exterior of the well tubular metal structure and configured to communicate measured data from the power consuming device.

[0020] In an embodiment, the communication unit may comprise an acoustic transmitter.

[0021] Furthermore, the coil may be used for communicating with a tool coil of a downhole tool within the well tubular metal structure.

[0022] The downhole completion system may further comprise a downhole tool having a tool axis, the downhole tool being arranged inside the well tubular metal structure and comprising a tool coil configured to generate power to the power receiving unit on the exterior of the well tubular metal structure.

[0023] Moreover, the tool coil may have windings wound around a tool coil axis which is parallel or coincident with the coil axis of the power receiving unit.

[0024] By the coil axis of the power receiving unit and the tool coil axis being parallel, a better power transfer is obtained.

[0025] Furthermore, the downhole tool may further comprise an acoustic receiver for receiving measured data from the power consuming device.

[0026] Moreover, the downhole tool may comprise at least one projectable element configured to project and bring the tool into metal-to-metal contact with the well tubular metal structure.

[0027] By having a projectable element, the tool may be brought into contact with the well tubular metal structure, thereby substantially reducing the distance between the coils, which increases the amount of power being transferred therebetween. Furthermore, the amount of fluid between the tool and the well tubular metal structure is reduced, which also improves the transfer of power between the coils. When the tool abuts the well tubular metal structure, a smaller fluid film will always be present between the tool and the well tubular metal structure, however, the thickness of the film is substantially reduced when the tool is pressed against the well tubular metal structure, thereby improving the power transfer between the tool and the power receiving device.

[0028] In addition, the downhole tool may comprise a metal tool housing electrically connected to the tool coil.

[0029] Also, the downhole tool may comprise a positioning unit configured to detect the position of the tool along the well tubular metal structure.

[0030] Additionally, the downhole tool may further comprise a communication module for communicating with the power receiving unit or the communication unit arranged outside the well tubular metal structure.

[0031] Furthermore, the downhole tool may further comprise a power supply, such as a battery or a wireline.

[0032] In an embodiment, the tool coil may generate a magnetic field configured to generate electrical current in the power receiving unit.

[0033] Furthermore, the power receiving unit may further comprise an acoustic unit receiving mechanical vibrations and transforming the vibrations into electrical power or signal.

[0034] The acoustic unit may comprise a piezoelectric element for transforming mechanical vibrations in the well tubular metal structure or the power receiving unit into electrical power.

[0035] When producing hydrocarbon-containing fluid from a reservoir downhole, the production deposits vibrations in the well tubular metal structure, and these vibrations are received and transformed into electrical power by the acoustic unit.

[0036] When intervening a well by means of an intervention tool, e.g. a self-propelling tool moving forward, by contacting the inner face of the well tubular metal structure, vibrations in the well tubular metal structure are generated. The vibrations created by the intervention tool may thus be received and transformed into electrical power by the acoustic unit.

[0037] The downhole completion system may further comprise an annular barrier to be expanded in an annulus between a well tubular metal structure and another well tubular metal structure or borehole downhole for providing zone isolation between a first zone and a second zone of a casing or borehole, the annular barrier having an axial extension and comprising a tubular part mounted as part of the well tubular metal structure; an expandable sleeve, the expandable sleeve surrounding the tubular part, each end section of the expandable sleeve being connected with the tubular part and extending along the axial extension; and an annular barrier space between the tubular part and the expandable sleeve.

[0038] Furthermore, the end sections of the expandable sleeve may be welded to the tubular part.

[0039] The annular barrier may further comprise at least one sealing element surrounding the expandable sleeve.

[0040] Moreover, the the sealing element may be arranged between two adjacent projections or in a groove of the expandable sleeve.

[0041] Finally, a ring-shaped retaining element may be arranged between two adjacent projections or in the groove for pressing the sealing element in the axial extension.

Brief description of the drawings

[0042] 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 downhole completion system in a borehole of a reservoir for charging a device outside a well tubular metal structure,
>
> Fig. 2 shows a partly cross-sectional view of another downhole completion system having a downhole tool,
>
> Fig. 3 shows another downhole completion system having several inductive coils,
>
> Fig. 4 shows another downhole completion system having an acoustic device,
>
> Fig. 5 shows another downhole completion system having windings of the coil wound around the well tubular metal structure, and
>
> Fig. 6 shows another downhole completion system having an annular barrier.

[0043] 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

[0044] Fig. 1 shows a downhole completion system 1 for charging a device 2 outside a well tubular metal structure 5 having an outer face 4 and a centre axis 6 and being used for producing hydrocarbon-containing fluid from a reservoir 40. The downhole completion system 1 comprises a power receiving unit 10 arranged outside the well tubular metal structure, and the power receiving unit 10 comprises an inductive coil 11 having windings 12 wound around a coil axis 14. The downhole completion system 1 further comprises a power consuming device 15, such as a sensor, arranged outside the well tubular metal structure 5 and configured to receive power from the power receiving unit 10. The coil axis 14 is parallel or coincident with the centre axis 6.

[0045] By having the coil axis 14 parallel or coincident with the centre axis 6, the power receiving unit 10 may easily and efficiently receive power from a coil 27 in a tool 25 inside the well tubular metal structure 5. Furthermore, by arranging the coil 27 inside the downhole tool 25 with a tool coil axis 29 parallel or coincident with the coil axis 14 of the power receiving unit 10, optimal power transfer can be obtained. If the coil axis 14 of the power receiving unit 10 is perpendicular to the centre axis 6 and the coil axis 29 of the downhole tool 25 is parallel to the centre axis, substantially no power is transferred between the two coils. Since downhole tools are limited in dimension, the tools are often made very long compared to their diameter, and a coil inside a tool is therefore best positioned with its coil axis parallel or coincident with the centre axis 6. Thus, by having the coil 11 of the power receiving unit 10 exterior of the well tubular metal structure 5 and having a coil axis 14 parallel or coincident with the tool axis 26, the power receiving unit 10 receives power quickly and efficiently from the coil 27 in the downhole tool 25 inside the well tubular metal structure 5 just by positioning the tool coil 27 substantially opposite the inductive coil 11, in the vicinity of the inductive coil, outside the well tubular metal structure.

[0046] As can be seen in Fig. 1, the power receiving unit 10 comprises a metal element 16 abutting the outer face 4 of the well tubular metal structure 5 so that a substantially optimal metal-to-metal contact to the well tubular metal structure is obtained without having to weld. The metal element 16 comprises a groove 18 in which the inductive coil 11 is arranged. Furthermore, the power consuming device 15 is fastened in the metal element 16 and electrically connected with the power receiving unit 10. Thus, the power consuming device is powered by the power receiving unit 10 which is again powered by the downhole tool 25 through the well tubular metal structure 5 without having to make any openings in the well tubular metal structure.

[0047] The power consuming device 15 comprises a sensor 19 configured to measure a property of the well, such as a pressure, a temperature, a fluid content or a fluid flow. The sensor 19 may not have a battery and may be powered solely through the power receiving unit 10 so that the sensor only performs measurements when the downhole tool 25 is in the vicinity of the power receiving unit 10 to power the sensor.

[0048] The inductive coil 11 comprises a metal core 17 which is electrically connected to the metal element 16 to improve the transfer of power between the downhole tool 25 and the power receiving unit 10. By connecting the metal core 17 of the coil of the power receiving unit 10 with the metal element 16 abutting the outer face 4 of the well tubular metal structure 5, thereby already being in metal-to-metal contact with the well tubular metal structure 5, a better transfer of electrical power is obtained between the well tubular metal structure 5 and the inductive coil 11 of the power receiving unit 10. As can be seen, the metal element 16 is a sleeve, allowing for easy mounting of the power receiving unit 10 on the outside, and from the outside. of the well tubular metal structure 5. No adjustment of the well tubular metal structure 5, also called the production casing, is needed, adjustments being welding and/or providing holes or grooves, which may weaken the well tubular metal structure.

[0049] As shown in Fig. 2, the downhole completion system 1 further comprises a downhole tool 25 having a tool axis 26, arranged inside the well tubular metal structure 5. The downhole tool 25 comprises a tool coil 27 configured to generate power to the power receiving unit 10 arranged outside the well tubular metal structure 5 so that power is transferred by means of induction. The tool coil has windings 28 wound around the tool coil axis 29 which is parallel or coincident with the coil axis 14 of the power receiving unit 10. The downhole tool 25 comprises two projectable elements 32 projectable from a tool housing 33 to press the downhole tool towards the well tubular metal structure 5 and the power receiving unit 10 and into metal-to-metal contact with the well tubular metal structure. Hereby, the distance between the coil of the power receiving unit 10 and the tool coil 27 is substantially reduced, which increases the amount of power being transferred therebetween. By pressing the downhole tool 25 against the well tubular metal structure 5, the amount of fluid between the tool and the well tubular metal structure is reduced, which also significantly improves the transfer of power between the coils. When the downhole tool 25 abuts the well tubular metal structure 5, a small fluid film will always be present between the tool and the well tubular metal structure, however, the thickness of the film is substantially reduced, thereby improving the transfer of power between the tool and the power receiving unit 10. The projectable elements 32 are in Fig. 2 projectable arms pivoting in the tool housing 33. The tool housing 33 may be a metal tool housing 33 electrically connected to the tool coil 27, thereby improving the electrical induction transfer. The downhole tool 25 further comprises a positioning unit 34 configured to detect a position of the tool along the well tubular metal structure 5 and thus align the tool 25 with the power receiving unit 10. The power consuming device 15 of the downhole completion system 1 is arranged adjacent the power receiving unit 10 which comprises the sensor 19.

[0050] In Fig. 3, the sleeve 16 comprises two sleeve parts 16a, 16b connected around the well tubular metal structure 5 by means of bolts 65 to obtain as close metal-to-metal contact with the well tubular metal structure as possible. The power consuming device 15 abuts the power receiving unit 10 and is electrically connected to the power consuming device 15. The power receiving unit 10 comprises two inductive coils 11 arranged in a groove 18 in the metal sleeve 16. The tool coil 27 is indicated by dotted lines and is arranged inside the well tubular metal structure 5 opposite the inductive coils 11 of the power receiving unit 10. The tool coil 27 generates a magnetic field which generates electrical current in the inductive coil 11 of the power receiving unit 10. In another embodiment, the power receiving unit 10 has more than two coils receiving power from the magnetic field generated by the tool coil 27 for powering a sensor of the power consuming device 15.

[0051] In Fig. 2, the downhole tool 25 further comprises a communication module 35 having an acoustic receiver 31 for receiving measured data from the power consuming device 15. The acoustic receiver 31 communicates with an acoustic transmitter 23 of a communication unit 22 arranged outside the well tubular metal structure 5. By having an acoustic receiver 31 and an acoustic transmitter 23, data from the sensor 19 of the power consuming device 15 can be transmitted to the downhole tool 25, using a smaller amount of power than by using the coils 11, 27 of the tool 25 and the power receiving unit 10. The downhole completion system 1 further comprises a rechargeable battery 21 electrically connected with the power consuming device 15 and the power receiving unit 10. The coils charge the battery 21 which is then able to power the power consuming device 15 over a longer period of time than when the downhole tool 25 is arranged opposite the power receiving unit 10. The downhole tool 25 further comprises a power supply 38, such as a battery or a wireline.

[0052] In another embodiment, the inductive coil 11 is used for communicating with the tool coil 27 of the downhole tool 25 within the well tubular metal structure 5. The communication module 35 of the downhole tool 25 is thus used for communicating with the power receiving unit 10 or the communication unit 22 having a coil and being arranged outside the well tubular metal structure 5.

[0053] In order to power the power consuming device 15, the power receiving unit 10 may further comprise an acoustic unit 36, as shown in Fig. 4. The acoustic unit 36 receives mechanical vibrations and transforms the vibrations into electrical power which can be used to power the sensor of the power consuming device 15. The acoustic unit 36 may be used as acoustic transmitter for communicating data regarding the sensor to the downhole tool 25. The acoustic unit 36 comprises a piezoelectric element 37 for transforming mechanical vibrations in the well tubular metal structure 5 or the power receiving unit 10 into electrical power. The acoustic unit 36 may be powered when producing hydrocarbon-containing fluid from a reservoir downhole where the production deposits vibrations in the well tubular metal structure 5, which vibrations are received and transformed into electrical power by the acoustic unit. The acoustic unit 36 may also be powered when intervening a well by means of an intervention tool, e.g. a self-propelling tool moving forward, by contacting the inner face 3 of the well tubular metal structure 5 and thus generating vibrations in the well tubular metal structure. The vibrations created by the intervention tool may thus be received and transformed into electrical power by the acoustic unit 36.

[0054] In Fig. 5, the windings 12 of the inductive coil 11 of the power receiving unit 10 are wound around the well tubular metal structure 5, and a sleeve 16 is arranged outside the windings. The power receiving unit 10 is electrically connected with the power consuming device 15 so as to power the same when receiving power from the downhole tool within the well tubular metal structure 5. Thus, the coil axis 14 is coincident with the centre axis 6.

[0055] As shown in Fig. 6, the downhole completion system 1 may further comprise an annular barrier 50 to be expanded in an annulus 101 between a well tubular metal structure 5 and another well tubular metal structure or a borehole 7 downhole for providing zone isolation between a first zone 102 and a second zone 103 of a casing or borehole. The annular barrier 50 comprises a tubular part 53 mounted as part of the well tubular metal structure 5 and an expandable sleeve 54 surrounding the tubular part. Each end section 55 of the expandable sleeve 54 along the axial extension is connected with the tubular part 53, thereby defining an annular barrier space 56 between the tubular part and the expandable sleeve. The end sections 55 of the expandable sleeve 54 may welded to the tubular part 53 or mounted by means of connection parts 61, as shown in Fig. 6. The annular barrier 50 has two sealing elements 57 surrounding the expandable sleeve 54 and arranged between two adjacent projections or in a groove 58 of the expandable sleeve. A ring-shaped retaining element 59 is arranged between two adjacent projections or in the groove 58 for pressing the sealing element 57 in the axial extension to provide a better seal. The annular barrier 50 is connected with the power receiving unit 10 which is arranged adjacent the connection parts 61.

[0056] The downhole tool 25 is arranged opposite the power receiving unit 10 transmitting electrical power to the inductive coil 11 of the power receiving unit 10 by means of induction. The power receiving unit 10 is electrically connected with the power consuming device 15 to power the same to perform e.g. measurements of a property of the reservoir fluid. The measured data may be transferred to the downhole tool 25 before the tool moves. The communication between the sensor and the tool may be performed by means of the coils generating a magnetic field for both charging and communicating. Thus, the sensor can communicate measured data while the annular barrier 50 is expanded. The annular barrier 50 may be expanded by means of pressurised fluid inside the well tubular metal structure and allow tubular metal structure to flow in though an expansion opening 62 in the tubular part 53 or by a thermally decomposable compound in the space adapted to generate gas or supercritical fluid upon decomposition when heated.

[0057] 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.

[0058] By a well tubular metal structure, production casing or casing is meant any kind of pipe, tubing, tubular, liner, string etc. used downhole in relation to oil or natural gas production.

[0059] In the event that the tool is not submergible 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®.

[0060] 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 downhole completion system (1) for charging a device (2) outside a well tubular metal structure (5), comprising:

- the well tubular metal structure having an inner (3) and an outer face (4) and a centre axis (6),
- a power receiving unit (10) arranged outside the well tubular metal structure, comprising:
    - an inductive coil (11) having windings (12) around a coil axis (14), and
- a power consuming device (15) arranged outside the well tubular metal structure, configured to receive power from the power receiving unit,

wherein the coil axis is parallel or coincident with the centre axis.

2. A downhole completion system according to claim 1, wherein the power receiving unit comprises a metal element (16) abutting the outer face of the well tubular metal structure.

3. A downhole completion system according to claim 1 or 2, wherein the windings are wound around the well tubular metal structure.

4. A downhole completion system according to any of the preceding claims, wherein the coil comprises a metal core (17) which is electrically connected to the metal element.

5. A downhole completion system according to claim 4, wherein the metal element comprises a groove (18) in which the coil is arranged.

6. A downhole completion system according to any of the preceding claims, wherein the power consuming device comprises a sensor (19) configured to measure a property of the well, such as a pressure, a temperature, a fluid content or a fluid flow.

7. A downhole completion system according to any of the preceding claims, further comprising a downhole tool (25) having a tool axis (26), the downhole tool being arranged inside the well tubular metal structure and comprising a tool coil (27) configured to generate power to the power receiving unit outside the well tubular metal structure.

8. A downhole completion system according to claim 7, wherein the tool coil has windings (28) wound around a tool coil axis (29) which is parallel or coincident with the coil axis of the power receiving unit.

9. A downhole completion system according to claim 7 or 8, wherein the downhole tool comprises at least one projectable element (32) configured to project and bring the tool into metal-to-metal contact with the well tubular metal structure.

10. A downhole completion system according to any of claims 7-9, wherein the downhole tool comprises a metal tool housing (33) electrically connected to the tool coil.

11. A downhole completion system according to any of claims 7-9, wherein the downhole tool comprises a positioning unit (34) configured to detect the position of the tool along the well tubular metal structure.

12. A downhole completion system according to any of the preceding claims, wherein the tool coil generates a magnetic field configured to generate electrical current in the power receiving unit.

13. A downhole completion system according to any of the preceding claims, wherein the power receiving unit further comprises an acoustic unit (36) receiving mechanical vibrations and transforming the vibrations into electrical power or signal.

14. A downhole completion system according to claim 13, wherein the acoustic unit comprises a piezoelectric element (37) for transforming mechanical vibrations in the well tubular metal structure or the power receiving unit into electrical power.

15. A downhole completion system according to any of the preceding claims, further comprising an annular barrier (50) to be expanded in an annulus (101) between a well tubular metal structure and another well tubular metal structure or borehole (7) downhole for providing zone isolation between a first zone (102) and a second zone (103) of a casing or borehole, the annular barrier having an axial extension (52) and comprising:

- a tubular part (53) mounted as part of the well tubular metal structure,
- an expandable sleeve (54), the expandable sleeve surrounding the tubular part, each end section (55) of the expandable sleeve being connected with the tubular part and extending along the axial extension, and
- an annular barrier space (56) between the tubular part and the expandable sleeve.

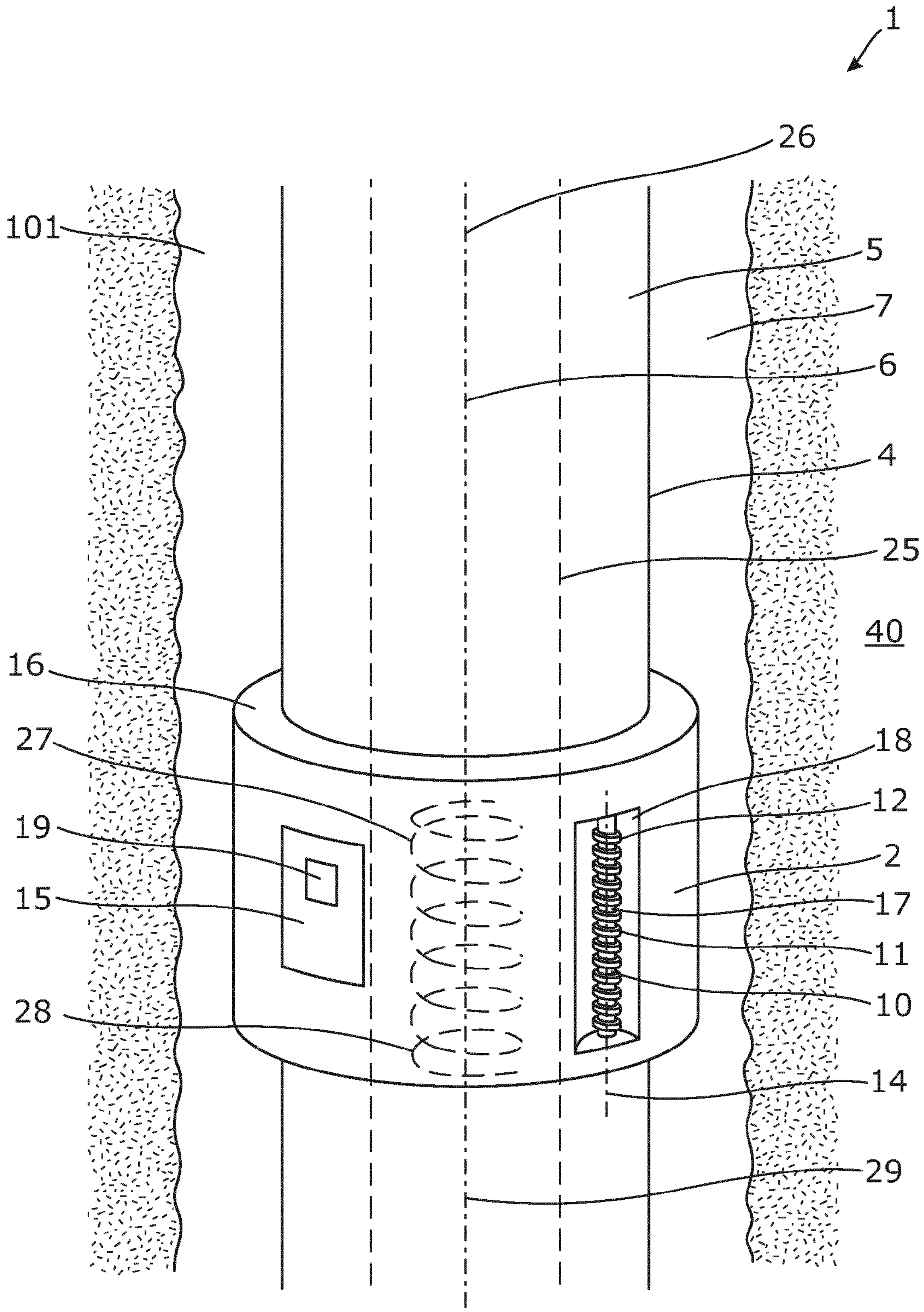

Fig. 1

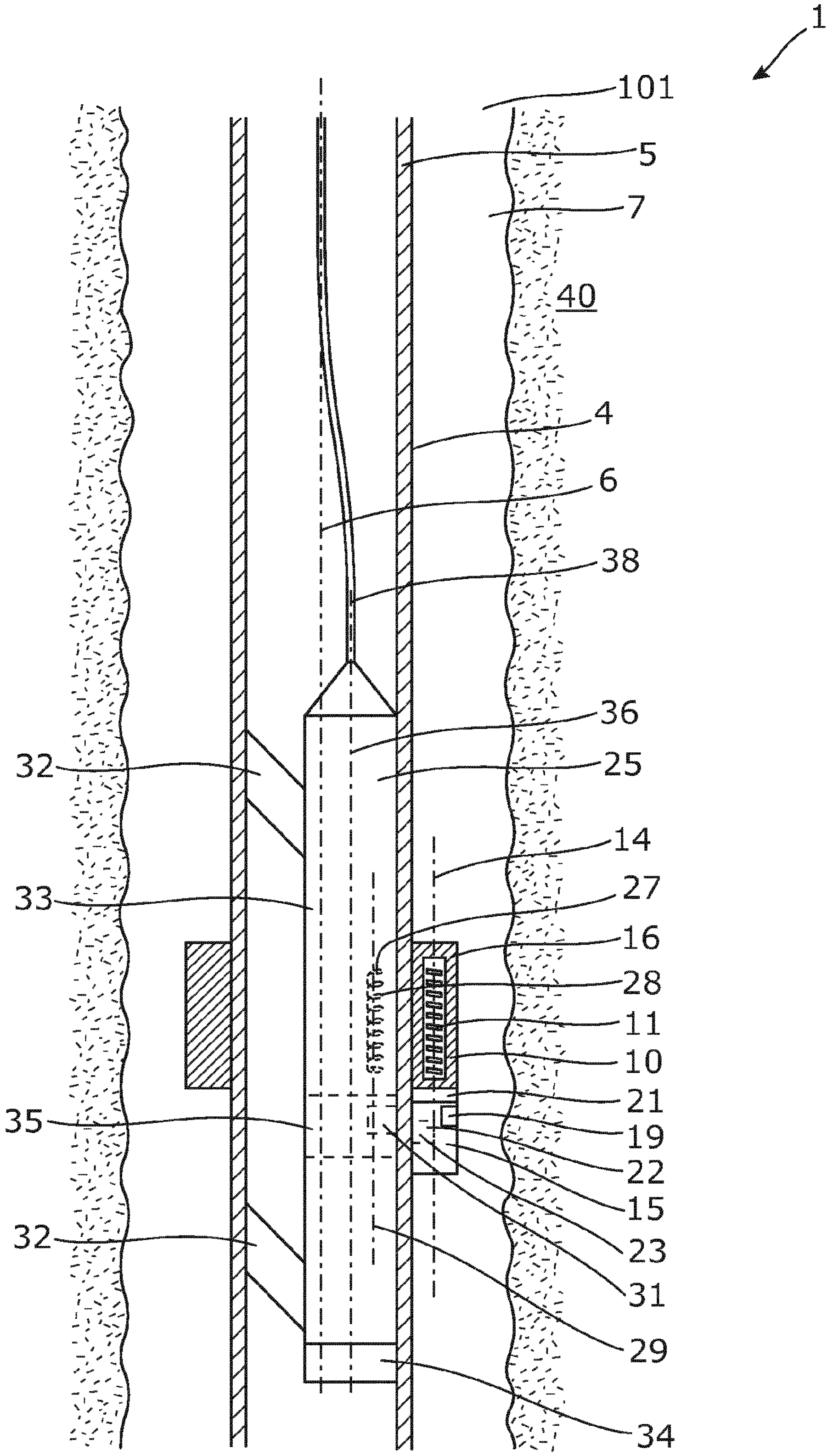
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Fig. 2

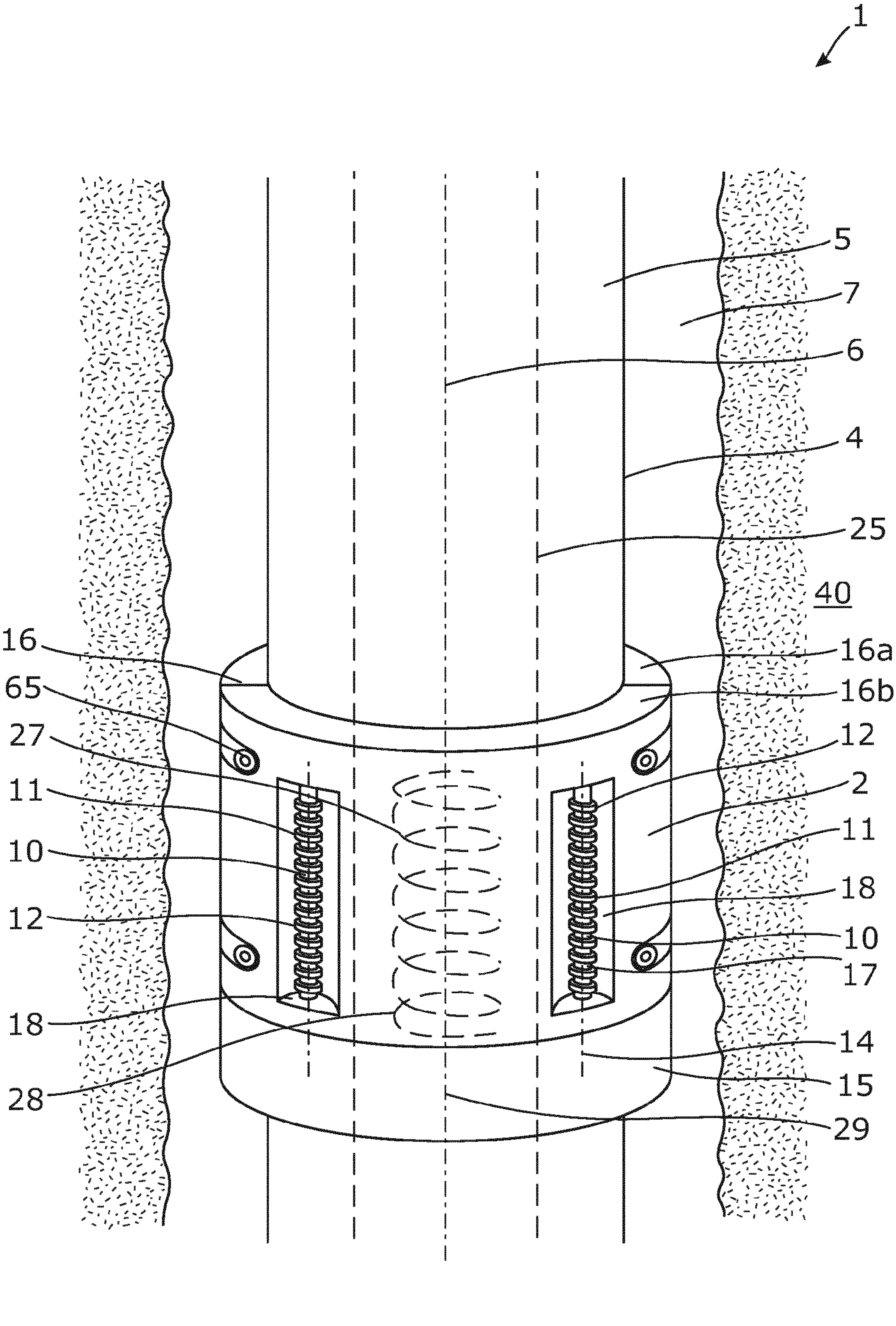

Fig. 3

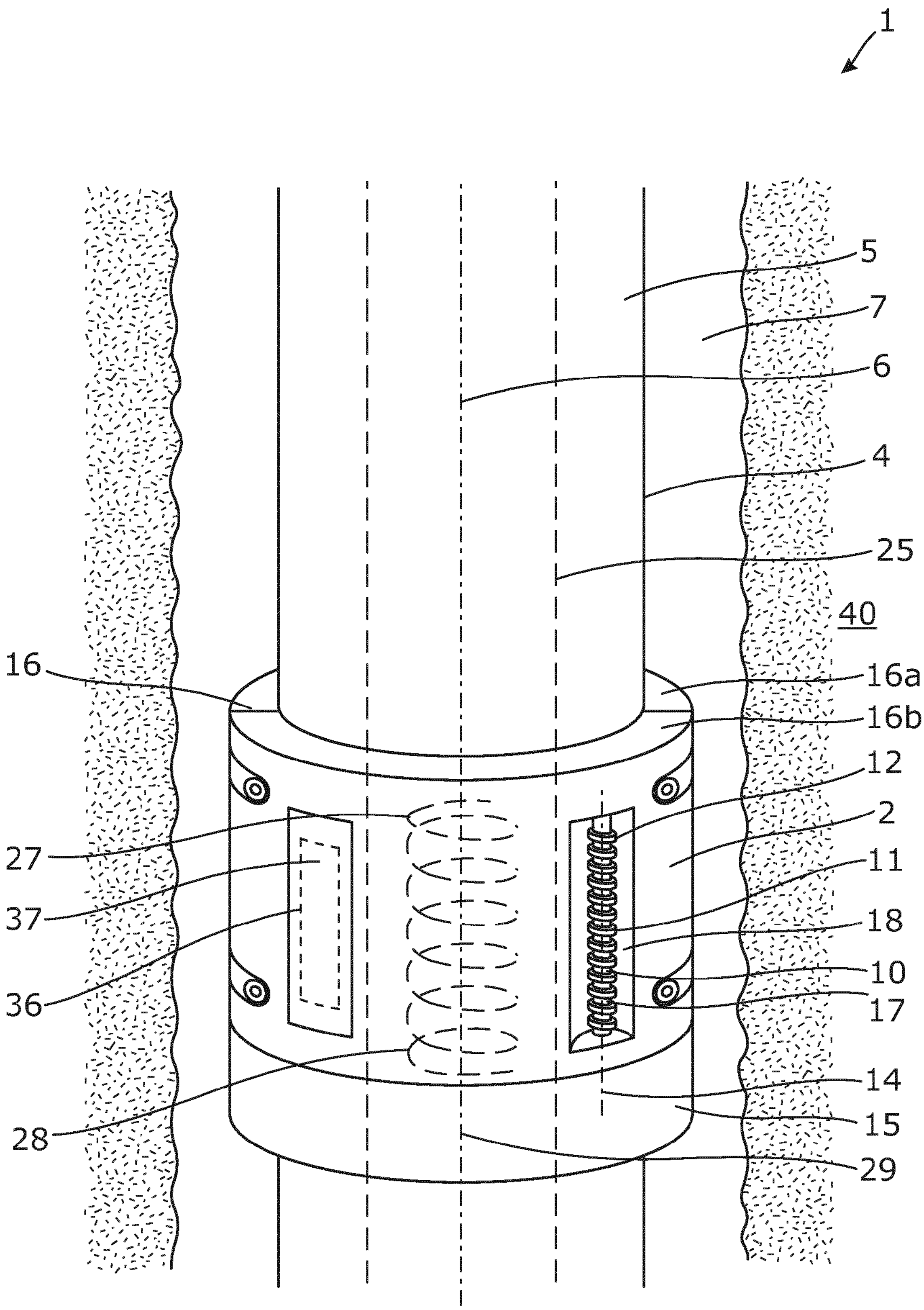

Fig. 4

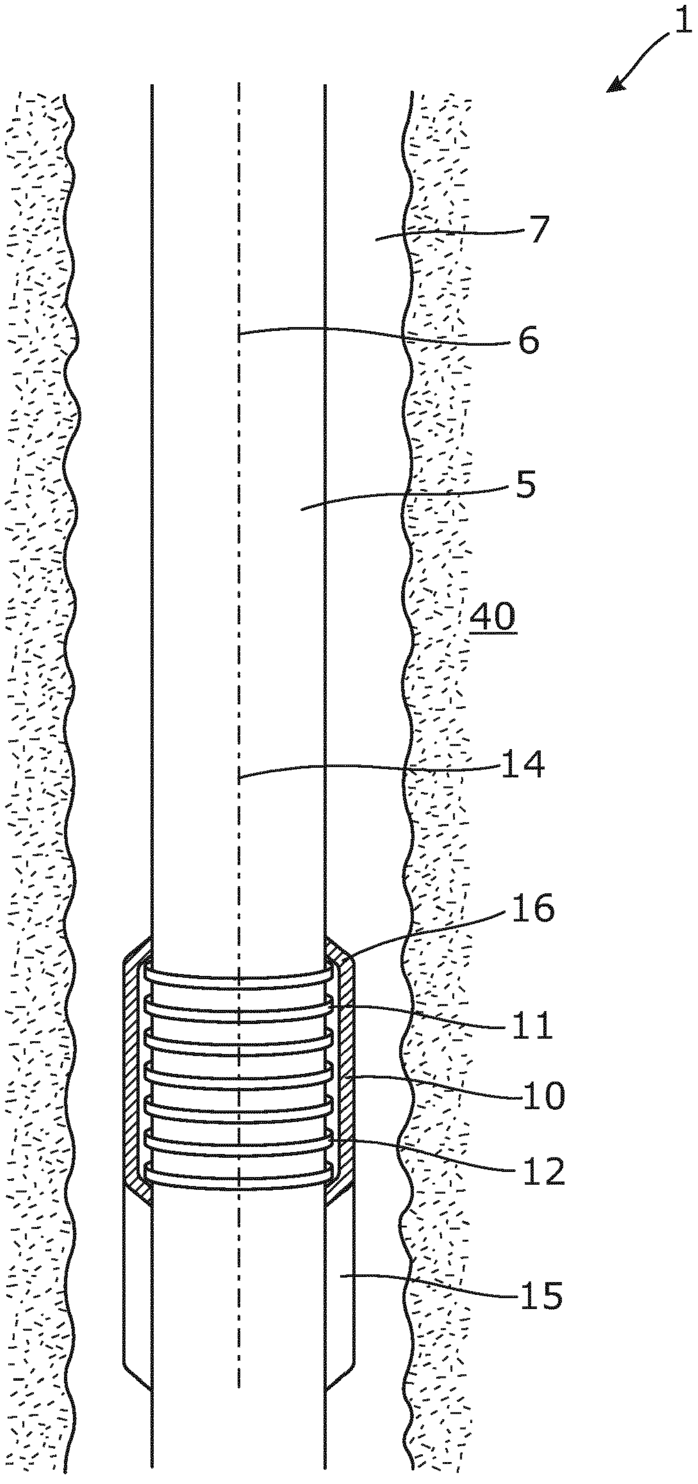

Fig. 5

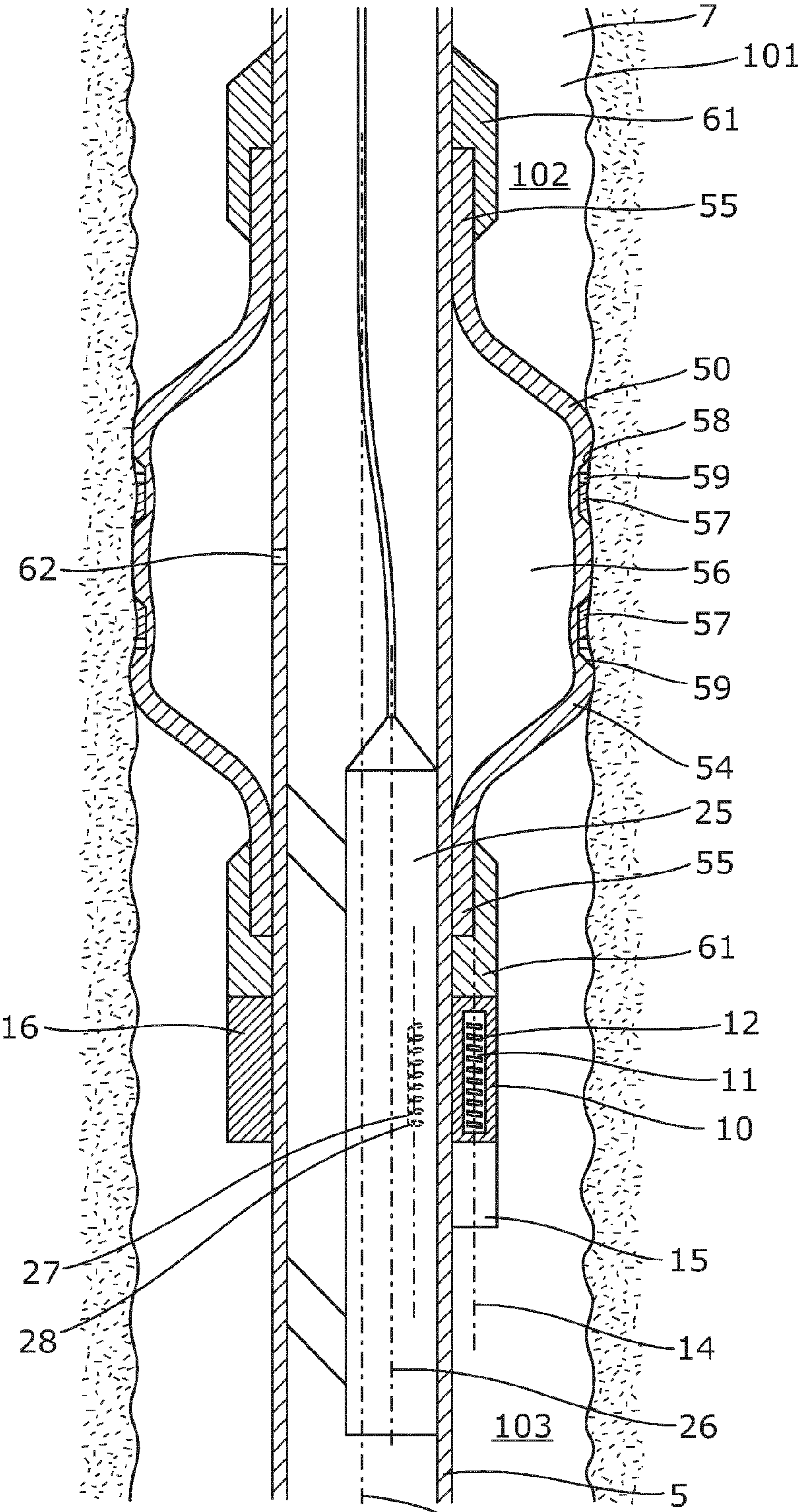
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Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 15 17 0311

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	11 September 2015	Posavec, Daniel

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 17 0311

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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11-09-2015

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