(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 299 575 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
28.03.2018 Bulletin 2018/13

(21) Application number: **18154379.4**

(22) Date of filing: **31.01.2018**

(51) Int Cl.:
E21B 43/10 *(2006.01)* ***E21B 33/124*** *(2006.01)*
E21B 33/127 *(2006.01)*

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

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

(72) Inventors:
- **HAZEL, Paul**
  Aberdeen, Aberdeenshire AB41/7JQ (GB)
- **VASQUES, Ricardo Reves**
  3450 Allerød (DK)

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

(54) DOWNHOLE COMPLETION SYSTEM AND METHOD

(57) The present invention relates to a downhole completion system for being arranged in a wellbore, comprising several casing sections having a casing length of 10-14 metres mounted as one well tubular metal structure by means of casing collars, wherein a number of the several casing sections each comprises at least three annular barriers each comprising an expandable metal sleeve configured to be expanded to abut the wellbore, the annular barriers of each casing section having a common longitudinal extension of at least 50% of the casing length. The present invention also relates to a downhole method for completing a well having a wellbore.

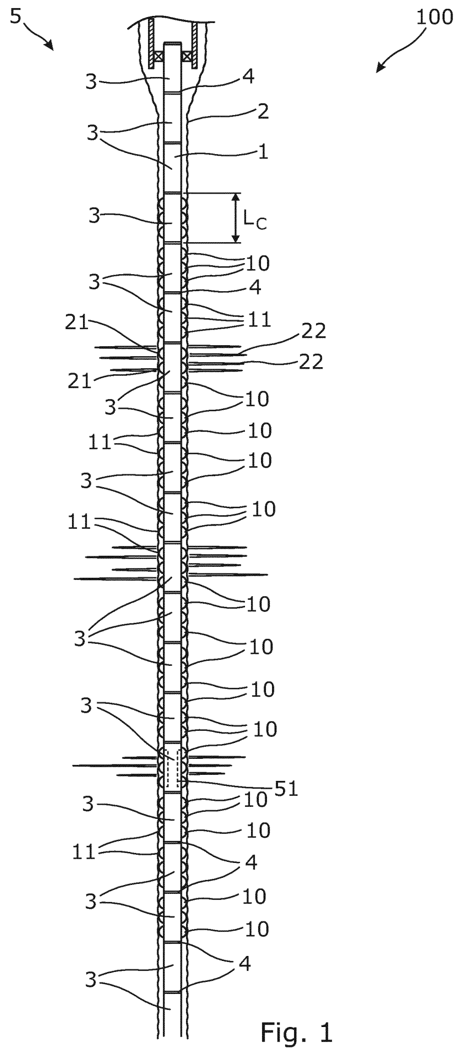

Fig. 1

EP 3 299 575 A2

Description

[0001] The present invention relates to a downhole completion system for being arranged in a wellbore, comprising several casing sections having a casing length of 10-14 metres mounted as one well tubular metal structure by means of casing collars. The present invention also relates to a downhole method for completing a well having a wellbore.

[0002] During the completion of a well, annular barriers are positioned at predetermined positions for providing zone isolation between different zones, for instance between a non-producing zone and a production zone. However, if the annular barriers are positioned incorrectly, they may isolate inaccurately which results in the well not producing as intended.

[0003] It is an object of the present invention to wholly or partly overcome the above disadvantages and drawbacks of the prior art. More specifically, it is an object to provide an improved downhole completion system having a high flexibility in relation to providing zone isolation and production zones.

[0004] The above objects, together with numerous other objects, advantages and features, which will become evident from the below description, are accomplished by a solution in accordance with the present invention by a downhole completion system for being arranged in a wellbore, comprising several casing sections having a casing length of 10-14 metres mounted as one well tubular metal structure by means of casing collars,
wherein a number of the several casing sections each comprises at least three annular barriers each comprising an expandable metal sleeve configured to be expanded to abut the wellbore, the annular barriers of each casing section having a common longitudinal extension of at least 50% of the casing length.

[0005] Furthermore, at least one of the expanded metal sleeves may have a plurality of perforations.

[0006] In addition, each section may have a first end part and a second end part, at least the first end part may having at least 1 metre which is free from annular ba rriers.

[0007] Moreover, the annular barriers may be arranged with a mutual distance of less than 100 cm, preferably less than 50 cm.

[0008] Also, each annular barrier may have a barrier length of 1-2.5 metres.

[0009] Furthermore, each casing section may have a base pipe.

[0010] Each of the expandable metal sleeves may surround and may fasten to the same base pipe, forming an annular space between each expandable metal sleeve and the base pipe.

[0011] In addition, each space may comprise at least one thermally decomposable compound, which compound is thermally decomposable below a temperature of 400°C and is adapted to generate gas or super-critical fluid upon decomposition.

[0012] Moreover, the compound may comprise nitrogen.

[0013] The compound may be selected from a group consisting of: ammonium dichromate, ammonium nitrate, ammonium nitrite, barium azide, sodium nitrate or a combination thereof.

[0014] Also, the compound may decompose at temperatures above 100°C, preferably above 180°C.

[0015] Furthermore, the annular space is pre-pressurised to a pressure above 5 bar, preferably above 50 bar and more preferably above 100 bar, even more preferably above 250 bar.

[0016] The compound may be present in the form of a powder, a powder dispersed in a liquid or a powder dissolved in a liquid.

[0017] In addition, the base pipe may have at least one opening opposite each of the expandable metal sleeves for expanding the expandable metal sleeves by allowing pressurised fluid to enter the openings.

[0018] The annular barriers may comprise a valve in fluid communication with the openings.

[0019] Furthermore, the expandable metal sleeves may be fastened to the base pipe by means of welding, crimping or connection parts connecting the expandable metal sleeves to the base pipe.

[0020] Also, the expandable metal sleeves of each casing section may be connected to form part of the base pipe, so that an inner face of the expandable metal sleeves forms part of an inner face of the base pipe.

[0021] The expandable metal sleeves of each casing section may be connected directly or indirectly, forming a connection area.

[0022] Moreover, the expandable metal sleeves of each casing section may be connected indirectly by means of a tubular connection part.

[0023] In addition, the expandable metal sleeves of each casing section may be connected directly end to end in an overlapping manner.

[0024] The downhole completion system may further comprise a patch to be expanded inside the casing section, so that each end of the patch overlaps the connection area.

[0025] Furthermore, each expandable metal sleeve may comprise a plurality of sealing elements.

[0026] Also, each expandable metal sleeve may comprise sections having an increased thickness, which sections are expanded less than other sections of the expandable metal sleeve.

[0027] A number of the several casing sections may each comprise at least four or five annular barriers.

[0028] In addition, the sealing elements may comprise key rings, coiled springs or a combination thereof.

[0029] The present invention also relates to a downhole method for completing a well having a wellbore, comprising:

- mounting a well tubular metal structure from several casing section of the downhole completion system ad described above,

- providing the well tubular metal structure in the wellbore, and
- expanding the expandable metal sleeves of the annular barriers to abut the wellbore.

[0030] Furthermore, the expansion of the expandable metal sleeves of the annular barriers may be performed sequentially.

[0031] The downhole method may further comprise perforating at least one of the expandable metal sleeves, creating access of reservoir fluid into the casing sections and into the well tubular metal structure.

[0032] The downhole method may further comprise expanding a patch inside the well tubular metal structure opposite the perforated expandable metal sleeve for sealing off the perforations.

[0033] 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 partly cross-sectional view of a downhole completion system arranged in a wellbore of a well having several casing sections,

Fig. 2 shows a perspective of a casing section comprising four annular barriers configured to be expanded to abut the wellbore,

Fig. 3A shows a side view of another casing section having four annular barriers,

Fig. 3B shows a cross-sectional view of the casing section of Fig. 3A,

Fig. 4A shows a side view of another casing section having four annular barriers,

Fig. 4B shows a cross-sectional view of the casing section of Fig. 4A,

Fig. 5A shows a cross-sectional view of an embodiment of an annular barrier,

Fig. 5B shows a cross-sectional view of another embodiment of an annular barrier,

Fig. 6 shows a cross-sectional view of another embodiment of an annular barrier,

Fig. 7 shows a cross-sectional view of another casing section having four annular barriers,

Fig. 8 shows a cross-sectional view of a sealing element of an annular barrier,

Fig. 9 shows a cross-sectional view of another sealing element of an annular barrier, and

Fig. 10 shows a cross-sectional view of another sealing element of an annular barrier.

[0034] 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.

[0035] Fig. 1 shows a downhole completion system 100 arranged in a wellbore 2 of a well 5. The downhole completion system 100 comprises several casing sections 3 having a casing length of 10-14 metres which is a standard length, so that the casing section, also called casing joints, can fit into the conventional rig equipment when mounting the well tubular metal structure 1 and lowering the well tubular metal structure into the wellbore. The several casing sections 3 are mounted as one well tubular metal structure 1 by means of casing collars 4. A number of the several casing sections 3 each comprises at least three annular barriers 10 so that when expanded, each of these casing sections 3 provides three isolations dividing the annulus in four zones. Each annular barrier 10 comprises an expandable metal sleeve 11 configured to be expanded to abut the wellbore 2. The annular barriers 10 of each casing section have a common longitudinal extension L_A of at least 50% of the casing length L_C as seen in Fig. 2.

[0036] By having several casing sections 3 each comprising at least three annular barriers 10, the operator of the well is not limited to arranged the hydra-carbon-producing zones in predetermined areas, but can freely make perforations where the hydra-carbon-producing zones are very long after the system has been completed. The operator can thus quickly complete the well and subsequently make more accurate measurements for determining exactly where the hydra-carbon-producing layers are in the formation, and then perforate through the expandable metal sleeves of the annular barriers and even through the casing collars. The adjacent non-perforated annular barriers will provide the zonal isolation around the hydra-carbon-producing zone. Furthermore, when producing, the hydra-carbon-producing zones move and then the perforated zone can easily be patched off and new perforations at another location can be made for providing access to the hydra-carbon-producing zone.

[0037] As can be seen from Fig. 1, after perforation some of the expanded metal sleeves of the annular barriers have a plurality of perforations 21 and fractures 22 extending further into the formation. The fractures are mainly created by a subsequent fracturing operation.

[0038] In Fig. 2, the casing section having annular barriers has a first end part 23 and a second end part 24, and at least the first end part has at least 1 metre which is free from annular barriers, so that the casing section can be mounted by a rough neck. The annular barriers 10 are arranged with a mutual distance D_{AB} of less than

100 cm, preferably less than 50 cm. Each annular barrier 10 has a barrier length L_B of 1-2.5 metres as shown in Fig. 3B. The annular barriers of Fig. 3A have a common longitudinal extension L_A of at least 50% of the casing length L_C. In Fig. 3B, the casing section is shown having a base pipe 25 and each of the expandable metal sleeves 11 surrounds and fastens to the same base pipe 25, forming annular spaces 26 between the expandable metal sleeves 11 and the base pipe 25.

[0039] Each annular space may comprise at least one thermally decomposable compound, which compound is thermally decomposable below a temperature of 400°C and is adapted to generate gas or super-critical fluid upon decomposition. Thus, the decomposition of the compound is activated by a temperature increase, and the annular barriers are in this way expanded without pressurising the well tubular metal structure from within. The compound comprises nitrogen. The compound is selected from a group consisting of: ammonium dichromate, ammonium nitrate, ammonium nitrite, barium azide, sodium nitrate or a combination thereof. The compound decomposes at temperatures above 100°C, preferably above 180°C. The annular space is pre-pressurised to a pressure above 5 bar, preferably above 50 bar and more preferably above 100 bar, even more preferably above 250 bar. The compound is present in the form of a powder, a powder dispersed in a liquid or a powder dissolved in a liquid.

[0040] As seen in Fig. 9, the base pipe may also have at least one opening 27 opposite each of the expandable metal sleeves 11 for expanding the expandable metal sleeves by allowing pressurised fluid to enter the openings. In another embodiment, the annular barriers may further comprise a valve or valve assembly in fluid communication with the openings. The valve assembly operates between a first position in which fluid is allowed to enter the annular space to expand the expandable metal sleeve and a second position in which the opening is blocked and even permanently blocked. The valve assembly may be arranged outside the base pipe and connected to the opening by means of flow lines. The valve assembly may, in the second position, also equalise the pressure within the space with the pressure in the annulus surrounding the well tubular metal structure.

[0041] In Figs. 3A and 3B, the expandable metal sleeves 11 are fastened to the base pipe 25 by means of welding, but in another embodiment the expandable metal sleeve may be fastened to the base pipe by means of crimping and/or connection parts connecting the expandable metal sleeves to the base pipe in known ways.

[0042] In Figs. 4A and 4B, the expandable metal sleeves 11 of the casing section 3 are connected to form part of the base pipe 25, so that an inner face 28 of the expandable metal sleeves 11 forms part of an inner face 29 of the base pipe 25. The expandable metal sleeves thus form the base pipe together with tubular connection parts 31, and the expandable metal sleeves of the casing section are connected indirectly by means of the tubular connection parts.

[0043] In another embodiment, the expandable metal sleeves of the casing section are connected directly end to end in an overlapping manner, forming a connection area in the overlapping part. Thus, the expandable metal sleeves of each casing section having annular barriers may be connected directly or indirectly, forming the connection area 32, as seen in Figs. 4A and 4B. In a subsequent operation, a patch may be expanded inside the casing section, so that each end of the patch overlaps the connection area. The connection area is an area which is more rigid than the expandable metal sleeves, and the connection area does not expand when the expandable metal sleeves expand. Thus, the connection areas can be used for support for the patch. The connection areas also provide the base pipe with stability both before and after expansion of the expandable metal sleeve.

[0044] In Fig. 4B, the expandable metal sleeve 11 forms an end of the casing section 3, so that the expandable metal sleeve 11 is connected to the next casing section 3 by means of a casing collar 4.

[0045] In Figs. 3A-4B, each expandable metal sleeve 11 comprises a plurality of sealing elements 33 and the expandable metal sleeves also comprises sections 34 having an increased thickness, which sections 34 are expanded less than other sections 35 of the expandable metal sleeve 11.

[0046] In Figs. 6 and 8, each sealing element 33 comprises a sealing part 36 and key rings 37 as back-up to the sealing part 36. The section 34 having an increased thickness creates a groove 39 in which the sealing part 36 and key rings 37 are arranged. As seen in Fig. 8, the expandable metal sleeve may have a first thickness T1 opposite the groove 39 and a second thickness T2 outside the groove in the other sections 35. So the other sections 35 may have different thicknesses but thicknesses that are smaller than the thickness of section 34 having the increased thickness. In Fig. 10, an intermediate element 38 is arranged between the split ring-shaped retaining element in the form of key rings 37 and the sealing element 36. In this embodiment, the split ring-shaped retaining element 37 partly overlaps the intermediate element 38. The intermediate element 38 may be made of a flexible material and is adapted to maintain the split ring-shaped retaining element 37 in position and function as protection and support of the sealing element 36. The split ring-shaped retaining element or key rings 37, the intermediate element 38 and the sealing element 36 are placed in the groove 39 between the first and second projections, i.e. sections 34.

[0047] In Fig. 9, each sealing element 33 comprises a coiled spring or coiled springs 41 underneath a sealing sleeve 42 having an aperture 43. All the components of the sealing elements 33 in Fig. 9 are of metal and are thus very suitable in high temperature wells.

[0048] In Figs. 5a and 5B, the expandable metal sleeve 11 has a first end 14 and a second end 15 and an outer face 16 facing the wellbore/borehole. The annular barrier 10 comprises a first end part 17 having a first end 17A connected to the first end 14 of the expandable metal sleeve and a second end 17B for being mounted as part of the base pipe 25 of the casing section 3 of the well tubular metal structure 1. The annular barrier 10 further comprises a second end part 18 having a first end 18A connected to the second end of the expandable metal sleeve and a second end 18B for being mounted to another annular barrier and as part of the well tubular metal structure. The first end 17A of the first end part 17 is connected end to end to the first end 14 of the expandable metal sleeve 11, and the first end 18A of the second end part 18 is connected end to end to the second end 15 of the expandable metal sleeve. The second ends 17B, 18B of the end parts are provided with male or female thread connections for being mounted to corresponding male or female thread connections of other annular barriers of the casing sections. Sealing means 46 is provided between the connections.

[0049] The invention also relates to a downhole method for completing a well having a wellbore, in which the well tubular metal structure 1 is mounted from several casing sections 3 of the downhole completion system 100, then the well tubular metal structure is provided in the wellbore, and subsequently the expandable metal sleeves of the annular barriers are expanded to abut the wellbore. The expansion may be performed substantially simultaneously by pressurising the well tubular metal structure or may be performed sequentially, e.g. by means of a tool isolating part of the well tubular metal structure opposite the opening(s).

[0050] Subsequently, at least one of the expandable metal sleeves is perforated, e.g. by intervening by means of a perforation tool/gun, creating access of reservoir fluid into the casing sections and into the well tubular metal structure. Prior to perforation, measurements may be performed in order to determine where to perforate, i.e. where the hydro-carbon fluid is present.

[0051] In the event that the well starts producing in a non-optimal manner, a patch 51 (shown by dotted line in Fig. 1) made be inserted by means of a tool and expanded inside the well tubular metal structure opposite of perforated expandable metal sleeve for sealing off the perforations. Subsequently, new perforations across and through the annular barriers can be made to provide access for the hydro-carbon containing fluid to be produced up the well tubular metal structure.

[0052] 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.

[0053] By a casing string 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.

[0054] In the event that the perforation 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®.

[0055] 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 (100) for being arranged in a wellbore (2), comprising several casing sections (3) having a casing length of 10-14 metres mounted as one well tubular metal structure (1) by means of casing collars (4), wherein a number of the several casing sections each comprises at least three annular barriers (10) each comprising an expandable metal sleeve (11) configured to be expanded to abut the wellbore, the annular barriers of each casing section having a common longitudinal extension (L_A) of at least 50% of the casing length (L_C).

2. A downhole completion system according to claim 1, wherein at least one of the expanded metal sleeves has a plurality of perforations (21).

3. A downhole completion system according to any of the preceding claims, wherein each section has a first end part (23) and a second end part (24), at least the first end part having at least 1 metre which is free from annular barriers.

4. A downhole completion system according to any of the preceding claims, wherein the annular barriers are arranged with a mutual distance (D_{AB}) of less than 100 cm, preferably less than 50 cm.

5. A downhole completion system according to any of the preceding claims, wherein each annular barrier has a barrier length (L_B) of 1-2.5 metres.

6. A downhole completion system according to any of the preceding claims, wherein each casing section has a base pipe (25).

7. A downhole completion system according to claim 6, wherein each of the expandable metal sleeves

surrounds and fastens to the same base pipe, forming an annular space (26) between each expandable metal sleeve and the base pipe.

8. A downhole completion system according to claim 7, wherein each space comprises at least one thermally decomposable compound, which compound is thermally decomposable below a temperature of 400°C and is adapted to generate gas or super-critical fluid upon decomposition.

9. A downhole completion system according to claim 6, wherein the base pipe has at least one opening (27) opposite each of the expandable metal sleeves for expanding the expandable metal sleeves by allowing pressurised fluid to enter the openings.

10. A downhole completion system according to any of the claims 6-9, wherein the expandable metal sleeves are fastened to the base pipe by means of welding, crimping or connection parts connecting the expandable metal sleeves to the base pipe.

11. A downhole completion system according to claim 6, wherein the expandable metal sleeves of each casing section are connected to form part of the base pipe, so that an inner face (28) of the expandable metal sleeves forms part of an inner face (29) of the base pipe.

12. A downhole completion system according to claim 11, wherein the expandable metal sleeves of each casing section are connected directly or indirectly, forming a connection area (32).

13. A downhole method for completing a well (5) having a wellbore (2), comprising:

- mounting a well tubular metal structure (1) from several casing section (3) of the downhole completion system (100) according to any of the claims 1-12,
- providing the well tubular metal structure in the wellbore, and
- expanding the expandable metal sleeves (11) of the annular barriers (10) to abut the wellbore.

14. A downhole method according to claim 13, further comprising perforating at least one of the expandable metal sleeves, creating access of reservoir fluid into the casing sections and into the well tubular metal structure.

15. A downhole method according to claim 14, further comprising expanding a patch (51) inside the well tubular metal structure opposite the perforated expandable metal sleeve for sealing off perforations (21).

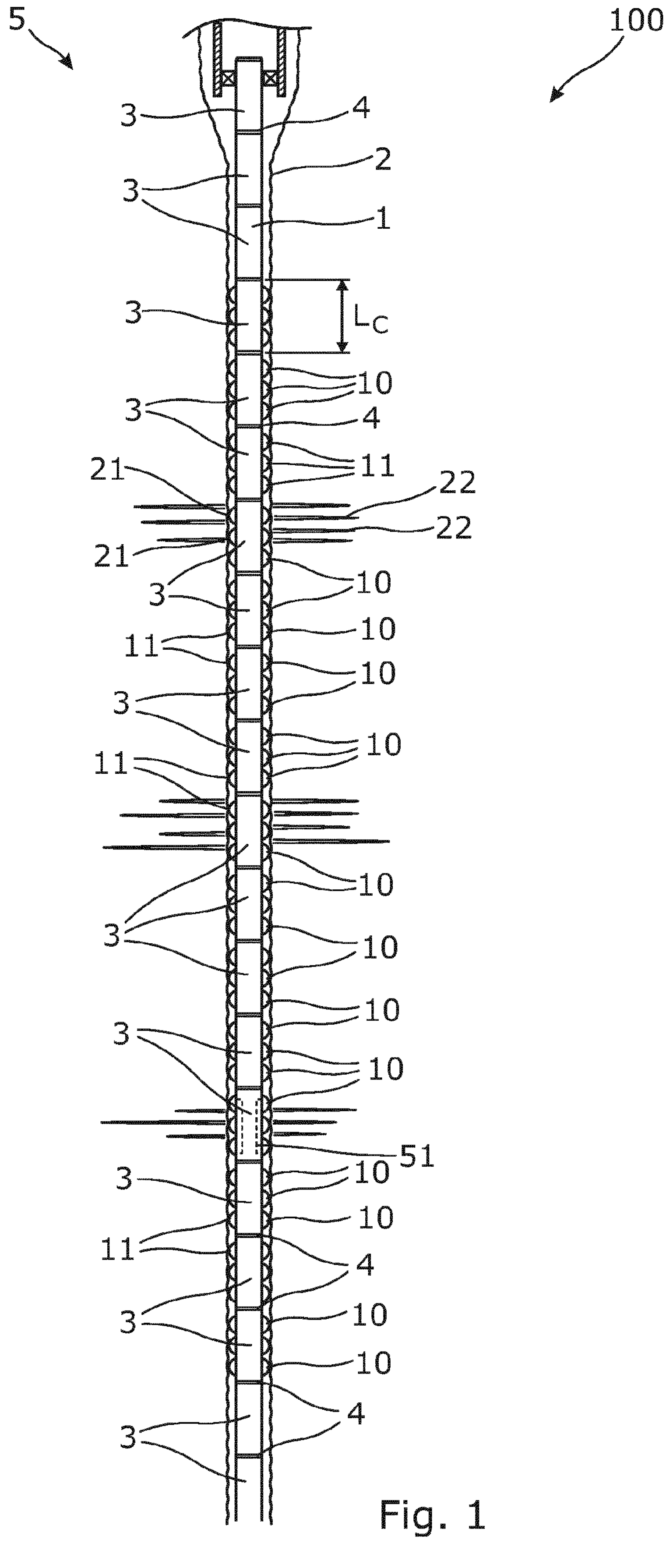

Fig. 1

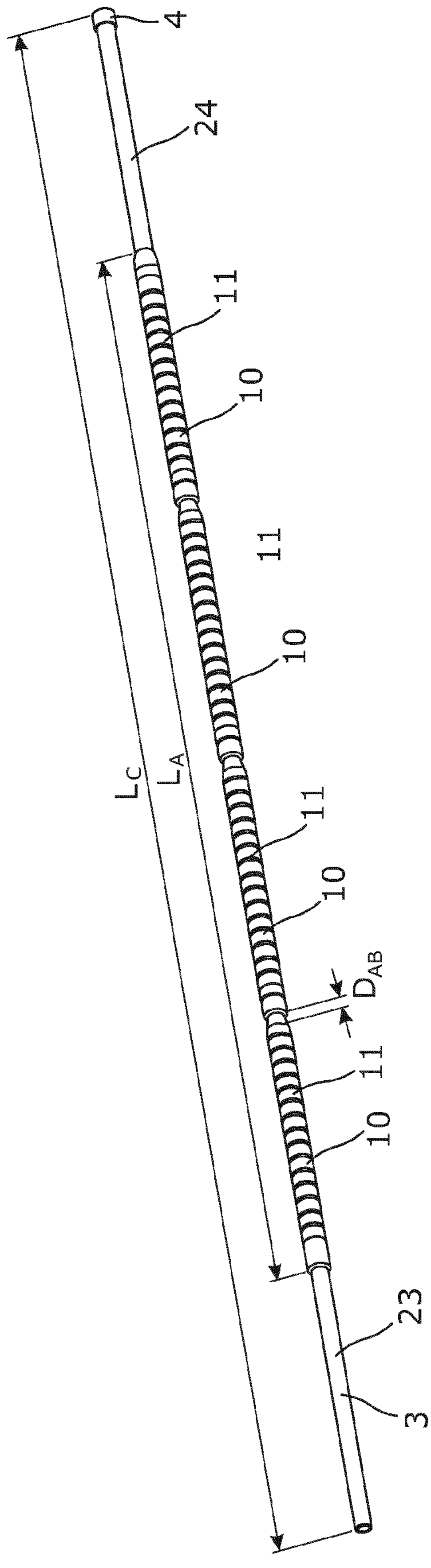

Fig. 2

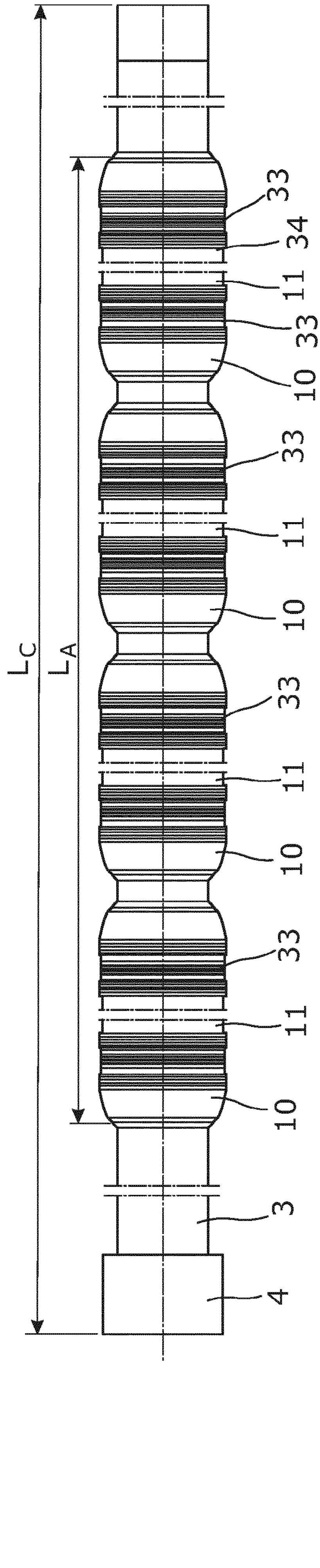

Fig. 3A

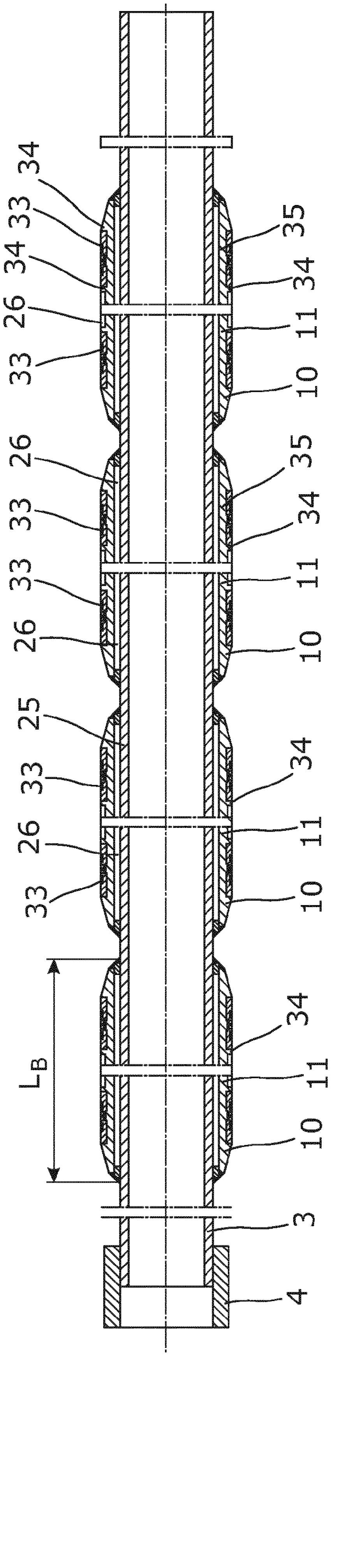

Fig. 3B

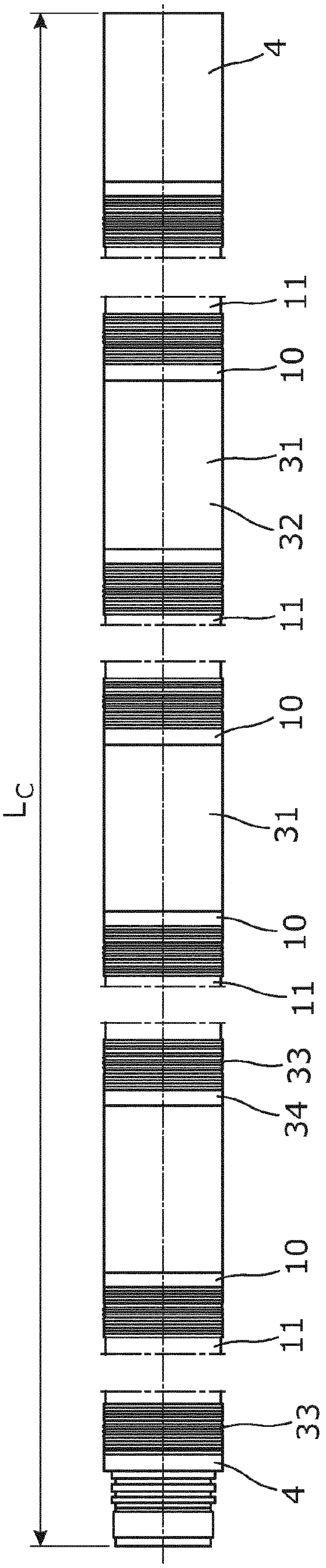

Fig. 4A

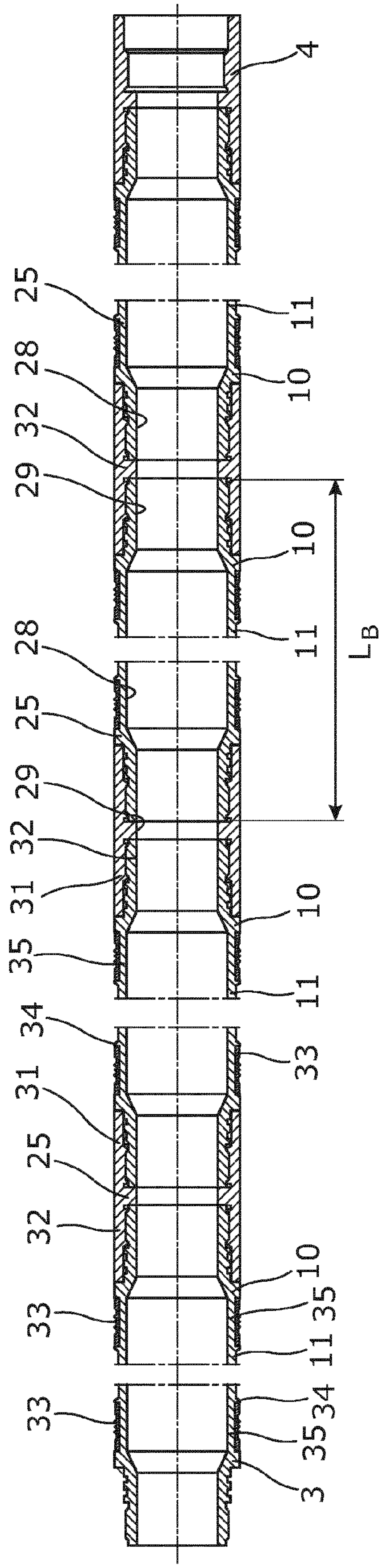

Fig. 4B

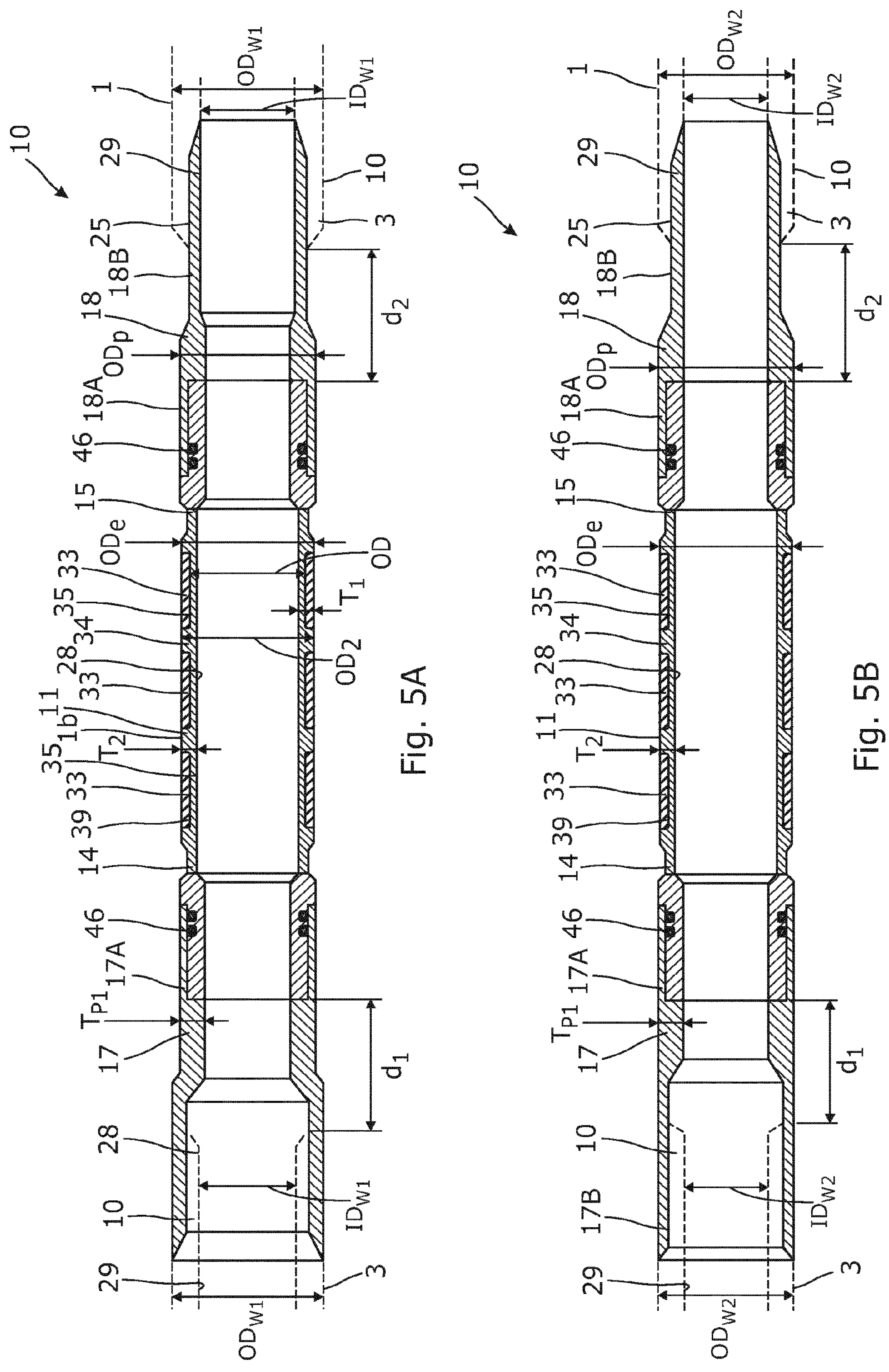
10
1
29
25
18B
18
ODp
18A
46
15
ODe
33
35
34
28
11
1b
T2
39
14
17A
TP1
17
10
ODW1
IDW1
3
d2
OD
T1
OD2
d1
17B
ODW2
IDW2

Fig. 5A

Fig. 5B

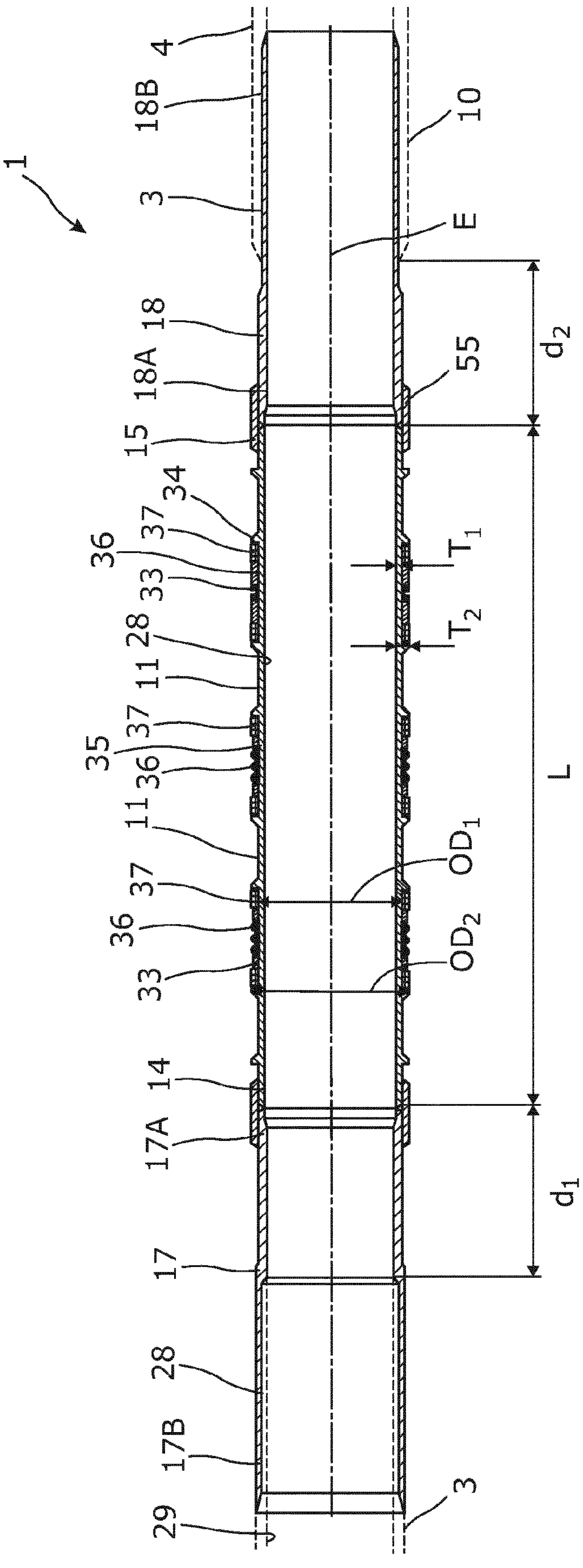
1
4
18B
3
10
E
18
18A
55
d2
15
34
37
36
33
28
11
T1
T2
37
35
36
11
L
37
36
OD1
OD2
33
14
17A
d1
17
28
17B
29
3

Fig. 6

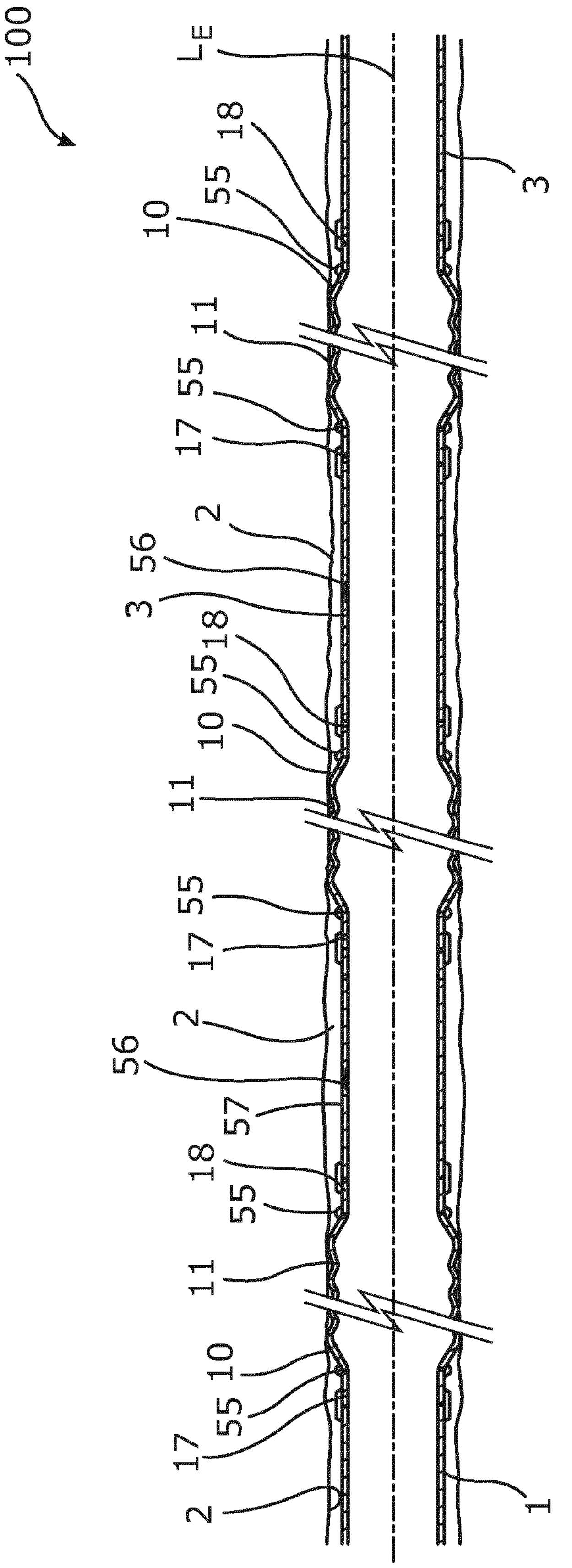
100
L_E
18
55
10
3
11
55
17
2
56
3
18
55
10
11
55
17
2
56
57
18
55
11
10
55
17
2
1

Fig. 7

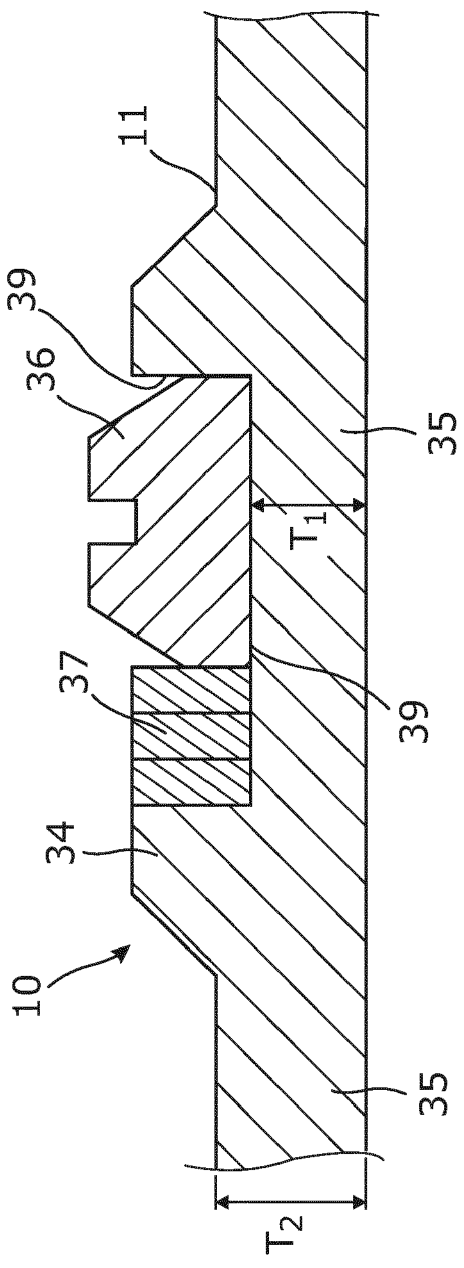

Fig. 8

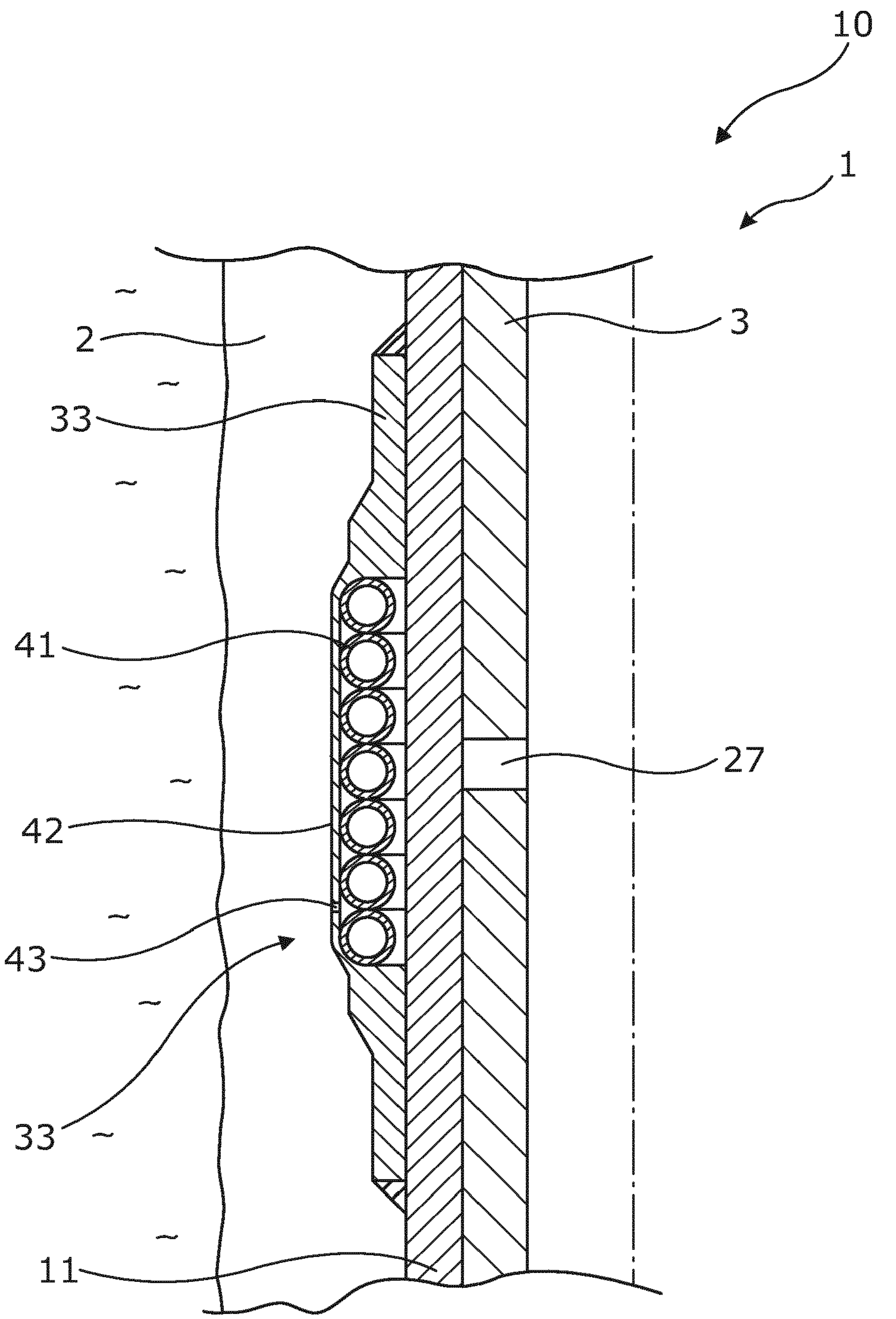

Fig. 9

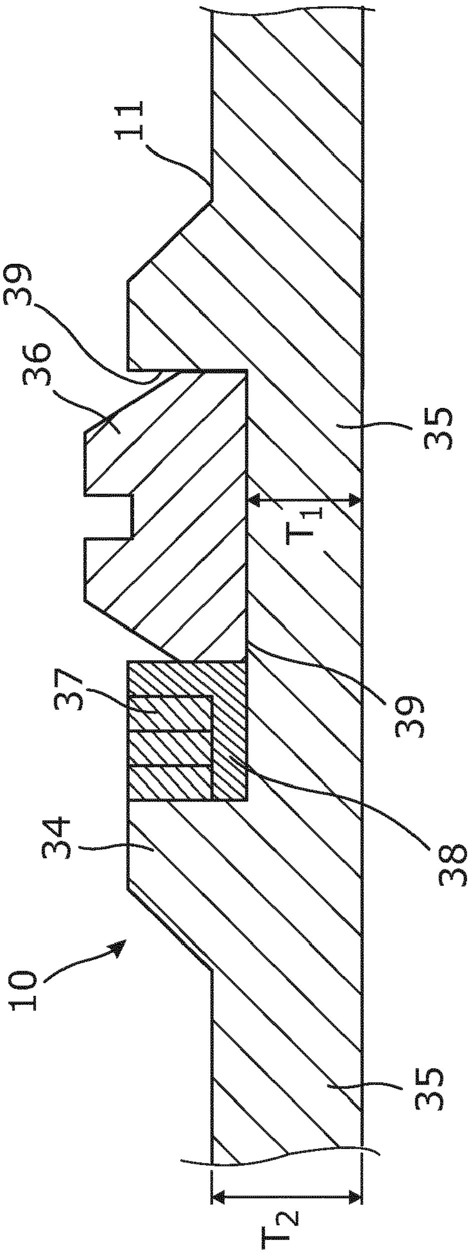

Fig. 10