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(54) DOWNHOLE ANNULAR BARRIER PROVIDED WITH AN ELECTRICAL CONDUCTOR

(57) The present invention relates to an annular barrier (10) for being expanded in an annulus (2) between a well tubular structure (1) and a wall (5) of a borehole (6) or another well tubular structure downhole for providing zone isolation between a first zone having a first pressure and a second zone. The annular barrier comprises a tubular metal part (7) for mounting as part of the well tubular structure, the tubular metal part having a first expansion opening (3) , an axial extension (L) and an outer face (4); an expandable sleeve (8) surrounding the tubular metal part and having an inner face (9) facing the tubular metal part and an outer face (16) facing the wall of the borehole; a first connection part (11) and a second connection part (12) configured to connect a first end (13) and a second end (14), respectively, of the expandable sleeve with the tubular metal part; and an annular space (15) between the inner face of the expandable sleeve and the tubular metal part. The annular barrier further comprises an electrical conductor (17) extending from the first connection part to the second connection part. Furthermore, the present invention relates to a downhole system.

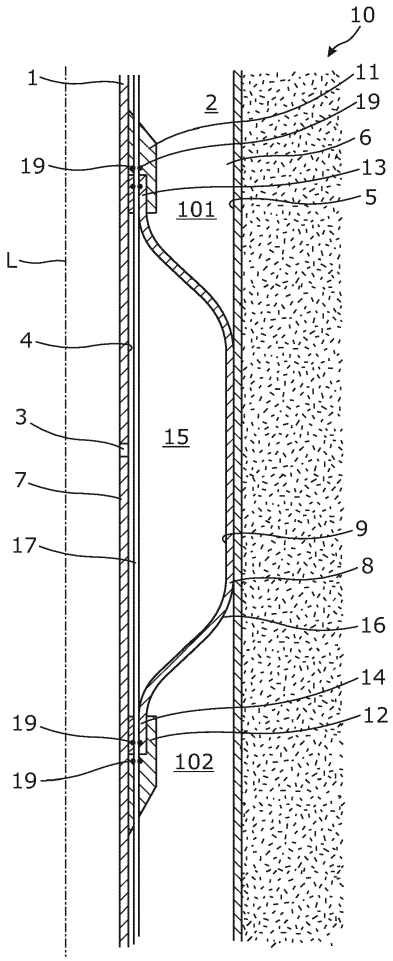

Fig. 1

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Description

Field of the invention

[0001] The present invention relates to an annular barrier for being expanded in an annulus between a well tubular structure and a wall of a borehole or another well tubular structure downhole for providing zone isolation between a first zone having a first pressure and a second zone. Furthermore, the present invention relates to a downhole system.

Background art

[0002] In recent years, the number of tool intervention operations in wells has increased, and hydrocarbon wells are therefore made without electrical lines running inside the casing which may conflict with intervention tools.

[0003] However, electricity is still needed for powering electrical devices arranged inside or outside the casing several kilometres down, as the completions become more and more developed, and this conflicts with the importance of keeping the casing free of electrical lines without breaking the main barriers of the well.

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 annular barrier and downhole system in which powering of electrical devices arranged inside or outside a well tubular structure several kilometres down is possible while still being able to perform tool intervention.

[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 an annular barrier for being expanded in an annulus between a well tubular structure and a wall of a borehole or another well tubular structure downhole for providing zone isolation between a first zone having a first pressure and a second zone, the annular barrier comprising:

- a tubular metal part for mounting as part of the well tubular structure, the tubular metal part having a first expansion opening, an axial extension and an outer face,
- an expandable sleeve surrounding the tubular metal part and having an inner face facing the tubular metal part and an outer face facing the wall of the borehole,
- a first connection part and a second connection part configured to connect a first end and a second end, respectively, of the expandable sleeve with the tubular metal part, and
- an annular space between the inner face of the expandable sleeve and the tubular metal part,

wherein the annular barrier further comprises an electrical conductor extending from the first connection part to the second connection part.

[0006] By having the electrical conductor extending from the first connection part to the second connection part, electricity can be supplied to an electric device further down the well without breaking the barrier between the first and the second zone. The connection parts do not move, and it is thus simple to provide a sufficient seal between the connection parts and the electrical conductor.

[0007] Thus, the connection parts may be non-slidable in relation to the tubular metal part.

[0008] In an embodiment, the annular barrier described above may further comprise a tunnel arranged in the space between the first connection part and the second connection part, in which tunnel the electrical conductor extends.

[0009] Furthermore, the first and the second connection part may each have an electrical connection configured to connect with the electrical conductor.

[0010] The annular barrier described above may further comprise a sealing means for sealing around the electrical conductor.

[0011] In addition, the electrical conductor may be soldered to the connection parts.

[0012] Also, the sealing means may seal around the electrical conductor between the electrical conductor and one of the connection parts or the tunnel.

[0013] In addition, the annular barrier described above may further comprise a sensor electrically connected with the electrical conductor.

[0014] The expandable sleeve may be made of metal so that the annular barrier is a metal annular barrier.

[0015] Furthermore, at least one sealing means may be provided on the outer face of the expandable sleeve of the metal annular barrier.

[0016] Also, the annular barrier may comprise an expansion unit so that fluid passing the expansion opening is led past the expansion unit before entering the annular space.

[0017] In addition, the expansion unit may comprise a permanent closing mechanism for preventing fluid communication between the well tubular structure and the annular space in a first position.

[0018] Furthermore, the permanent closing mechanism is a two-way valve comprising a second position in which fluid communication between the annular space and the annulus or the second zone is provided.

[0019] The present invention furthermore relates to a downhole system comprising:

- a well tubular structure, and
- a first annular barrier being an annular barrier described above, wherein the tubular metal part is mounted as part of the well tubular structure.

[0020] The downhole system may further comprise a

first electrical unit arranged on an outer face of the well tubular structure and electrically connected with the electrical conductor.

[0021] In an embodiment, the electrical unit may be an inductive coupler part.

[0022] Furthermore, the downhole system may further comprise a second electrical unit arranged inside the well tubular structure and configured to abut an inner face of the well tubular structure.

[0023] In an embodiment, the second electrical unit may be an inductive coupler part.

[0024] The downhole system may further comprise a second well tubular structure arranged at least partly within a first well tubular structure, the second electrical unit being arranged outside the second well tubular structure.

[0025] Moreover, the second electrical unit may be electrically connected to a third electrical unit via a second electrical conductor.

[0026] In addition, downhole system may further comprise a second annular barrier through which the second electrical conductor extends.

[0027] Also, the downhole system may further comprise a lateral tubular structure connected with one of the well tubular structures, and wherein a third electrical unit may be arranged outside the lateral tubular structure.

[0028] Additionally, the downhole system may further comprise a tool arranged in the well tubular structure, the tool comprising an inductive tool coupler part configured to be electrically connected with the inductive coupler part.

[0029] Finally, the downhole system may further comprise a sensor arranged outside one of the well tubular structures.

Brief description of the drawings

[0030] 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 cross-sectional view of an annular barrier having an electrical conductor,

Fig. 2 shows a cross-sectional view of an annular barrier having an electrical conductor connected to connection parts via electrical connections,

Fig. 3 shows a cross-sectional view of another annular barrier having a tunnel in which the electrical conductor runs,

Fig. 4 shows a cross-sectional view of a downhole system,

Fig. 5 shows a cross-sectional view of another downhole system having several electrical units,

Fig. 6 shows a cross-sectional view of yet another downhole system having a lateral tubular structure with a further electrical unit,

Fig. 7 shows a cross-sectional view of another downhole system having several electrical units arranged down the well, and

Fig. 8 shows a cross-sectional view of yet another downhole system having several electrical units arranged down the well and in a lateral tubular structure.

[0031] 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

[0032] Fig. 1 shows an annular barrier 10 in a well, expanded in an annulus 2 between a well tubular structure 1 and a wall 5 of another well tubular structure downhole for providing zone isolation between a first zone 101 and a second zone 102. The annular barrier 10 comprises a tubular metal part 7 for mounting as part of the well tubular structure 1, the tubular metal part having an axial extension L along the longitudinal extension of the well tubular structure. The tubular metal part 7 has a first expansion opening 3 through which pressurised fluid enters for expanding the annular barrier 10. The annular barrier 10 further comprises an expandable sleeve 8 surrounding the tubular metal part 7 and having an inner face 9 facing an outer face 4 of the tubular metal part, and an outer face 16 of the expandable sleeve 8 faces the wall of the well tubular structure 1. A first end 13 of the expandable sleeve 8 is connected to the tubular metal part 7 by a first connection part 11, and a second end 14 of the expandable sleeve is connected to the tubular metal part by a second connection part 12. Thus, an annular space 15 is enclosed between the inner face 9 of the expandable sleeve 8 and the tubular metal part 7, which space expands as the expandable sleeve expands due to the pressurised fluid let into the annular space. The annular barrier 10 further comprises an electrical conductor 17 extending from the first connection part 11 to the second connection part 12 and through the annular space 15 so that electricity can be conducted past the annular barrier to an electrically demanding unit further down the well without breaking the seal between the first and the second zone provided by the annular barrier.

[0033] In Figs. 2 and 3, the annular barrier 10 is expanded between the well tubular structure 1 and the wall 5 of a borehole 6. In Fig. 2, the first and the second connection part 11, 12 each have an electrical connection 24 connected to the electrical conductor 17, so that the

electrical conductor is formed of a first part 35 extending in a first zone 101, a second part 36 extending inside the annular barrier 10, and a third part 37 extending in a second zone 102. The electrical conductor 17 can thus be formed of several parts forming one electrical conductor.

[0034] In Fig. 3, the annular barrier 10 further comprises a tunnel 18 in the form of a tube arranged in the annular space 15 and extending between the first connection part 11 and the second connection part 12. The electrical conductor 17 runs in the tunnel 18, and a sealing means 19 is provided around the tunnel and around the electrical conductor 17 so that fluid from the first zone 101 is hindered in flowing into the second zone 102, and vice versa. Instead of having a sealing means 19 around the electrical conductor 17 in the tunnel 18, the tunnel may be designed to collapse at a certain pressure when the annular barrier 10 expands, as the pressure inside the annular space 15 forces the tunnel to collapse and shrink around the electrical conductor.

[0035] As shown in Fig. 2, the sealing means 19 may also be arranged in such a way that it seals directly around the electrical conductor 17 and is arranged in the connection parts 11, 12 and/or as part of the electrical connections 24. The annular barrier 10 further comprises a sensor 23 electrically connected with the electrical conductor 17 for taking measurements of e.g. pressure and temperature or the expansion ratio of the expandable sleeve 8 during expansion of the annular barrier. As can be seen, the electrical conductor 17 extends further past the sensor 23 to be electrically connected with other electrical devices further down the well.

[0036] In Fig. 3, the annular barrier 10 comprises an expansion unit 41 arranged at the first expansion opening 3 so that the pressurised fluid enters the first expansion opening 3 and flows into the expansion unit 41 before being led into the annular space 15. The expansion unit 41 comprises a permanent closing mechanism which closes the fluid communication between the inside of the well tubular structure 1 and the annular space 15 in a first position after expansion of the expandable sleeve 8 and thus the annular barrier 10, and in a second position allows for fluid communication between the first zone 101 and the annular space 15 so that the pressure can be equalised therebetween, should the pressure in the second zone 102 increase during e.g. fracturing. Thus, the permanent closing mechanism is a two-way valve and may even function as a three-way valve where fluid may also be led from the well tubular structure to the annulus.

[0037] Fig. 4 shows a downhole system 100 comprising the well tubular structure 1 and a first annular barrier 10 being the annular barrier described above, where the tubular part is mounted as part of the well tubular structure. The electrical conductor 17 is led past the annular barrier 10, as described above, without breaking the barrier between the first zone 101 and the second zone 102 provided by the annular barrier 10. Furthermore, the electrical conductor 17 is electrically connected to a first electrical unit 20 arranged on an outer face 21 of the well tubular structure 1. The electrical unit 20 is an inductive coupler part 20A, meaning that a tool inside the well tubular structure 1 can be recharged by abutting the inner face of the well tubular structure opposite the inductive coupler part, and the tool can thus be charged without having to emerge all the way to surface or the well head, since power is conducted in the electrical conductor past one or more annular barrier(s) and further down the well. Furthermore, the well tubular structure 1 is intact, as the inductive coupler part 20A is arranged on the outside of the well tubular structure.

[0038] The downhole system 100 of Fig. 5 further comprises a second electrical unit 20B arranged inside the first well tubular structure 1, 1A configured to abut an inner face 22 of the first well tubular structure and a second well tubular structure 1B arranged partly within the first well tubular structure 1A. The second electrical unit 20B is an inductive coupler part 20C, and electricity is thus conducted through the first well tubular structure 1A and further conducted in the electrical conductor 17 outside of the second well tubular structure 1B. The downhole system 100 further comprises a second annular barrier 10B having a tubular metal part 7 mounted as part of the second well tubular structure 1B and expanded between the first well tubular structure 1, 1A and the second well tubular structure 1, 1B. The electrical conductor 17 extends through the first annular barrier to the first electrical unit, and a second electrical conductor 17B extends from the second electrical unit 20B through a third annular barrier 10C to a third electrical unit 20D which can then be arranged several kilometres further down the well. The second electrical unit 20B is electrically connected to the third electrical unit 20D via the second electrical conductor 17B, and a tool inside the second well tubular structure 1B can thus be electrically powered several kilometres down the well by abutting the inner face of the second well tubular structure opposite the inductive coupler part of the second electrical unit 20B

[0039] The downhole system 100 shown in Fig. 6 comprises a lateral tubular structure 31 extending from a window opening in the second well tubular structure 1B. The downhole system 100 further comprises a tool 50 arranged in the lateral tubular structure 31 of the well tubular structure 1, and the tool comprises an inductive tool coupler part 51 configured to be electrically connected with the inductive coupler part when the tool abuts the inner face of the lateral tubular structure 31, as shown. The downhole system 100 further comprises a sensor 23 arranged outside one of the second well tubular structures for measuring e.g. temperature and/or pressure.

[0040] In Fig. 7, the downhole system 100 has a sleeve 55 movable by the sleeve control 57 for uncovering an aperture 54 or aligning a sleeve opening 58 with the aperture 54 allowing fluid to flow therethrough. The sleeve control 57 further comprises an inductive tool coupler part 51 for receiving control signals from surface to open, choke or close fluid communication through the aperture.

The sleeve control 57 is thus permanently installed in the production casing 1B, ready to move the sleeve from one position to another in order to choke, open or close fluid communication from the reservoir. The sleeve control 57 has its own power supply and can operate on its own when receiving a control signal during production of fluid from the reservoir, without the well being intervened by commonly used intervention tools. The inductive tool coupler part 51 of the sleeve control 57 of the tool 50 is arranged in the fixation unit 61 abutting the restriction 39 and the inner face of the casing 1B. The first electrical unit 20a arranged on an outer face of the first well tubular structure 1A and a second electrical unit 20b arranged on an inner face of the first well tubular structure 1A communicate via the casing/well tubular structure 1A. The second electrical unit 20b and a third electrical unit 20C arranged further down the well communicate via the electrical conductor 17 running through an annular barrier 10. The inductive tool coupler part 51 and the third electrical unit 20C are electrically connected via electromagnetic induction and transfer signals and electrical power between them through the well tubular structure 1B. The sleeve control 57 comprises a first part 68 having members 69 engaging the profile 56, and a second part 70 having the fixation unit 61 fixating the sleeve control 57 in the casing. The sleeve control 57 comprises an actuator 72 for moving the first part 68 in relation to the second part 60, and a power supply 64, such as a battery, supplying power to the actuator. The battery may be charged through the well tubular structure 1B by the third electrical unit 20C.

[0041] The power supply may also be recharged by the inductive tool coupler part 51 converting mud pulses, an electrical field or acoustic waves into electrical energy. The inductive tool coupler part 51 may also comprise a propeller 21A in connection with a generator 22A for recharging the power supply by converting rotational energy generated by fluid in the production casing 2 into electrical energy, as shown in Fig. 7.

[0042] In Fig. 8, the downhole system 100 comprises completion components 55 where a first part 5a of the completion component is a member 69 engaging the profile 56 of a second part 5b of the completion component. Thus, the first part 5a of the completion component is arranged at the component control 57. The inductive tool coupler part 51 of the component control 57 is arranged in the fixation unit 61 abutting the restriction 39 and the inner face of the casing 2. The first electrical unit 20a arranged on an outer face of the intermediate casing and a second electrical unit 20b arranged on an inner face of the intermediate casing communicate via the well tubular structure 1A. The first electrical unit 20a is electrically connected to surface via wiring 17 extending through the main barrier 65. The first electrical unit 20a and the second electrical unit 20b are electrically connected via electromagnetic induction and transfer signals and electrical power between them through the intermediate casing 1A. The third electrical unit 20c is connected with the second electrical unit 20b by means of wiring or an electrical conductor, such as a cable, a cord or a wire running through an annular barrier 10. The third electrical unit 20c is arranged on the outer face of the production casing 1B further down the well but above the lateral tubular structure 81. A fourth communication unit 20d is arranged opposite the inductive tool coupler part 51 of the component control 57. The third and fourth communication units are electrically connected via wiring 17. The fourth communication unit 20d and the inductive tool coupler part 51 transfer signals and electrical power between them via electromagnetic induction through the production casing 1B. The third electrical unit 20c is furthermore electrically connected with a fifth electrical unit 20e arranged outside the main casing which is the production casing 1B. The fifth electrical unit 20e is arranged opposite an inductive tool coupler part 51 of another component control 57 in the main casing and transfers signals and power by means of electromagnetic induction through the production casing 1B. Both the wiring 17 between the second electrical unit 20b and the third electrical unit 20c and between the third electrical unit 20c and the fourth electrical unit 20d runs past an annular barrier 10. The wiring 17 extends in through one of the connection parts 11, 12 connecting the expandable sleeve 8 with the tubular part 7, and past the space 15 and through the other connection part further down the well. The wiring 17 of Fig. 8 between the third electrical unit 20c and the fifth electrical unit 20e extends past the lateral tubular structure 81 on the outside of the main casing 1B and through the annular barrier 10 arranged further down the main casing.

[0043] All the communication units each comprises an inductive coupler for transferring power from one communication unit to another through the casing by means of electromagnetic induction. The casing may have non-magnetic sections opposite the communication units to optimise the transfer by electromagnetic induction.

[0044] The tool may be a stroking tool which is a tool providing an axial force, e.g. for opening or closing a sliding sleeve. The stroking tool comprises an electrical 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 into the piston housing on one side and simultaneously suck fluid out on the other side of the piston.

[0045] 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.

[0046] By a well tubular structure is meant any kind of pipe, tubing, tubular, liner, string etc. used downhole in relation to oil or natural gas production.

[0047] In the event that the tool is not submergible all

the way into the well tubular structure, 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 well tubular structure for propelling the tractor and the tool forward in thewell tubular structure. A downhole tractor is any kind of driving tool capable of pushing or pulling tools in a well downhole, such as a Well Tractor®.

[0048] 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. An annular barrier (10) for being expanded in an annulus (2) between a well tubular structure (1) and a wall (5) of a borehole (6) or another well tubular structure downhole for providing zone isolation between a first zone (101) having a first pressure (P_1) and a second zone (102), the annular barrier comprising:

- a tubular metal part (7) for mounting as part of the well tubular structure, the tubular metal part having a first expansion opening (3), an axial extension (L) and an outer face (4),
- an expandable sleeve (8) surrounding the tubular metal part and having an inner face (9) facing the tubular metal part and an outer face (16) facing the wall of the borehole,
- a first connection part (11) and a second connection part (12) configured to connect a first end (13) and a second end (14), respectively, of the expandable sleeve with the tubular metal part, and
- an annular space (15) between the inner face of the expandable sleeve and the tubular metal part,

wherein the annular barrier further comprises an electrical conductor (17) extending from the first connection part to the second connection part.

2. An annular barrier according to claim 1, further comprising a tunnel (18) arranged in the space between the first connection part and the second connection part, in which tunnel the electrical conductor extends.

3. An annular barrier according to claim 1 or 2, wherein the first and the second connection part each have an electrical connection (24) configured to connect with the electrical conductor.

4. An annular barrier according to any of the preceding claims, further comprising a sealing means (19) for sealing around the electrical conductor.

5. An annular barrier according to any of the preceding claims, further comprising a sensor (23) electrically connected with the electrical conductor.

6. A downhole system (100) comprising:

- a well tubular structure (1), and
- a first annular barrier (10) being an annular barrier according to any of claims 1-4, wherein the tubular metal part is mounted as part of the well tubular structure.

7. A downhole system according to claim 6, further comprising a first electrical unit (20) arranged on an outer face (21) of the well tubular structure and electrically connected with the electrical conductor.

8. A downhole system according to claim 7, wherein the electrical unit is an inductive coupler part (20A).

9. A downhole system according to any of claims 6-8, further comprising a second electrical unit (20B) arranged inside the well tubular structure and configured to abut an inner face (22) of the well tubular structure.

10. A downhole system according to claim 9, further comprising a second well tubular structure (1B) arranged at least partly within a first well tubular structure (1A), the second electrical unit being arranged outside the second well tubular structure.

11. A downhole system according to claim 9 or 10, wherein the second electrical unit is electrically connected to a third electrical unit (20D) via a second electrical conductor (17B).

12. A downhole system according to claim 11, further comprising a second annular barrier (10B) through which the second electrical conductor extends.

13. A downhole system according to any of claims 6-12, further comprising a lateral tubular structure (31) connected with one of the well tubular structures, and wherein a third electrical unit is arranged outside the lateral tubular structure.

14. A downhole system according to any of claims 6-13, further comprising a tool (50) arranged in the well tubular structure, the tool comprising an inductive tool coupler part (51) configured to be electrically connected with the inductive coupler part.

15. A downhole system according to any of claims 6-14, further comprising a sensor (23) arranged outside

one of the well tubular structures.

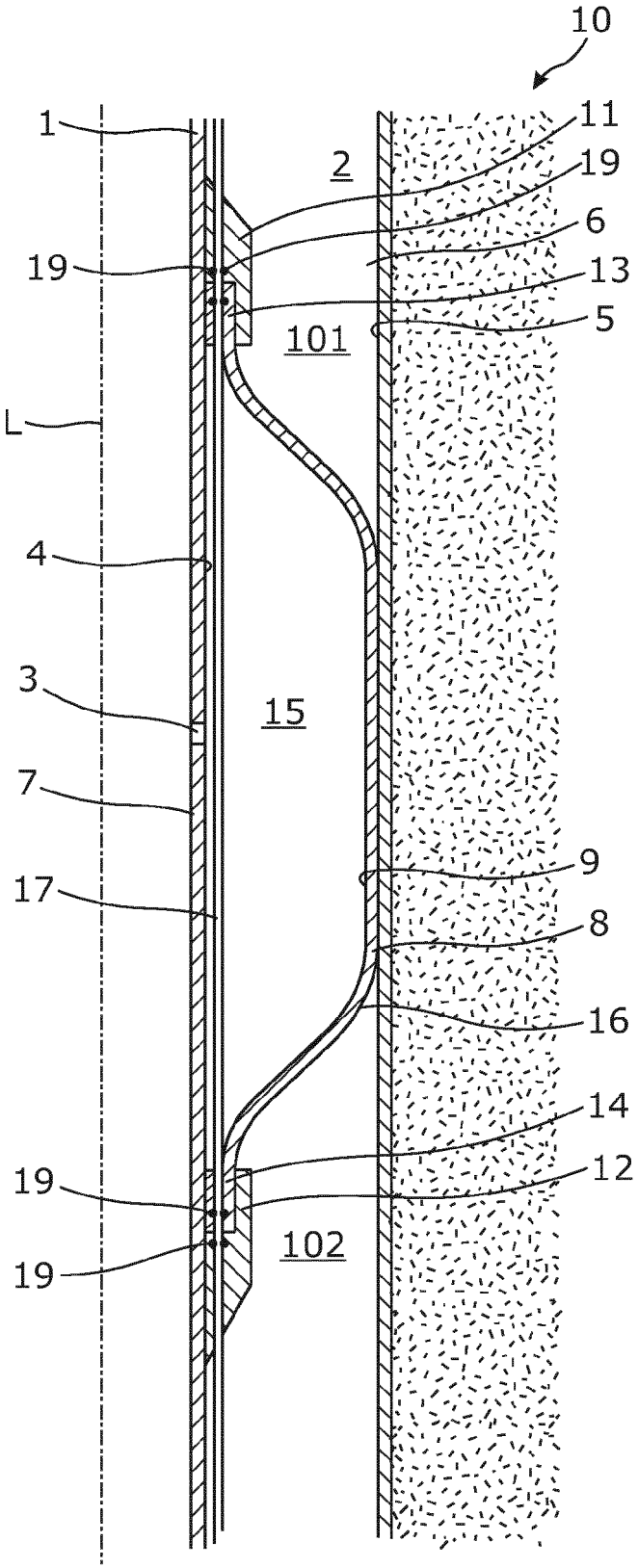

Fig. 1

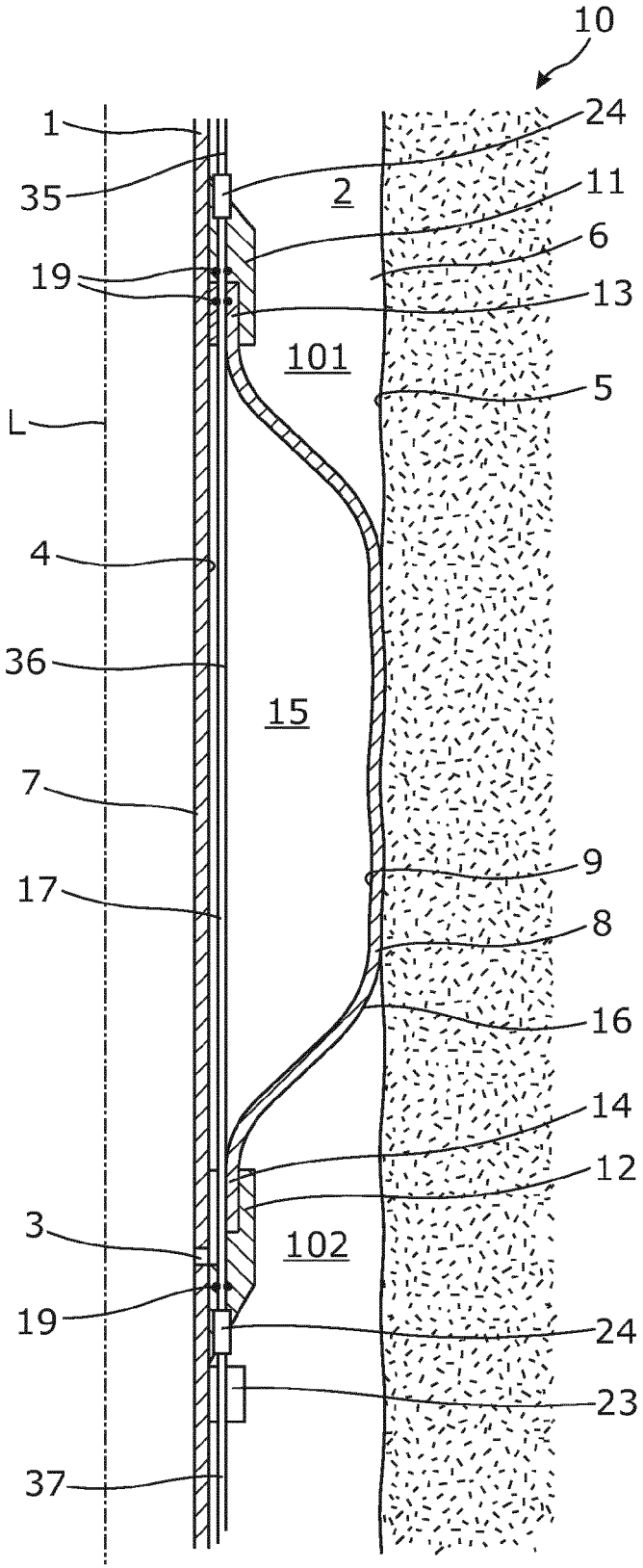

Fig. 2

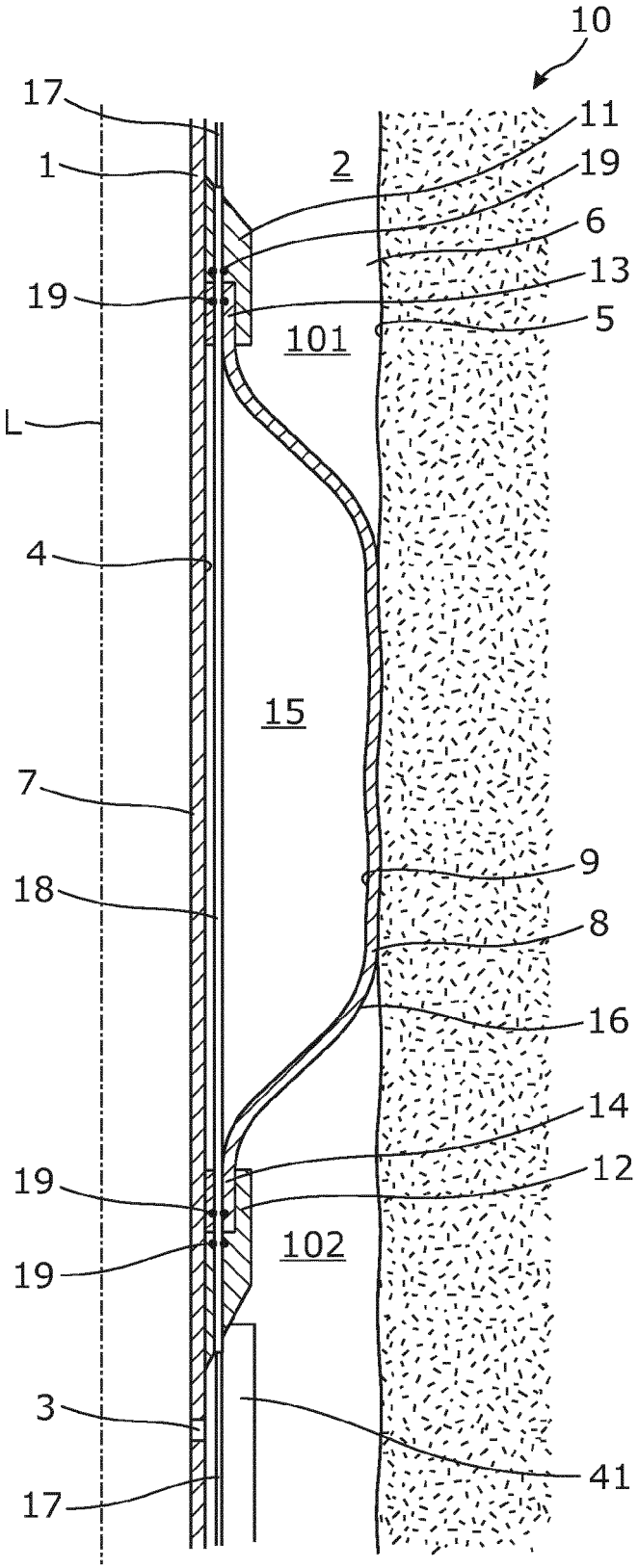

Fig. 3

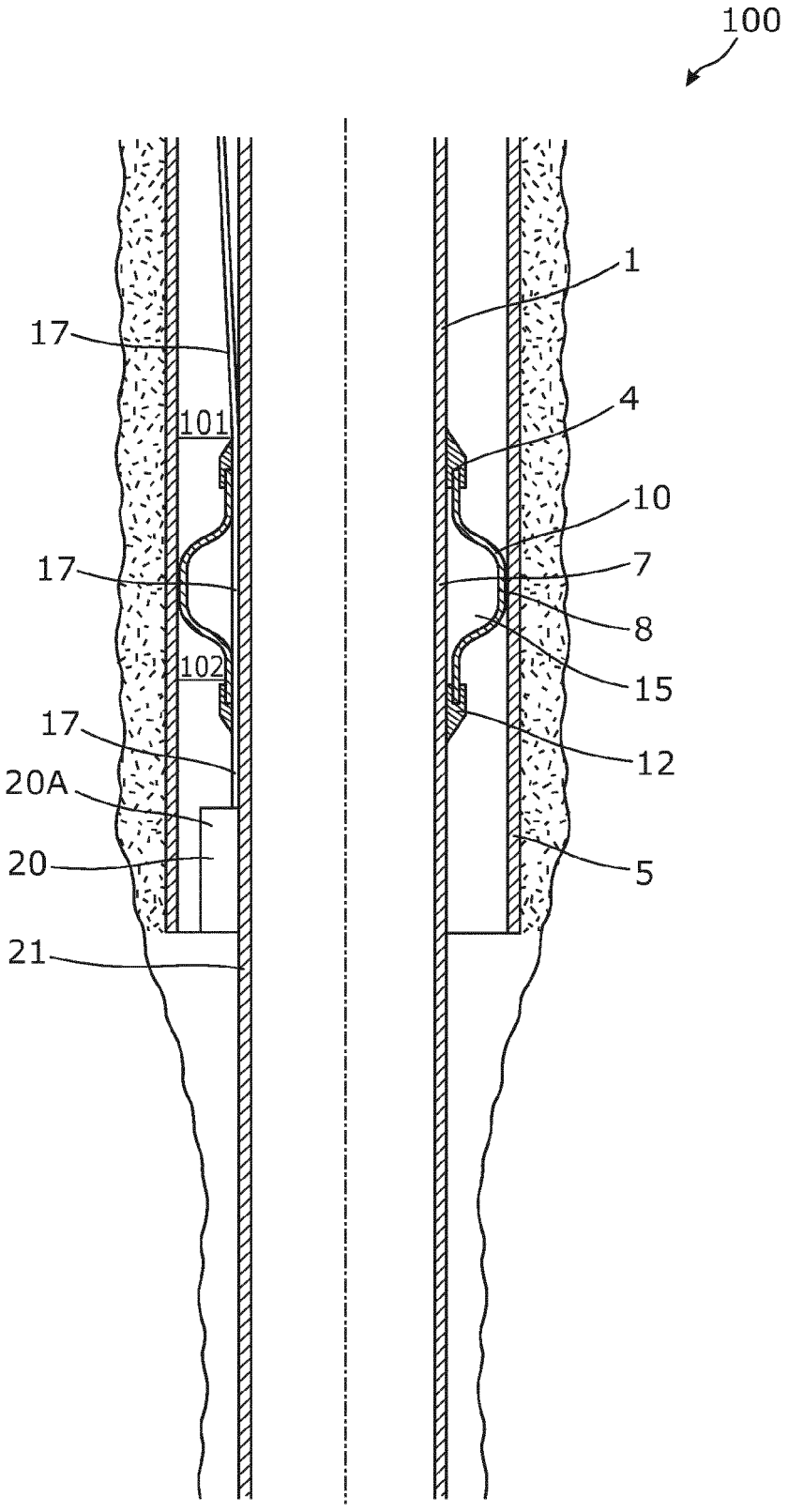

Fig. 4

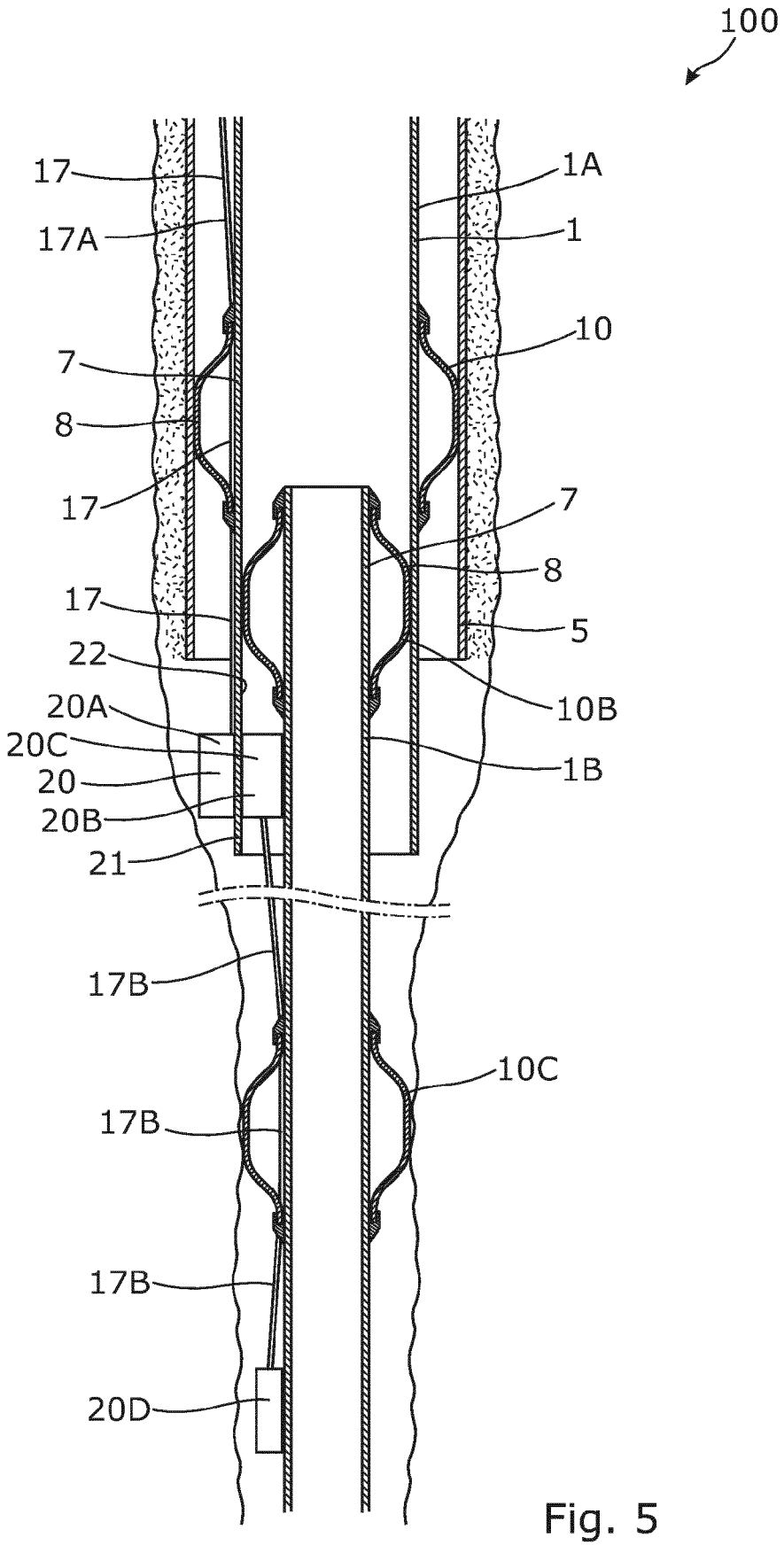
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Fig. 5

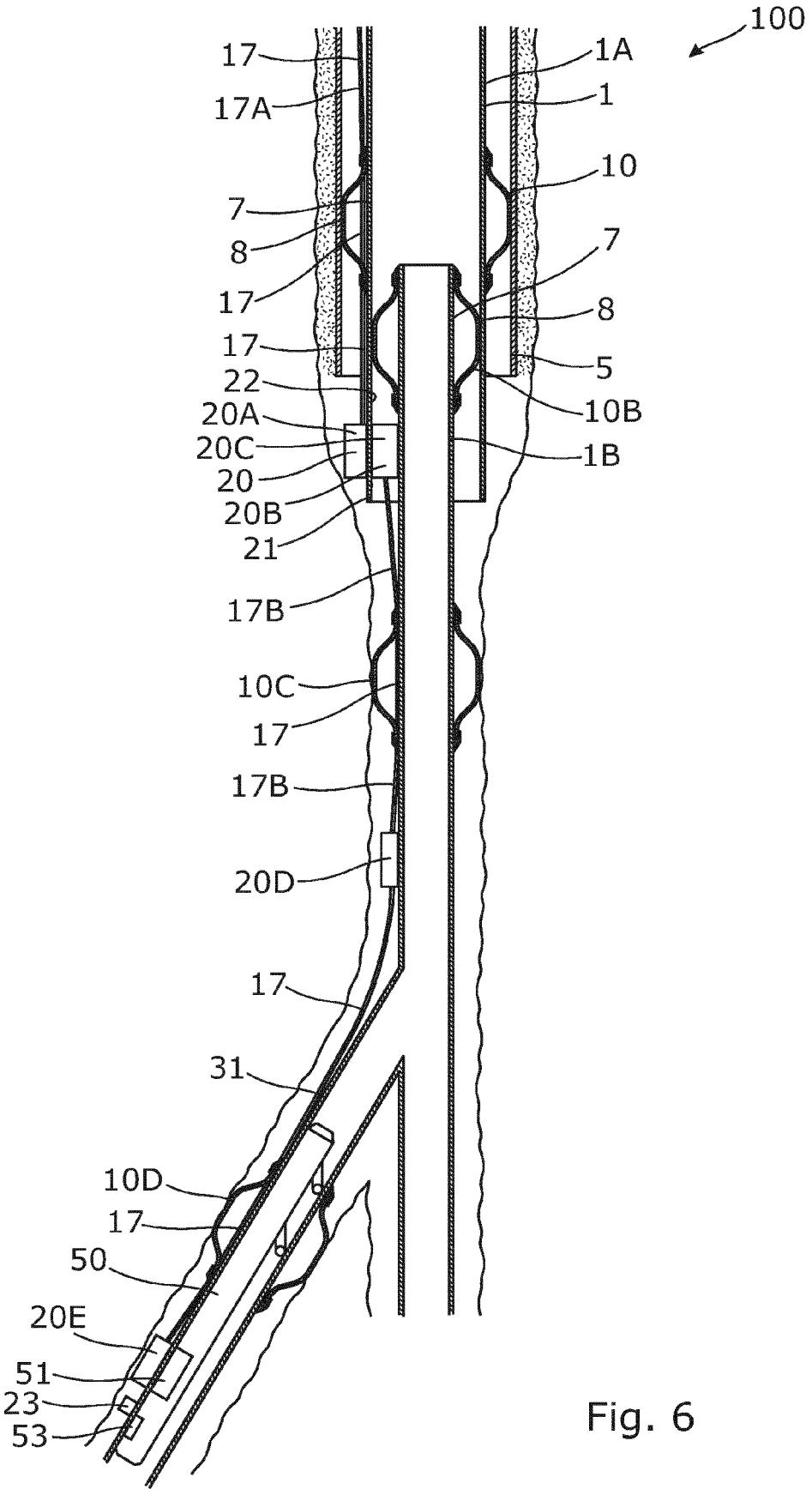
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Fig. 6

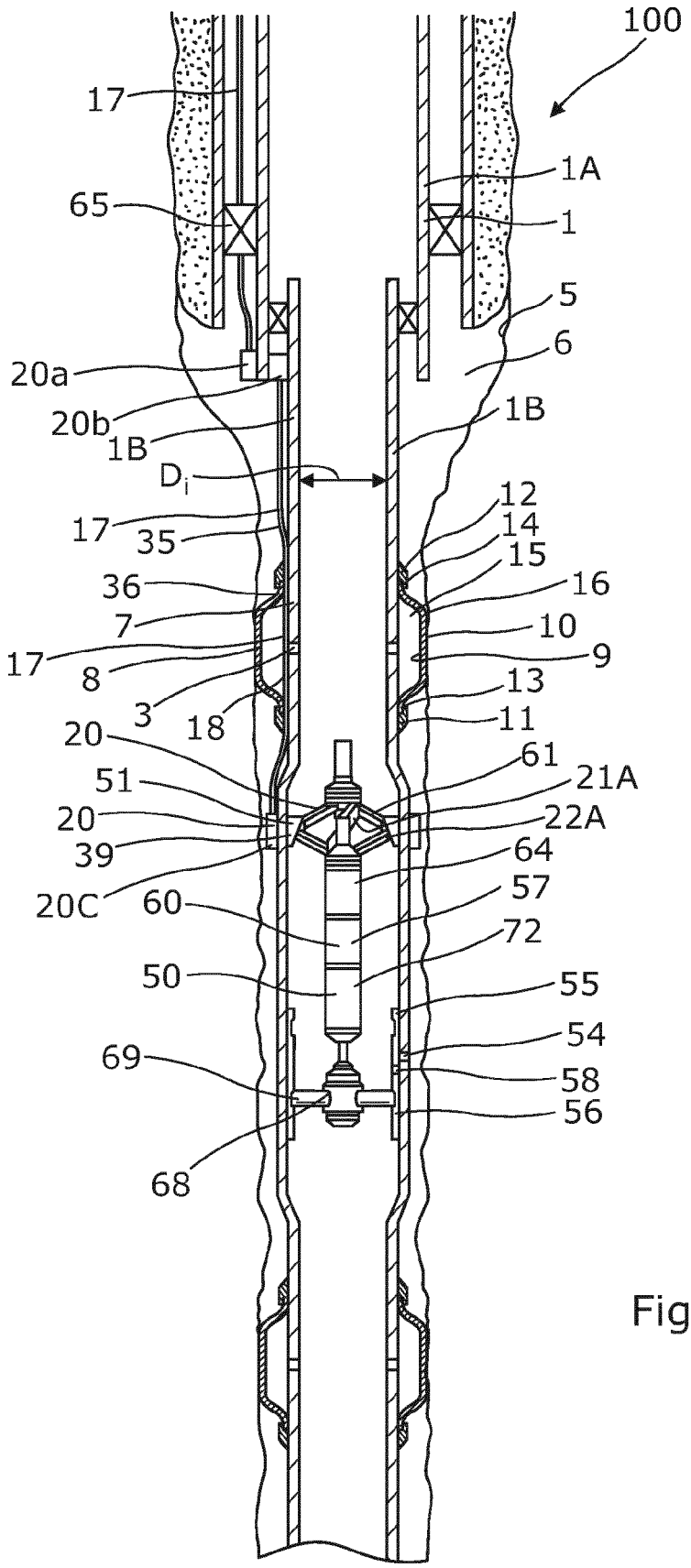
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Fig. 7

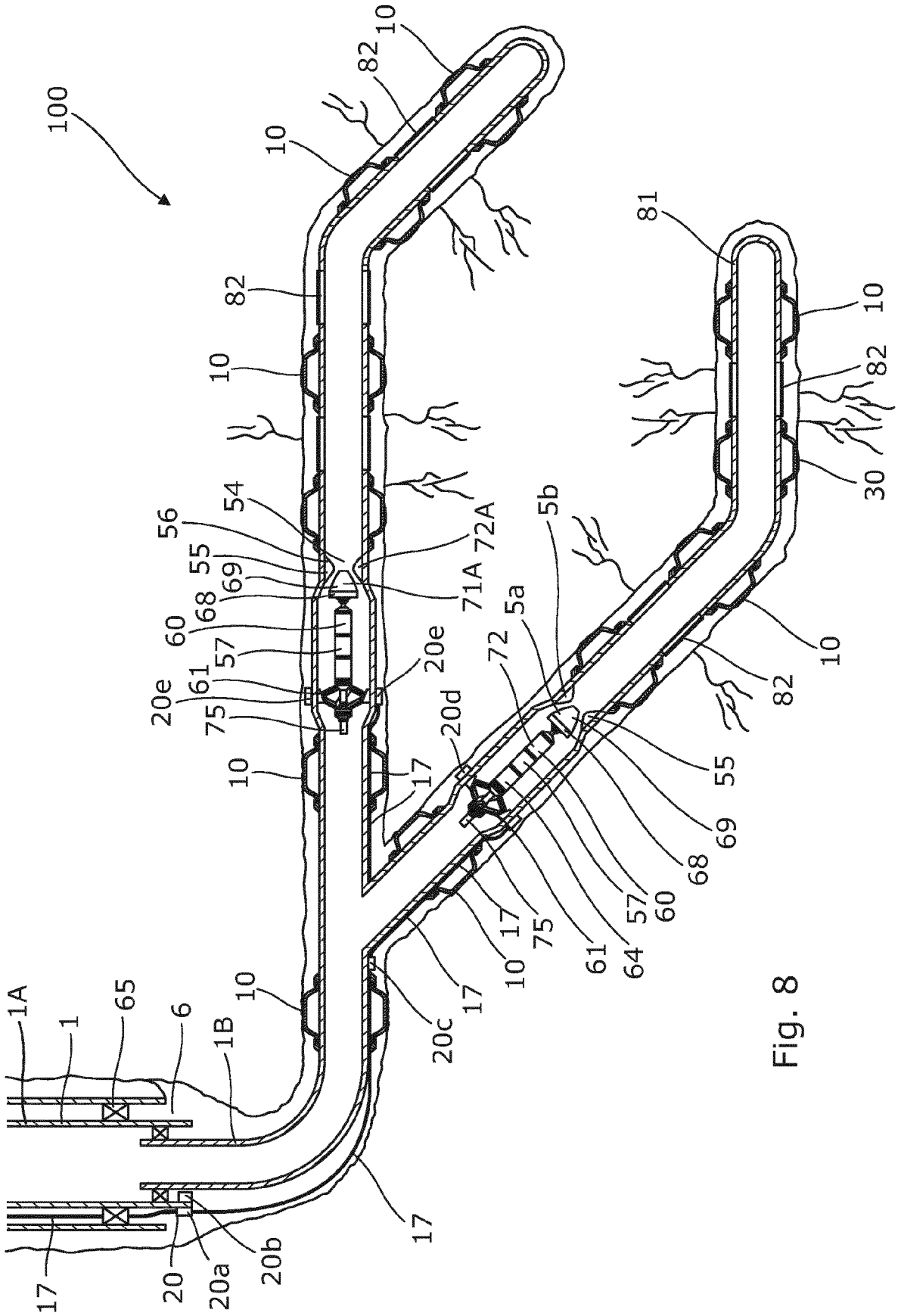
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Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 16 15 0086

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	EP 2 642 066 A1 (WELLTEC AS [DK]) 25 September 2013 (2013-09-25) * paragraphs [0056], [0058]; figure 2 *	1-6, 12-15 7-11	INV. E21B33/127 E21B17/02
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