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(54) **Title**: A DOWNHOLE EXPANDABLE TUBULAR

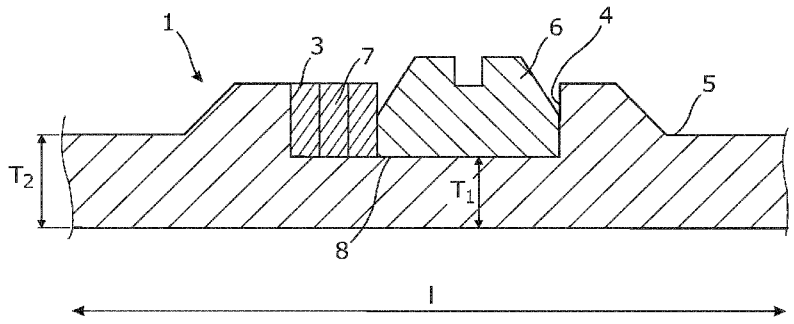

Fig. 2

(57) **Abstract**: The present invention relates to a downhole expandable tubular to be expanded in a well downhole from a first outer diameter to a second outer diameter to abut against an inner face of a casing or borehole, the downhole expandable tubular having an outer face and a longitudinal extension and comprising at least one first circumferential edge and at least one second circumferential edge provided on the outer face and spaced apart in the longitudinal extension, wherein a sealing element and a split ring-shaped retaining element are arranged between the first and second circumferential edges, the split ring-shaped retaining element forming a back-up for the sealing element and wherein the split ring-shaped retaining element has more than one winding, so that when the expandable tubular is expanded from the first outer diameter to the second outer diameter, the split ring-shaped retaining element partly unwinds. Furthermore, the present invention relates to an annular barrier.

A DOWNHOLE EXPANDABLE TUBULAR

Field of the invention

The present invention relates to a downhole expandable tubular to be expanded in a well downhole. Furthermore, the present invention relates to an annular barrier.

Background art

In wellbores, expandable tubulars are used for different purposes, such as for sealing off an opening in the casing, in the form of a patch or liner, for providing a barrier to flow between an inner and an outer tubular structure, or between an inner tubular structure and the inner wall of the borehole, in the form of an annular barrier, or for providing a liner hanger.

When the expandable tubulars are being used to seal off e.g. an opening or a zone, separate sealing elements are often provided on an exterior face of the expandable tubular for enhancing the sealing properties. However, it has been experienced that it is difficult to control the position of the sealing element during expansion of the expandable tubulars, causing the sealing element to possibly be displaced from its intended position, whereby there is a risk that the sealing properties may not be as intended.

Summary of the invention

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 a downhole expandable tubular with enhanced sealing properties.

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 expandable tubular to be expanded in a well downhole from a first outer diameter to a second outer diameter to abut against an inner face of a casing or borehole, the downhole expandable tubular having an outer face and a longitudinal extension and comprising

at least one first circumferential edge and at least one second circumferential edge provided on the outer face and spaced apart in the longitudinal extension, wherein a sealing element and a split ring-shaped retaining element are arranged between the first and second circumferential edges, the split ring-shaped retaining element forming a back-up for the sealing element and wherein the split ring-shaped retaining element has more than one winding, so that when the expandable tubular is expanded from the first outer diameter to the second outer diameter, the split ring-shaped retaining element partly unwinds.

Hereby, it is obtained that the split ring-shaped retaining element ensures that the sealing element is maintained in the longitudinal extension of the downhole expandable tubular even when it is being expanded, so that the sealing element retains its intended position and the sealing properties of the downhole expandable tubular are enhanced. The sealing element may withstand a higher pressure on the side where the split ring-shaped retaining element is positioned, since the split ring-shaped retaining element functions as a back-up and support system for the sealing element.

Furthermore, the split ring-shaped retaining element may be arranged in an abutting manner to the sealing element.

Also, the split ring-shaped retaining element may preferably be made of material having a yield strength of at least 69 MPa, preferably at least 100 MPa.

In an embodiment, the split ring-shaped retaining element may unwind by less than one winding when the expandable tubular is expanded from the first outer diameter to the second outer diameter.

The more than one winding of the split ring-shaped retaining element may abut each other along the ring-shaped retaining element.

Moreover, the more than one winding of the split ring-shaped retaining element may be helically wound around the downhole expandable tubular.

Also, the split ring-shaped retaining element may have more than one winding in the second outer diameter of the downhole expandable tubular.

Furthermore, the split ring-shaped retaining element may have a width in the longitudinal extension, the width being substantially the same in the first outer diameter and the second outer diameter of the downhole expandable tubular.

In an embodiment, the split ring-shaped retaining element may have a plurality of windings.

The downhole expandable tubular according to the present invention may have a first thickness between the first and second circumferential edges and a second thickness in adjacent areas, the first thickness being smaller than the second thickness.

Hereby, it is obtained that expansion of the downhole expandable tubular is facilitated between the first and second circumferential edges, so that the downhole expandable tubular may expand more in this area than in the adjacent areas, whereby the sealing element may be further forced against the inner face of a casing or borehole.

Moreover, the split ring-shaped retaining element may, while partly unwinding, increase in outer diameter in at least one end.

Further, the split ring-shaped retaining element and the sealing element may substantially fill a gap provided between the first and second circumferential edges.

In an embodiment, the split ring-shaped retaining element may be made of a metallic material.

In another embodiment, the split ring-shaped retaining element may be made of a spring material.

Also, the split ring-shaped retaining element may have an inner diameter, the inner diameter being substantially equal to an outer diameter of the downhole expandable tubular between the first and second circumferential edges.

In one embodiment, the split ring-shaped retaining element may have a square cross-section.

In another embodiment, the split ring-shaped retaining element may have a circular cross-section.

Moreover, the sealing element may be partially cone-shaped.

A plurality of sealing elements may be arranged between the first and second circumferential edges.

Additionally, the split ring-shaped retaining element may be arranged on a first side of the sealing element, and a second split ring-shaped retaining element may be arranged on another side of the sealing element opposite the first side.

Also, the split ring-shaped retaining element may retain the sealing element in a position along the longitudinal extension of the downhole expandable tubular while expanding the split ring-shaped retaining element and the sealing element.

Moreover, the ring-shaped retaining element may be a split ring.

Further, the first and second circumferential edges may be part of a groove provided in the outer face of the downhole expandable tubular.

The downhole expandable tubular according to the present invention may comprise at least two projections providing the circumferential edges.

Moreover, the first and second circumferential edges may be extending in a radial extension in relation to the downhole expandable tubular, said radial extension being perpendicular to the longitudinal extension of the downhole expandable tubular.

In addition, an intermediate element may be arranged between the split ring-shaped retaining element and the sealing element.

Said split ring-shaped retaining element may partly overlap the intermediate element.

Further, the split ring-shaped retaining element and the intermediate element may be arranged in an abutting manner to the sealing element, so that at least

one of the split ring-shaped retaining element and the intermediate element may abut the sealing element.

Additionally, the sealing element may be made of an elastomer, rubber, polytetrafluoroethylene (PTFE) or another polymer.

Also, the intermediate element may be made of a flexible material. The flexible material may be Polytetrafluoroethylene (PTFE) as a base material with for instance brass, carbon and/or stainless steel contained therein.

Furthermore, the downhole expandable tubular may be made from one tubular metal blank.

The blank may be made by centrifugal casting or spin casting.

In an embodiment, the first and second circumferential edges may be provided by machining the blank.

The downhole expandable tubular according to the present invention may be machined from the blank by means of grinding, milling, cutting or latheing or by means of a similar method.

Moreover, the downhole expandable tubular may comprise a plurality of circumferential edges, projections and/or grooves along the longitudinal extension of the downhole expandable tubular.

Further, the downhole expandable tubular may be a patch to be expanded within a casing or well tubular structure in a well, a liner hanger to be at least partly expanded within a casing or well tubular structure in a well, or a casing to be at least partly expanded within another casing.

Also, the downhole expandable tubular may be provided with at least one circumferential projection.

The present invention also relates to an annular barrier to be expanded in an annulus between a well tubular structure and an inside wall of a borehole or a

casing downhole for providing zone isolation between a first zone and a second zone of the borehole, comprising:

- a tubular part for mounting as part of the well tubular structure,
- a downhole expandable tubular as mentioned above, surrounding the tubular part and having an outer face facing towards the inside wall of the borehole or the casing, each end of the downhole expandable tubular being connected with the tubular part,
- a space between the downhole expandable tubular and the tubular part, and
- an expansion opening in the tubular part through which fluid may enter into the space in order to expand the downhole expandable tubular.

Also, a sleeve may be arranged in between the downhole expandable tubular and the tubular part in the annular barrier, the sleeve being connected with the tubular part and the downhole expandable tubular, thus dividing the space into a first space section and a second space section.

The annular barrier according to the present invention may comprise several sleeves squeezed in between the tubular part and the downhole expandable tubular.

Furthermore, the downhole expandable tubular may have an opening providing fluid communication between the first or the second zone and one of the space sections.

Additionally, the projection may be a ring-shaped projection of an increased thickness in relation to other parts of the downhole expandable tubular, the ring-shaped projection providing an enforcement of the annular barrier when the annular barrier is expanded.

Moreover, the present invention relates to a downhole completion comprising a downhole expandable tubular as described above and a casing having an inner face against which at least part of the downhole expandable tubular may be expanded.

Also, the present invention relates to a downhole completion comprising a well tubular structure and an annular barrier as described above, where the tubular part of the annular barriers may be mounted as part of the well tubular structure.

Finally, the present invention relates to a method for positioning and maintaining a sealing element on a downhole expandable tubular while the downhole expandable tubular is expanded from a first outer diameter to a second outer diameter, comprising the steps of:

- arranging a sealing element circumferentially about the downhole expandable tubular between a first edge and second edge provided on an outer face of the downhole expandable tubular, and
- arranging a split ring-shaped retaining element about the downhole expandable tubular between the first edge and the sealing element, so that the split ring-shaped retaining element and the sealing element substantially fill out a gap between the first and second edges.

In an embodiment, an intermediate element may be arranged between the split ring-shaped retaining element and the sealing element.

The split ring-shaped retaining element may be arranged on a first side of the sealing element, and a second split ring-shaped retaining element may be arranged on another side of the sealing element opposite the first side.

Brief description of the drawings

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 part of the downhole expandable tubular in a non-expanded and expanded position, respectively,

Figs. 2-7 show in cross-sectional views of different embodiments of the split ring-shaped retaining element and sealing element arranged between a first and a second circumferential edge of the downhole expandable tubular,

Fig. 8 shows a part of the downhole expandable tubular in a side view,

Figs. 9-10 show the split ring-shaped retaining element,

Figs. 11a-b show the split ring-shaped retaining element in a perspective view,

Fig. 12 shows a cross-sectional view of a part of the downhole expandable tubular,

Fig. 13 shows a cross-sectional view of an embodiment of a downhole expandable tubular without the split ring-shaped retaining element and the sealing element,

Fig. 14 shows a cross-sectional view of a downhole expandable tubular in the form of a patch,

Fig. 15 shows a cross-sectional view of a downhole expandable tubular in the form of a liner hanger,

Fig. 16 shows a cross-sectional view of an annular barrier comprising a downhole expandable tubular,

Fig. 17 shows downhole completion having an annular barrier with a downhole expandable tubular, and

Fig. 18 shows another annular barrier having an intermediate sleeve for equalising the pressure across the downhole expandable tubular.

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

Fig. 1 shows a cross-sectional part of a downhole expandable tubular 1 according to the present invention in a non-expanded (left side of Fig.1) and expanded position (right side of Fig. 1), respectively. The downhole expandable tubular 1 is to be expanded in a well downhole from a first outer diameter D_1 to a second outer diameter D_2 in order to, in this embodiment, abut against an inner face 2 of a borehole.

The downhole expandable tubular 1 has a longitudinal extension l and comprises at least one first circumferential edge 3 and at least one second circumferential edge 4 provided on an outer face 5 of the downhole expandable tubular 1 and

spaced apart in the longitudinal extension. Furthermore, a sealing element 6 and a split ring-shaped retaining element 7 are arranged between the first and second circumferential edges 3, 4. The split ring-shaped retaining element 7 has more than one winding, so that when the downhole expandable tubular is expanded from the first outer diameter D_1 to the second outer diameter D_2, the windings of the split ring-shaped retaining element 7 partly unwinds. In the embodiment shown in Fig. 1, the split ring-shaped retaining element 7 has three windings. However, in other embodiments it may have two, four, five, six or seven windings, and even a higher number of windings is possible. The split ring-shaped retaining element 7 and the sealing element 6 occupy the gap between the first and second circumferential edges 3, 4. Thus, the split ring-shaped retaining element 7 is arranged in an abutting manner to the sealing element. Hereby, it is obtained that the split ring-shaped retaining element 7 ensures that the sealing element 6 is maintained and supported in the longitudinal extension of the downhole expandable tubular 1 even when it is being expanded, so that the sealing element 6 retains its intended position and the sealing properties of the downhole expandable tubular 1 are enhanced. Furthermore, tests have shown that the sealing element may withstand a higher pressure on the side where the split ring-shaped retaining element is positioned, since the split ring-shaped retaining ring functions as a back-up and support system for the sealing element. In addition, the split ring-shaped retaining element 7 has a width w in the longitudinal extension l, the width w being substantially the same in the first outer diameter D_1 and the second outer diameter D_2 of the downhole expandable tubular 1.

Fig. 2 shows an enlarged cross-sectional view of the downhole expandable tubular 1 shown in Fig. 1. The sealing element 6 abuts the second edge 4, and the split ring-shaped retaining element 6 is arranged between the first edge 3 and the sealing element 6. The split ring-shaped retaining element 7 has three windings and each winding has a square cross-section. In this embodiment, the first and second circumferential edges 3, 4 are part of a groove 8 provided in the outer face 5 of the downhole expandable tubular 1. The first and second circumferential edges 3, 4 are extending in a radial extension in relation to the downhole expandable tubular 1, said radial extension being substantially perpendicular to the longitudinal extension l of the downhole expandable tubular 1.

The downhole expandable tubular 1 has a first thickness T_1 between the first and second circumferential edges 3, 4, i.e. in the groove 8, and a second thickness T_2 in adjacent areas, the first thickness T_1 being smaller than the second thickness T_2. Hereby, it is obtained that expansion of the downhole expandable tubular 1 is facilitated between the first and second circumferential edges 3, 4, so that the downhole expandable tubular 1 may expand more in this area than in the adjacent areas, whereby the sealing element 6 may be further forced against the inner face of a casing or borehole (not shown).

Fig. 3 shows another embodiment of the downhole expandable tubular 1 wherein an intermediate element 9 is arranged between the split ring-shaped retaining element 7 and the sealing element 6. In this embodiment, the split ring-shaped retaining element 7 partly overlaps the intermediate element 9. The intermediate element 9 may be made of a flexible material and is adapted to maintain the split ring-shaped retaining element 7 in position and function as protection and support of the sealing element 6. The split ring-shaped retaining element 7, the intermediate element 9 and the sealing element 6 are placed in the groove 8 between the first and second circumferential edges 3, 4.

Fig. 4 shows an embodiment of the downhole expandable tubular 1, wherein the split ring-shaped retaining element 7 is arranged on a first side of the sealing element 6 and a second split ring-shaped retaining element 7 is arranged on another side of the sealing element 6 opposite the first side. The two second split ring-shaped retaining element 7 and the sealing element 6 are arranged in the groove 8 between the first and second circumferential edges 3, 4.

Fig. 5a shows an embodiment of the downhole expandable tubular 1, wherein first and second intermediate elements 9 are arranged between the split ring-shaped retaining elements 7 and the sealing element 6. In this embodiment, the windings of the split ring-shaped retaining elements 7 have a round cross-section and partly overlap the intermediate elements 9. In the same manner as shown in the preceding figures, the elements are arranged in the groove 8 between the first and second circumferential edges 3, 4.

Fig. 5b shows the embodiment of the downhole expandable tubular 1 of Fig. 5a in an expanded position up against an inner face 2 of a borehole or a casing. The intermediate elements 9 may preferably be made of a flexible material such as

reinforced Teflon, i.e. Polytetrafluoroethylene (PTFE) as a base material with for instance brass, carbon and/or stainless steel parts, such as fibres, contained therein. Accordingly, the intermediate elements 9 may change their geometrical shapes during expansion and due to the pressure present in the annulus, so that the intermediate elements become triangular in their cross-sections as shown in Fig. 5b, whereby the intermediate elements slope away from the sealing element 6 to the circumferential edges 3, 4. The split ring-shaped retaining elements 7 overlap the intermediate elements 9 and thus also have an inclined extension in the longitudinal extension of the downhole expandable tubular. Hereby it is obtained that the split ring-shaped retaining elements 7 and the intermediate elements 9 together function as back-up and support systems for the sealing element 6, causing the sealing element 6 to be able to withstand high pressures on both sides of the sealing element 6 before losing its sealing properties.

Fig. 6 shows yet another embodiment of the downhole expandable tubular 1, wherein first and second intermediate elements 9 are also arranged between the split ring-shaped retaining elements 7 and the sealing element 6. In this embodiment, the intermediate elements 9 have another shape than shown in Figs. 3 and 5, and the windings of the split ring-shaped retaining elements 7 abut the intermediate elements on one side, and the opposite side of the split ring-shaped retaining elements 7 abut first and second circumferential edges 3, 4, respectively. All the elements are arranged in the groove 8 between the first and second circumferential edges 3, 4.

In Fig. 7, another embodiment of the downhole expandable tubular 1 is shown, wherein the downhole expandable tubular 1 comprises at least two projections 10 providing the first and second circumferential edges 3, 4. The sealing element 6, intermediate elements 9 and the split ring-shaped retaining elements 7 are arranged between the two projections 10, i.e. the first and second circumferential edges 3, 4, so that the intermediate elements 9 abut the sealing element from either side and the split ring-shaped retaining elements 7 are arranged outside the intermediate elements 9.

In the shown embodiments, only one sealing element is shown. In other not shown embodiments, a plurality of sealing elements may be arranged between the first and second circumferential edges. The sealing element is preferably made of a sealant material such as rubber or elastomeric material,

polytetrafluoroethylene (PTFE) or another polymer, so that it is flexible and may be pushed up against an inner face. The sealing element may have different cross-sections, for instance cone-shaped or round, and it may comprise several projections.

In Fig. 8, the downhole expandable tubular 1 is partly shown in an exterior side view. The split ring-shaped retaining elements 7 each has three windings extending around the downhole expandable tubular 1, and the sealing element 6 is also extending around the expandable tubular. The first and second circumferential edges 3, 4 are also extending circumferentially around the expandable tubular 1.

The split ring-shaped retaining element is preferably made of material having a yield strength of at least 69 MPa, preferably at least 100 MPa. The split ring-shaped retaining element is preferably made of a metallic material, such as a spring material, or polyether ether ketone (PEEK) or similar material. Since the split ring-shaped retaining element 7 comprises more than one winding and is made by metallic material, it will, when the downhole expandable tubular 1 is expanded, also be expanded. Hereby it is obtained that the split ring-shaped retaining element 7 will function as an efficient expandable steel back-up and support system for the sealing element. For instance, when the downhole expandable tubular is expanded by 30%, the split ring-shaped retaining element 7 is unwound by approximately 30% of the circumference of the split ring-shaped retaining element 7, and thus the split ring-shaped retaining element 7 decreases its number of windings so that it is still capable of closing the gaps in the longitudinal extension, whereby the sealing element, the split ring-shaped retaining elements and the intermediate elements (if present) fill out the gap between the first and second circumferential edges 3, 4. In Figs. 9 and 10, a split ring-shaped retaining element 7 is shown. As described above, the split ring-shaped retaining element 7 comprises more than one winding which closely abut each other. During the expansion of the split ring-shaped retaining element 7, its diameter increases from D to D_e as described above and shown in Figs. 9 and 10. Due to the windings and the spring material, the windings will be displaced in relation to each other, and an end 11 of the split ring-shaped retaining element 7 will move from the position shown in Fig. 9 to the position shown in Fig. 10. Figs. 11a and 11b show a perspective view of the split ring-shaped retaining element 7 in a non-expanded and expanded position, respectively, whereby it is deducible

that the number of windings 7', 7'', 7''' of the split ring-shaped retaining element 7 decreases during expansion, since the perimeter or circumference of the split ring-shaped retaining element 7 increases during the expansion.

As shown in Fig. 12, the split ring-shaped retaining elements 7 are arranged on opposite sides of the sealing element 6, containing and maintaining the sealing element 6 within its circumferential edges. The split ring-shaped retaining elements 7 may have approximately 3.5 windings, and after expansion of the downhole expandable tubular, the split ring-shaped retaining element 7 has approximately 2.7 windings and thus substantially maintains its extension and width in the longitudinal extension of the downhole expandable tubular 1, even though the split ring-shaped retaining element 7 has been partly unwound. As shown in Fig. 11, the windings 7', 7'', 7''' of the split ring-shaped retaining element 7 are helically wound around the downhole expandable tubular 1.

In Fig. 13, the downhole expandable tubular 1 is shown without any split ring-shaped retaining element and sealing element. In this embodiment, it comprises two pairs of first and second circumferential edges 3, 4 and two grooves 8 provided in the outer face 5 of the downhole expandable tubular 1.

The downhole expandable tubular may be made from one tubular metal blank, wherein the blank may be made by centrifugal casting or spin casting. Furthermore, the first and second circumferential edges may be provided by machining the blank.

In Fig. 14, the downhole expandable tubular 1 is a patch which is expanded within a casing 12 part of a well tubular structure in a well. The patch is typically used for sealing off a leak or a perforated zone of openings 13 in the casing. The downhole expandable tubular 1 is inserted into the casing 12 having a first diameter, and when positioned opposite the openings 13, the expandable tubular is expanded to a second and larger diameter until the sealing elements 6 are pressed in between the downhole expandable tubular 1 and the inner face 2 of the casing 12, as shown in the encircled enlarged view. Since the sealing elements 6 are arranged between first and second circumferential edges 3, 4 on opposite sites of the perforated zone of openings 13, the zone is sealed off and the well fluid from the formation is prevented from flowing in through the openings 13.

In Fig. 15, the downhole expandable tubular 1 is a liner hanger where the downhole expandable tubular 1 has been partly expanded within an upper casing 12 forming part of a well tubular structure in a well. Above the upper casing 12, a wellhead 75 may be arranged. The downhole expandable tubular 1 has a first part 36 arranged opposite the upper casing 12 and a second part 37 arranged beneath the upper casing. The first part 36 of the downhole expandable tubular 1 has been expanded until the sealing elements 6 are pressed against the inner face 2 of the casing 12 and the second part 37 of the downhole expandable tubular 1 remains unexpanded.

Fig. 16 shows a cross-sectional view of an annular barrier 100 which has been expanded in an annulus 101 between a well tubular structure 300 and an inside face 2 of the borehole 200. The annular barrier 100 provides zone isolation between a first zone 102 and a second zone 103 of the borehole. The annular barrier 100 has an axial extension 22 which coincides with the longitudinal extension of the casing and well tubular structure 300. The annular barrier 100 comprises a tubular metal part 20, which may be a separate tubular part or a casing part for mounting a part of the well tubular structure 300. Furthermore, the annular barrier 100 comprises the downhole expandable tubular 1 which surrounds the tubular part, and each end 31, 32 of the downhole expandable tubular 1 is connected with the tubular part by means of connection parts 30. The downhole expandable tubular 1 and the tubular metal part 20 enclose an annular barrier space 21, and an expansion opening 23 is provided in the tubular part through which fluid may enter the space 21 in order to expand the downhole expandable tubular 1 as shown in Fig. 15. The downhole expandable tubular 1 is expanded until the sealing elements 6 or the projections or edges abut the inner face 2 of the borehole 200, so that fluid is prevented from flowing freely from the first zone 102 to the second zone 103.

As shown in Fig. 17, two annular barriers 100 are often used to isolate a production zone 400. A fracturing valve or section 600, also called the frac port, is arranged in between the annular barriers 100, so that when the annular barriers 100 have been expanded, the frac port 600 is opened and fluid is let into the formation for creating fractures in the formation to ease the flow of hydrocarbon-containing fluid, such as oil, into the well tubular structure 300. The fracturing valve or section 600 may also comprise an inlet section which may be

the same as the frac port. A screen may be arranged so that the fluid is filtered before flowing into the casing.

As shown in Fig. 18, the annular barrier further comprises a sleeve 25 arranged in between the downhole expandable tubular 1 and the tubular part 20. The sleeve 25 is connected with the tubular part 20 and the downhole expandable tubular 1, thus dividing the space into a first space section 21a and a second space section 21b. The sleeve is squeezed in between the tubular part and the downhole expandable tubular. The sleeve 25 may also be connected with the tubular part in another manner, such as crimped onto the tubular part. In order to equalise the pressure, the downhole expandable tubular has an opening 24 providing fluid communication between the first or the second zone and one of the space sections, thus equalising the pressure between the space and that zone. When e.g. performing hydralic fracturing or another well treatment, the pressure in one of the zones in which hydraulic fracturing is performed is increasing, and in order to prevent the expandable tubular from collapsing, the fluid is let in through the opening 24 and into the first space section 21a. When exposed to the increased pressure, the sleeve 25 moves towards the tubular part, thus yielding to the increased pressure in the first space section 21a, and the first space section 21a increases until the pressure equalises or the sleeve abuts the tubular part.

The downhole expandable tubular part may also be crimped onto the tubular part, or, if the annular barrier comprises a sleeve, crimped onto the sleeve at its ends. The sleeve is flexible and made of metal or a polymer, such as elastomer. As shown in Fig. 18, the projection is a ring-shaped projection of an increased thickness in relation to other parts of the downhole expandable tubular, the ring-shaped projection providing an enforcement of the annular barrier when the annular barrier is expanded.

In Fig. 18, the ring-shaped retaining element 10 of the annular barrier is a split ring having three windings. In the annular barriers shown in Figs. 16 and 18, the ends of the downhole expandable tubular may be welded to the tubular part, or the downhole expandable tubular may be crimped onto the tubular part. One end of the downhole expandable tubular may be sliding in relation to the tubular part.

The tubular blank may be made of any kind of metal, such as iron, steel or stainless steel, or more ductile materials, such as copper, aluminium, lead, tin, nickel, polymers, elastomers, rubber or a combination thereof.

By fluid or well fluid is meant any kind of fluid that may be present in oil or gas wells downhole, such as natural gas, oil, oil mud, crude oil, water, etc. By gas is meant any kind of gas composition present in a well, completion, or open hole, and by oil is meant any kind of oil composition, such as crude oil, an oil-containing fluid, etc. Gas, oil, and water fluids may thus all comprise other elements or substances than gas, oil, and/or water, respectively.

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

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 expandable tubular (1) to be expanded in a well downhole from a first outer diameter (D_1) to a second outer diameter (D_2) to abut against an inner face (2) of a casing or borehole, the downhole expandable tubular (1) having an outer face (5) and a longitudinal extension (l) and comprising:
at least one first circumferential edge (3) and at least one second circumferential edge (4) provided on the outer face and spaced apart in the longitudinal extension,
wherein a sealing element (6) and a split ring-shaped retaining element (7) are arranged between the first and second circumferential edges (3, 4), the split ring-shaped retaining element forming a back-up for the sealing element and
wherein the split ring-shaped retaining element (7) has more than one winding, so that when the expandable tubular is expanded from the first outer diameter (D_1) to the second outer diameter (D_2), the split ring-shaped retaining element (7) partly unwinds.

2. A downhole expandable tubular (1) according to claim 1, wherein the split ring-shaped retaining element (7) is arranged in an abutting manner to the sealing element.

3. A downhole expandable tubular (1) according to claim 1 or 2, wherein the split ring-shaped retaining element is preferably made of material having a yield strength of at least 69 MPa, preferably at least 100 MPa.

4. A downhole expandable tubular (1) according to any of claims 1-3, wherein the split ring-shaped retaining element (7) unwinds by less than one winding when the expandable tubular is expanded from the first outer diameter (D_1) to the second outer diameter (D_2).

5. A downhole expandable tubular (1) according to any of the preceding claims, wherein the split ring-shaped retaining element (7) has more than one winding in the second outer diameter (D_2) of the downhole expandable tubular.

6. A downhole expandable tubular (1) according to any of the preceding claims, wherein the split ring-shaped retaining element (7) has a width (w) in the longitudinal extension, the width being substantially the same in the first outer

diameter (D_1) and the second outer diameter (D_2) of the downhole expandable tubular.

7. A downhole expandable tubular (1) according to any of the preceding claims, wherein the split ring-shaped retaining element (7) has a plurality of windings.

8. A downhole expandable tubular (1) according to any of the preceding claims, wherein the downhole expandable tubular (1) has a first thickness (T_1) between the first and second circumferential edges (3, 4) and a second thickness (T_2) in adjacent areas, the first thickness (T_1) being smaller than the second thickness (T_2).

9. A downhole expandable tubular (1) according to any of the preceding claims, wherein the split ring-shaped retaining element (7) and the sealing element (6) substantially fill a gap provided between the first and second circumferential edges (3, 4).

10. A downhole expandable tubular (1) according to any of the preceding claims, wherein the split ring-shaped retaining element (7) is made of a spring material.

11. A downhole expandable tubular (1) according to any of the preceding claims, wherein the split ring-shaped retaining element (7) is arranged on a first side of the sealing element (6), and a second split ring-shaped retaining element (7) is arranged on another side of the sealing element (6) opposite the first side.

12. A downhole expandable tubular (1) according to any of the preceding claims, wherein the split ring-shaped retaining element (7) retains the sealing element (6) in a position along the longitudinal extension of the downhole expandable tubular while expanding the split ring-shaped retaining element and the sealing element.

13. A downhole expandable tubular according to any of the preceding claims, wherein the ring-shaped retaining element is a split ring.

14. A downhole expandable tubular (1) according to any of the preceding claims, wherein the first and second circumferential edges (3, 4) are part of a groove (8) provided in the outer face (5) of the downhole expandable tubular.

15. A downhole expandable tubular (1) according to any of the preceding claims, wherein the first and second circumferential edges (3, 4) are extending in a radial extension in relation to the downhole expandable tubular, said radial extension being perpendicular to the longitudinal extension (l) of the downhole expandable tubular.

16. A downhole expandable tubular (1) according to any of the preceding claims, wherein an intermediate element (9) is arranged between the split ring-shaped retaining element (7) and the sealing element (6).

17. A downhole expandable tubular according to claim 16, wherein the split ring-shaped retaining element (7) and the intermediate element are arranged in an abutting manner to the sealing element, so that at least one of the split ring-shaped retaining element (7) and the intermediate element abuts the sealing element.

18. A downhole expandable tubular according to claim 16 or 17, wherein the intermediate element is made of polytetrafluoroethylene (PTFE) or polymer.

19. A downhole expandable tubular according to any of the preceding claims, wherein the sealing element is made of an elastomer, rubber, polytetrafluoroethylene (PTFE) or another polymer.

20. A downhole expandable tubular (1) according to any of the preceding claims, wherein the downhole expandable tubular (1) is a patch to be expanded within a casing or well tubular structure in a well, a liner hanger to be at least partly expanded within a casing or well tubular structure in a well, or a casing to be at least partly expanded within another casing.

21. A downhole expandable tubular (1) according to any of the preceding claims, wherein the downhole expandable tubular is provided with at least one circumferential projection.

22. An annular barrier (100) to be expanded in an annulus (101) between a well tubular structure (300) and an inside wall of a borehole or a casing downhole for providing zone isolation between a first zone (102) and a second zone (103) of the borehole, comprising:

- a tubular part (20) for mounting as part of the well tubular structure (300),
- a downhole expandable tubular (1) according to any of the preceding claims, surrounding the tubular part (20) and having an outer face facing towards the inside wall of the borehole or the casing, each end of the downhole expandable tubular being connected with the tubular part,
- a space (21) between the downhole expandable tubular and the tubular part, and
- an expansion opening (23) in the tubular part through which fluid may enter into the space in order to expand the downhole expandable tubular.

23. An annular barrier according to claim 22, wherein a sleeve (25) is arranged in between the downhole expandable tubular and the tubular part, the sleeve being connected with the tubular part and the downhole expandable tubular, thus dividing the space into a first space section and a second space section.

24. An annular barrier according to claim 22 or 23, wherein the downhole expandable tubular has an opening (24) providing fluid communication between the first or the second zone and one of the space sections.

25. An annular barrier according to any of claims 22-24, wherein the projection is a ring-shaped projection of an increased thickness in relation to other parts of the downhole expandable tubular, the ring-shaped projection providing an enforcement of the annular barrier when the annular barrier is expanded.

26. A downhole completion comprising a downhole expandable tubular according to any of claims 1-21, and a casing having an inner face (3) against which at least part of the downhole expandable tubular is expanded.

27. A downhole completion comprising a well tubular structure and an annular barrier according to any of claims 22-26, where the tubular part of the annular barriers is mounted as part of the well tubular structure.

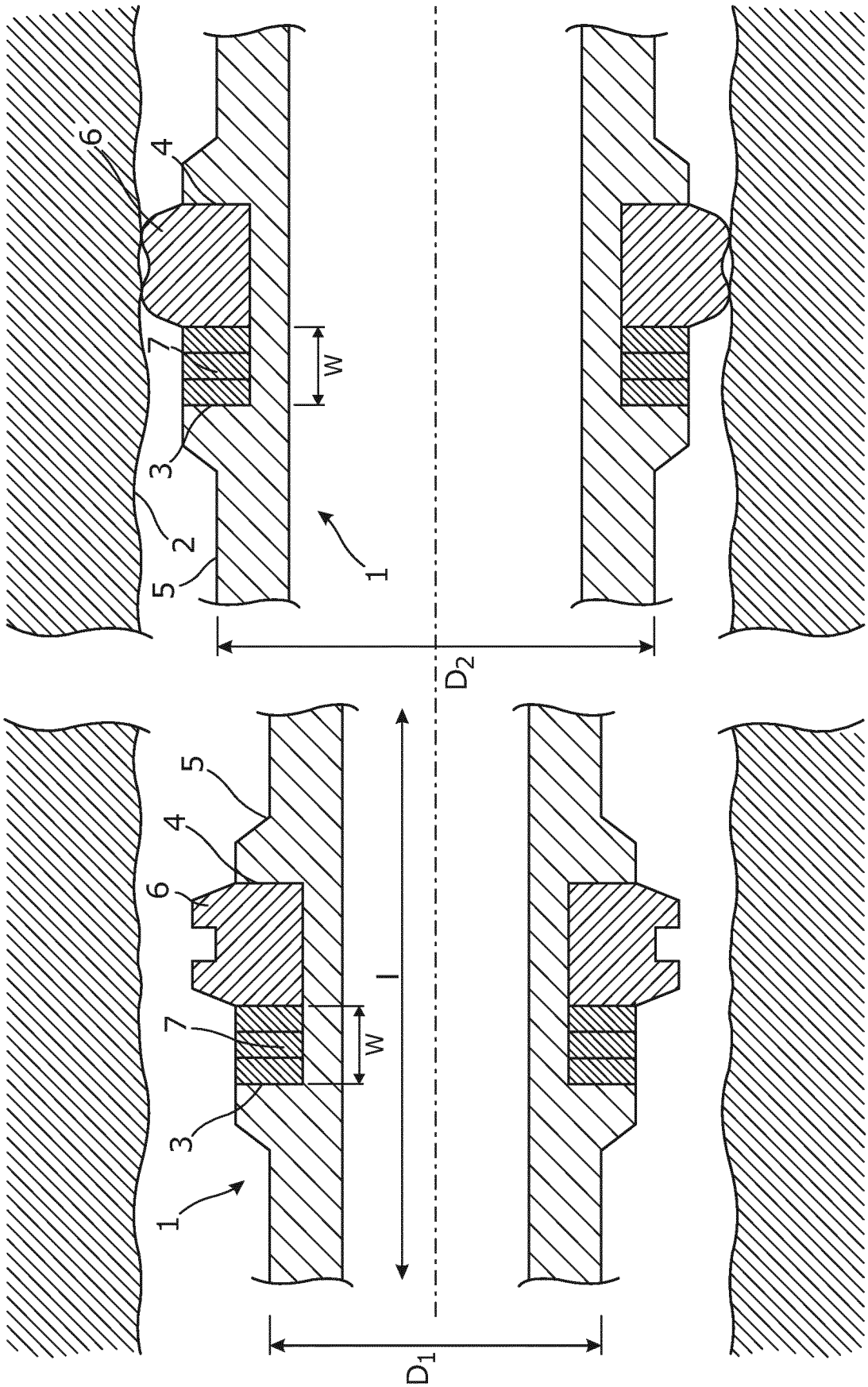

Fig. 1

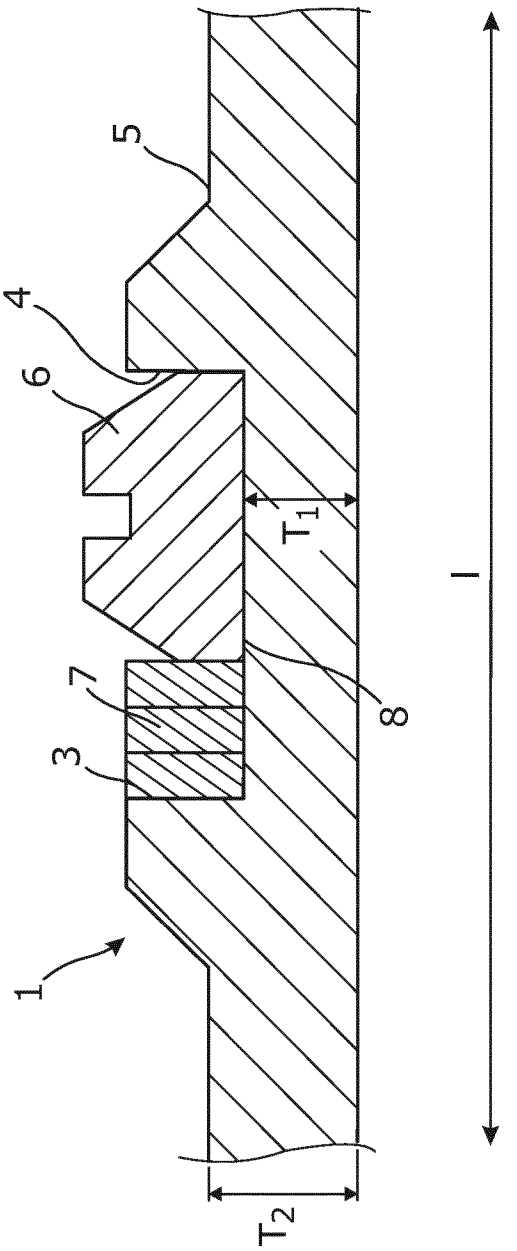

Fig. 2

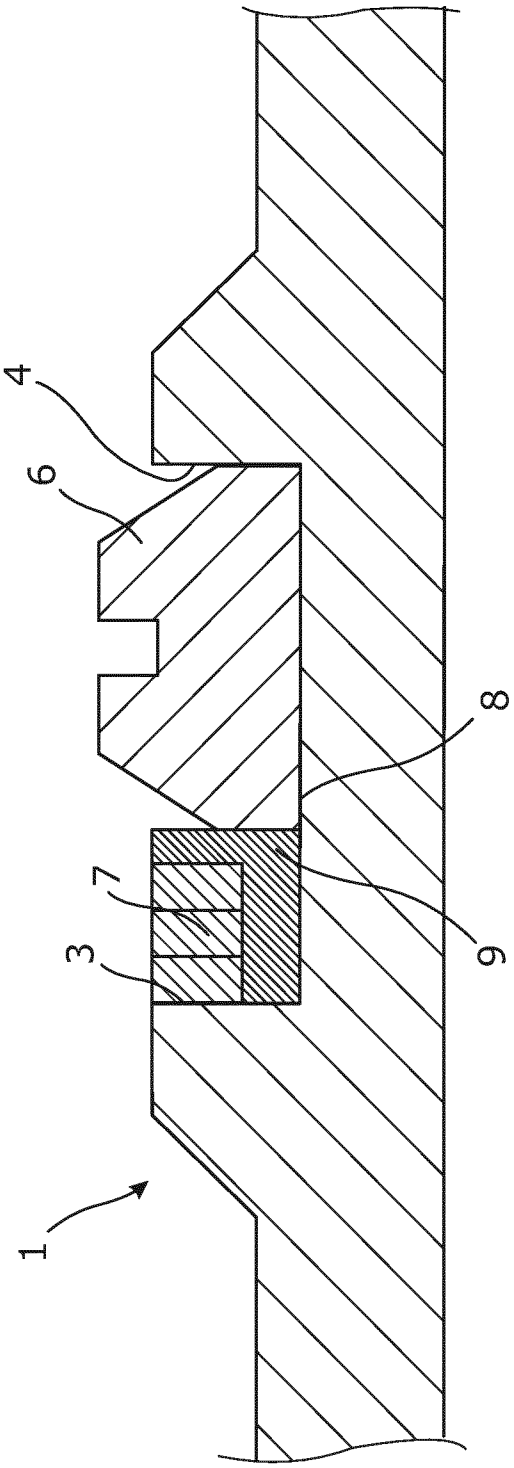

Fig. 3

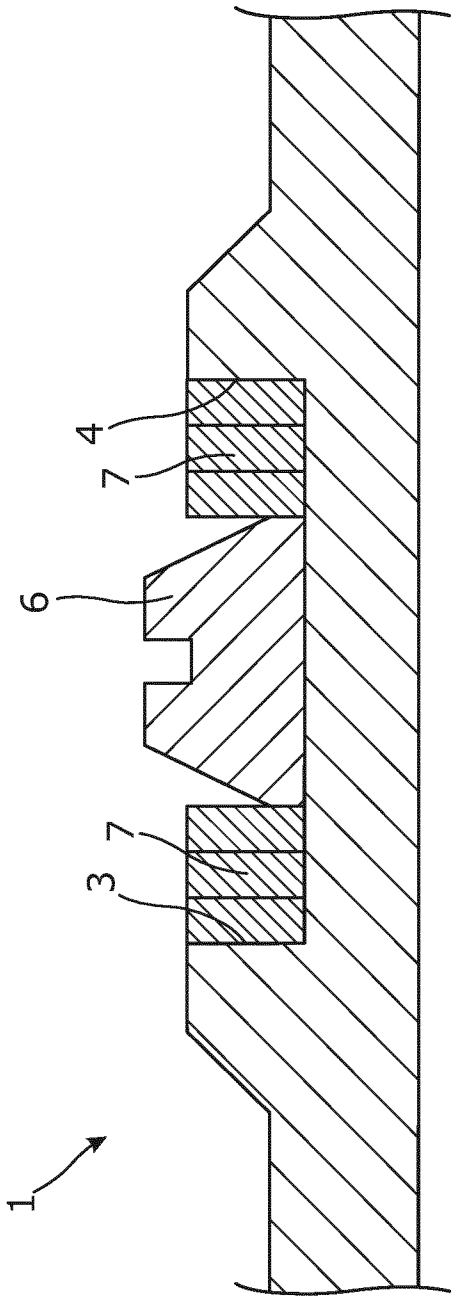

Fig. 4

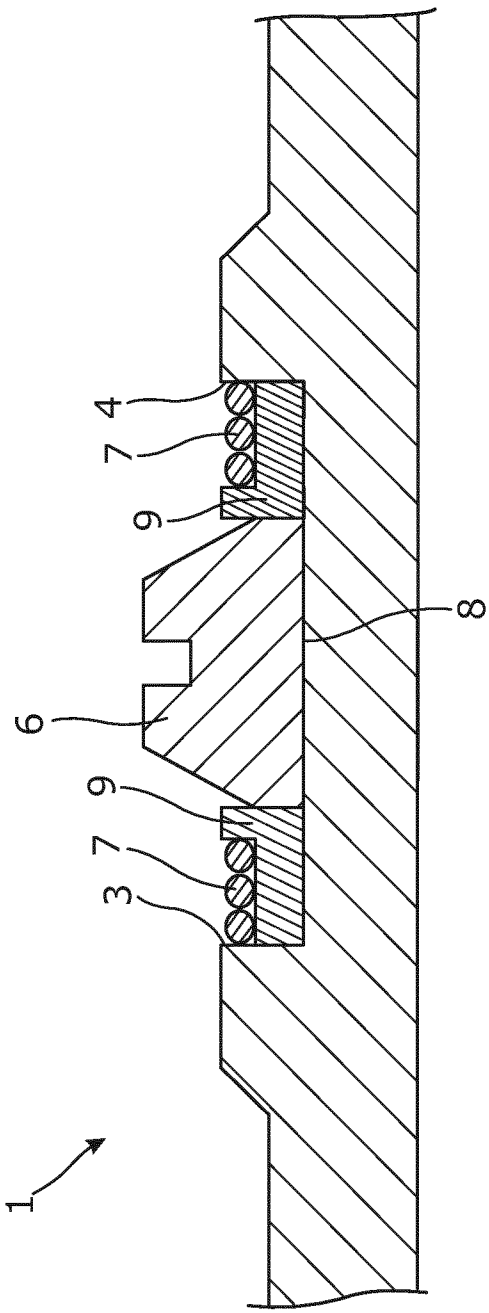

Fig. 5a

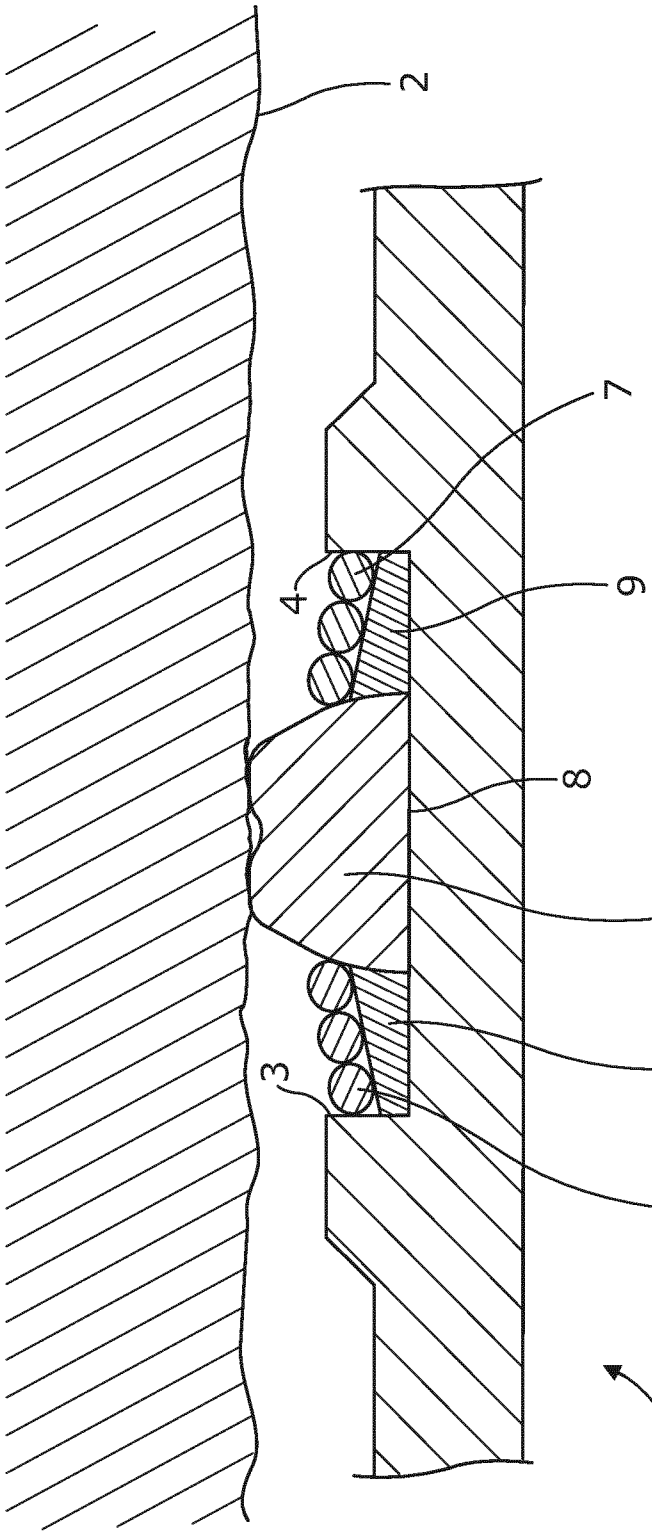

Fig. 5b

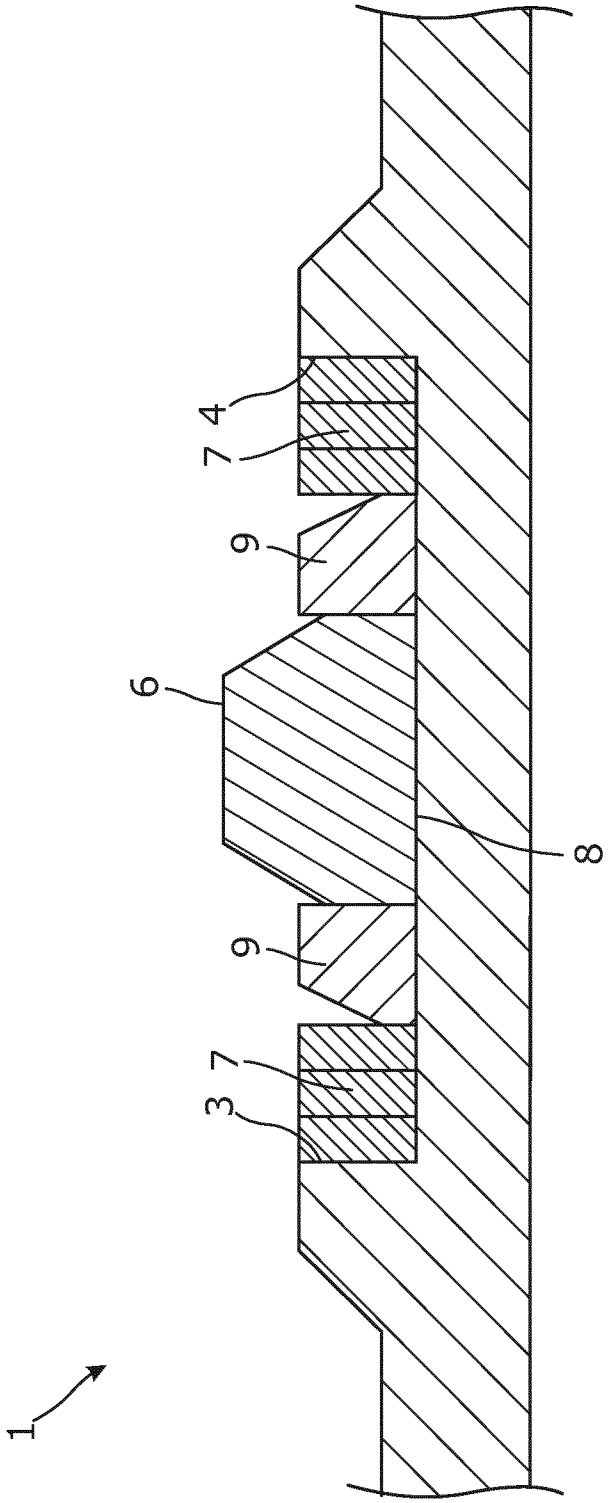

Fig. 6

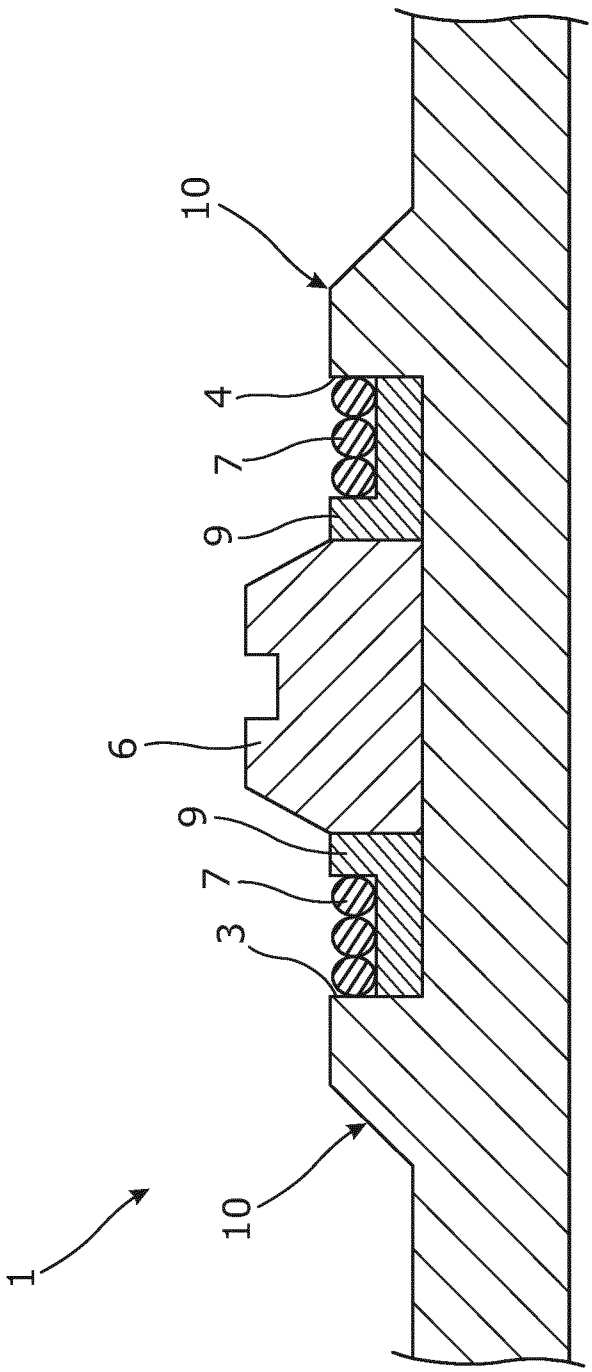

Fig. 7

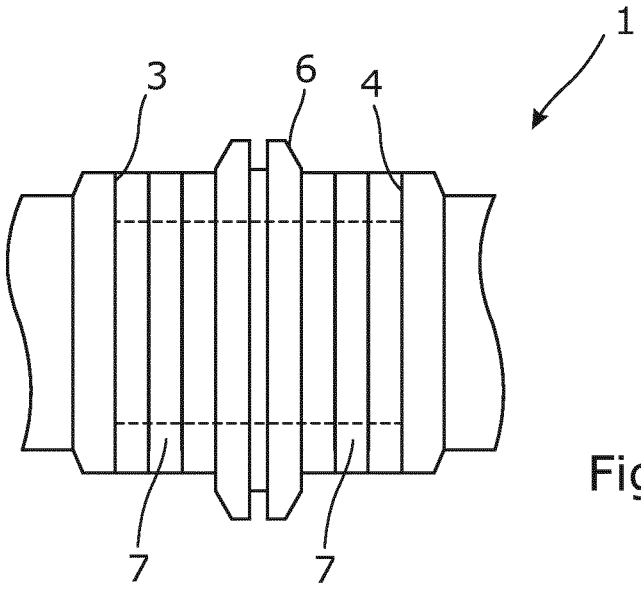

Fig. 8

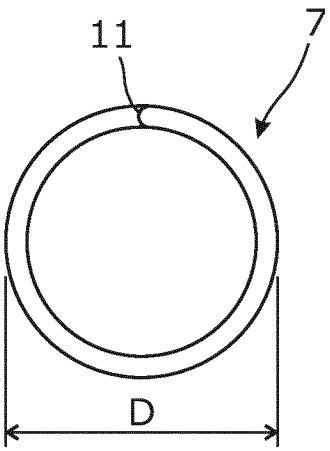

Fig. 9

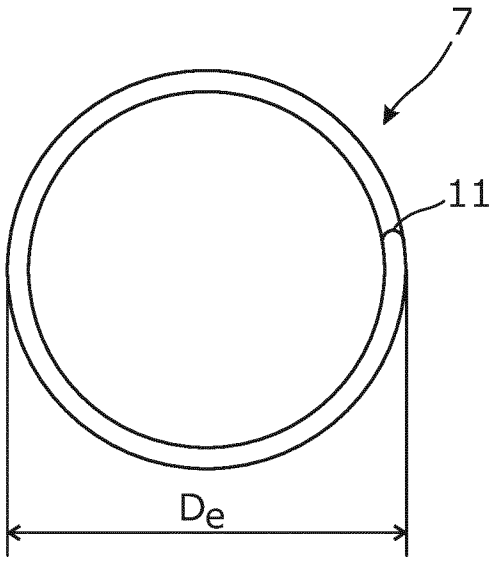

Fig. 10

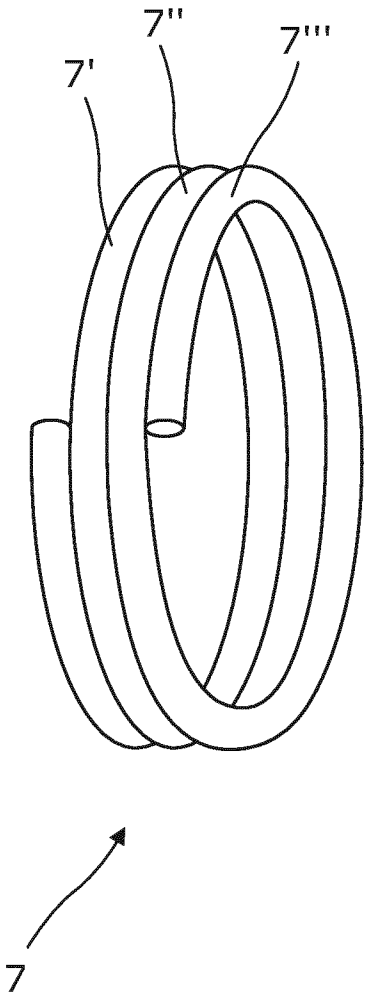

Fig. 11a

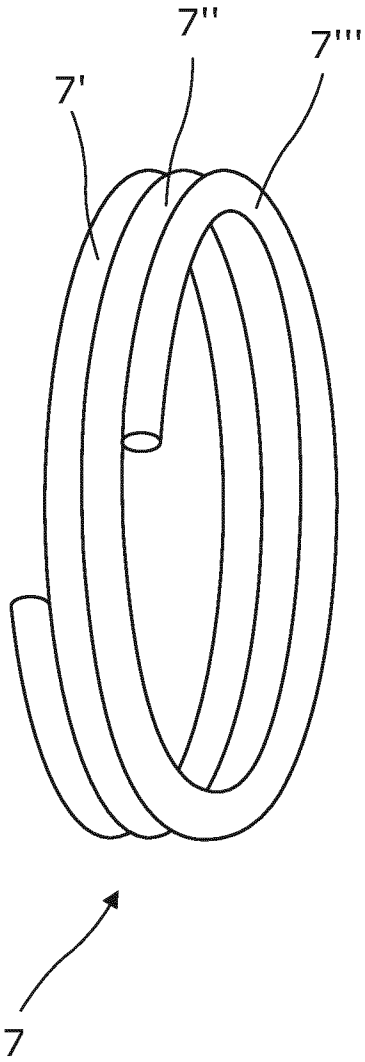

Fig. 11b

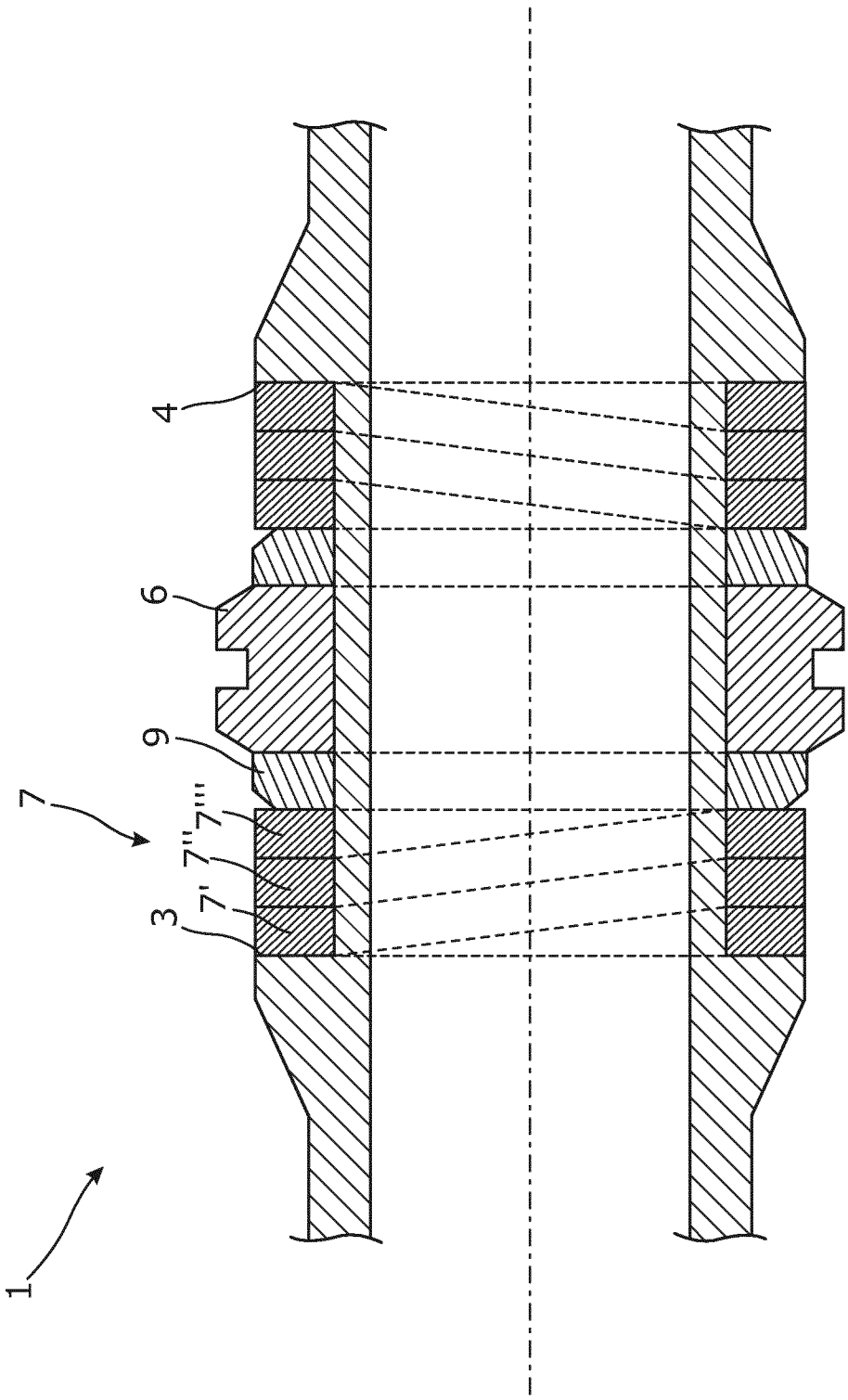

Fig. 12

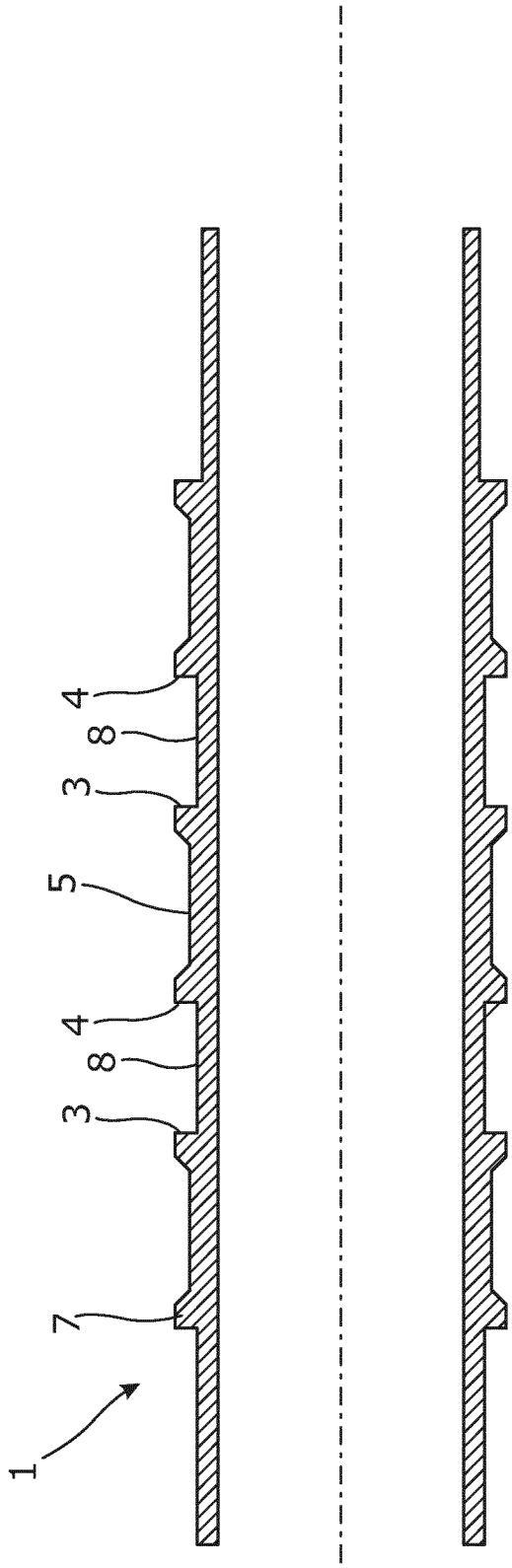

Fig. 13

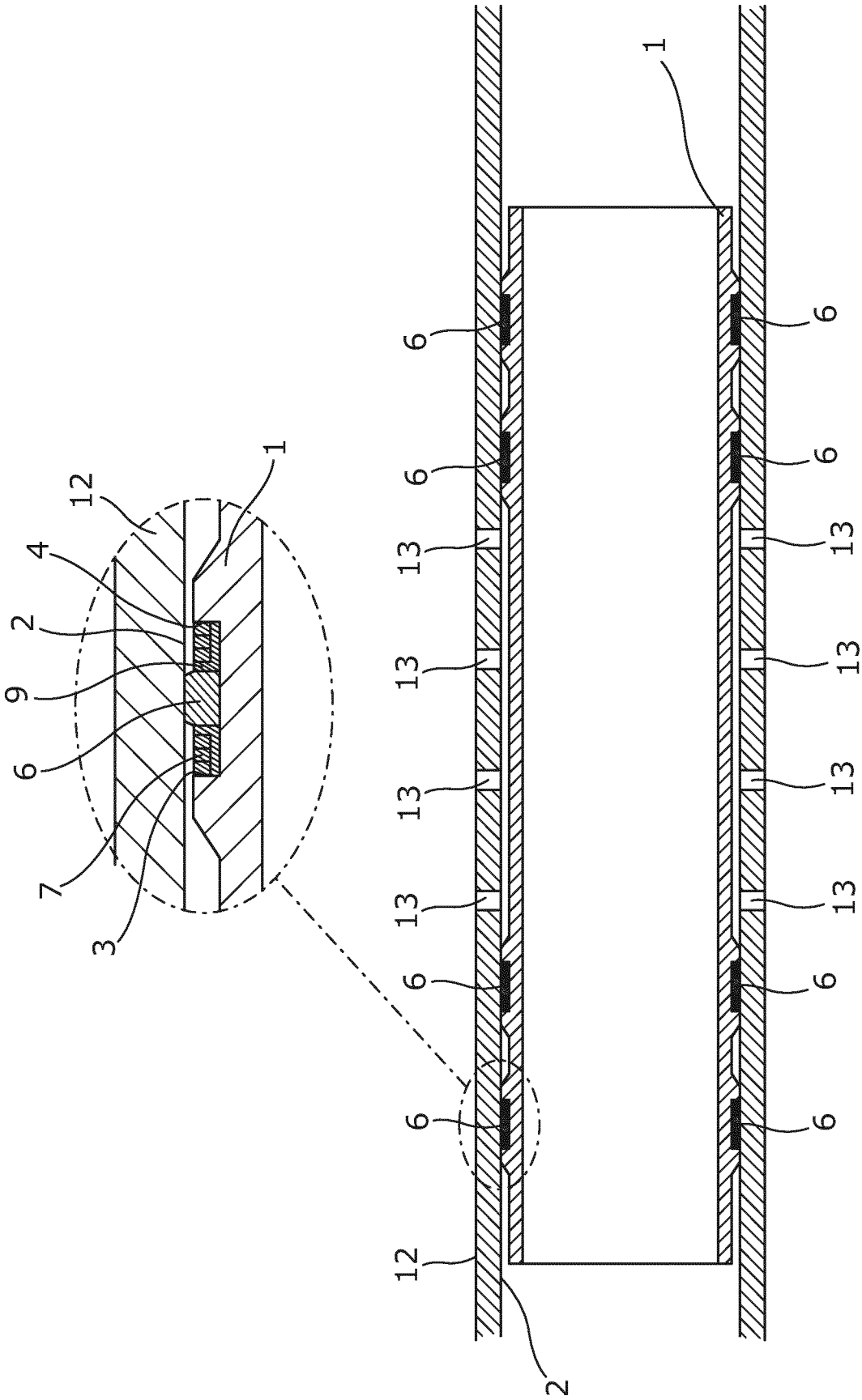

Fig. 14

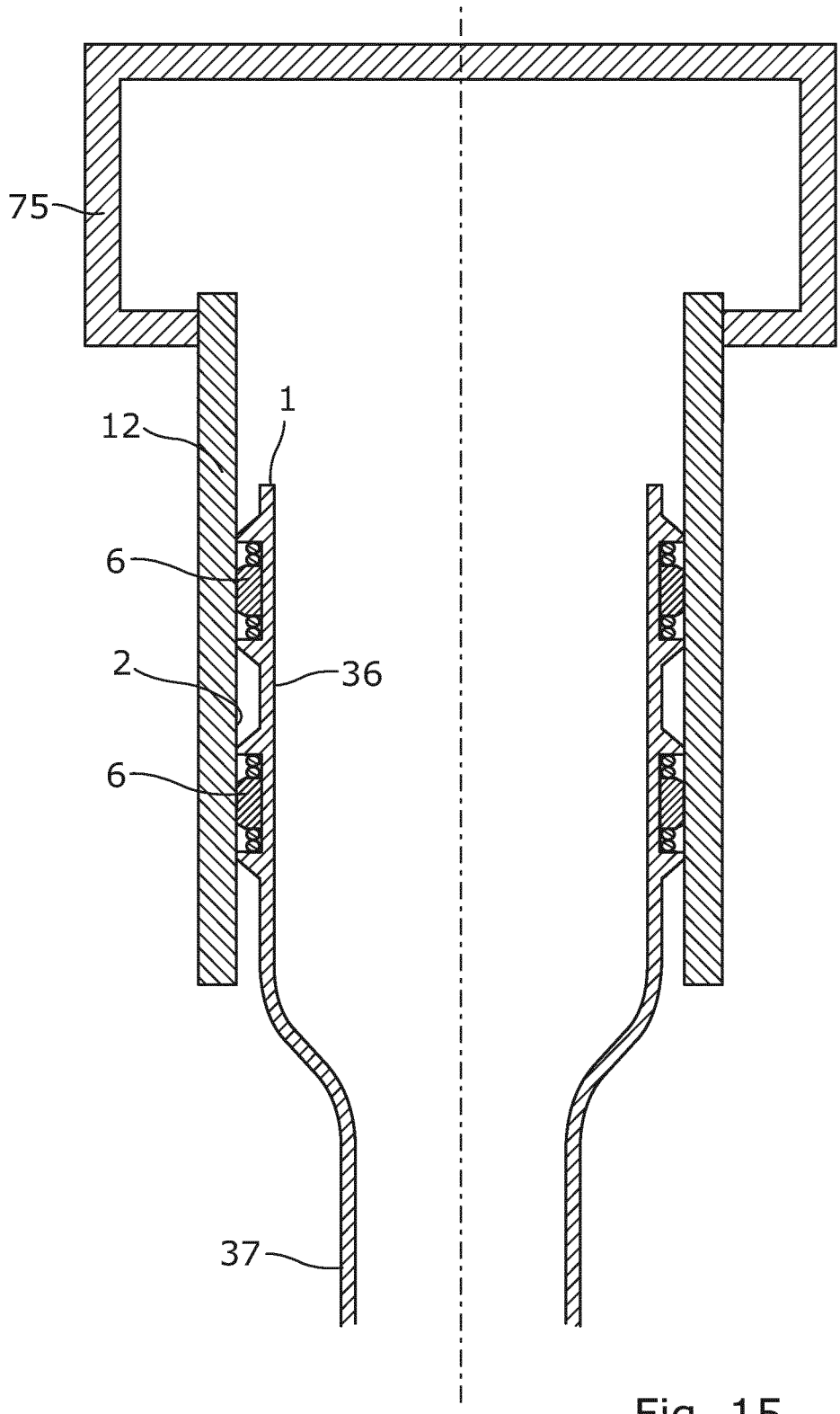

Fig. 15

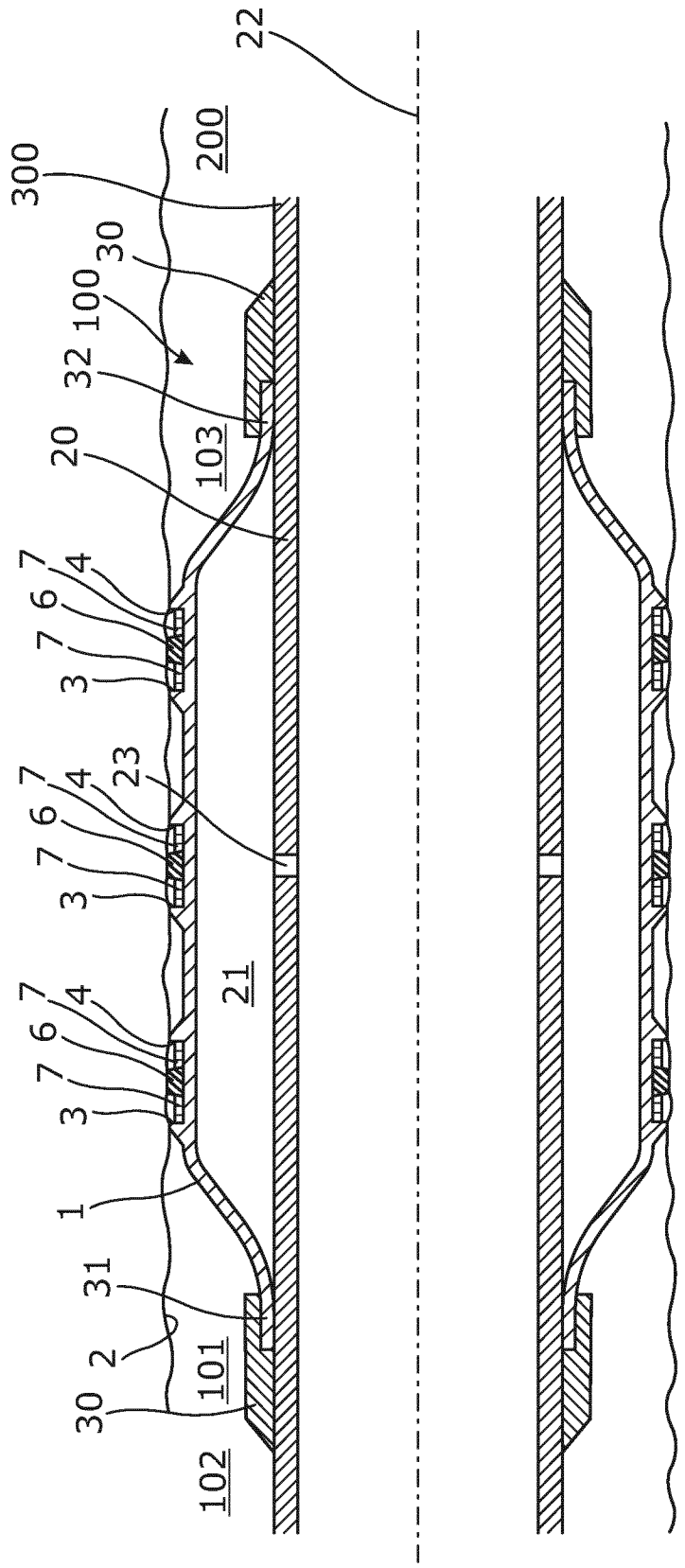

Fig. 16

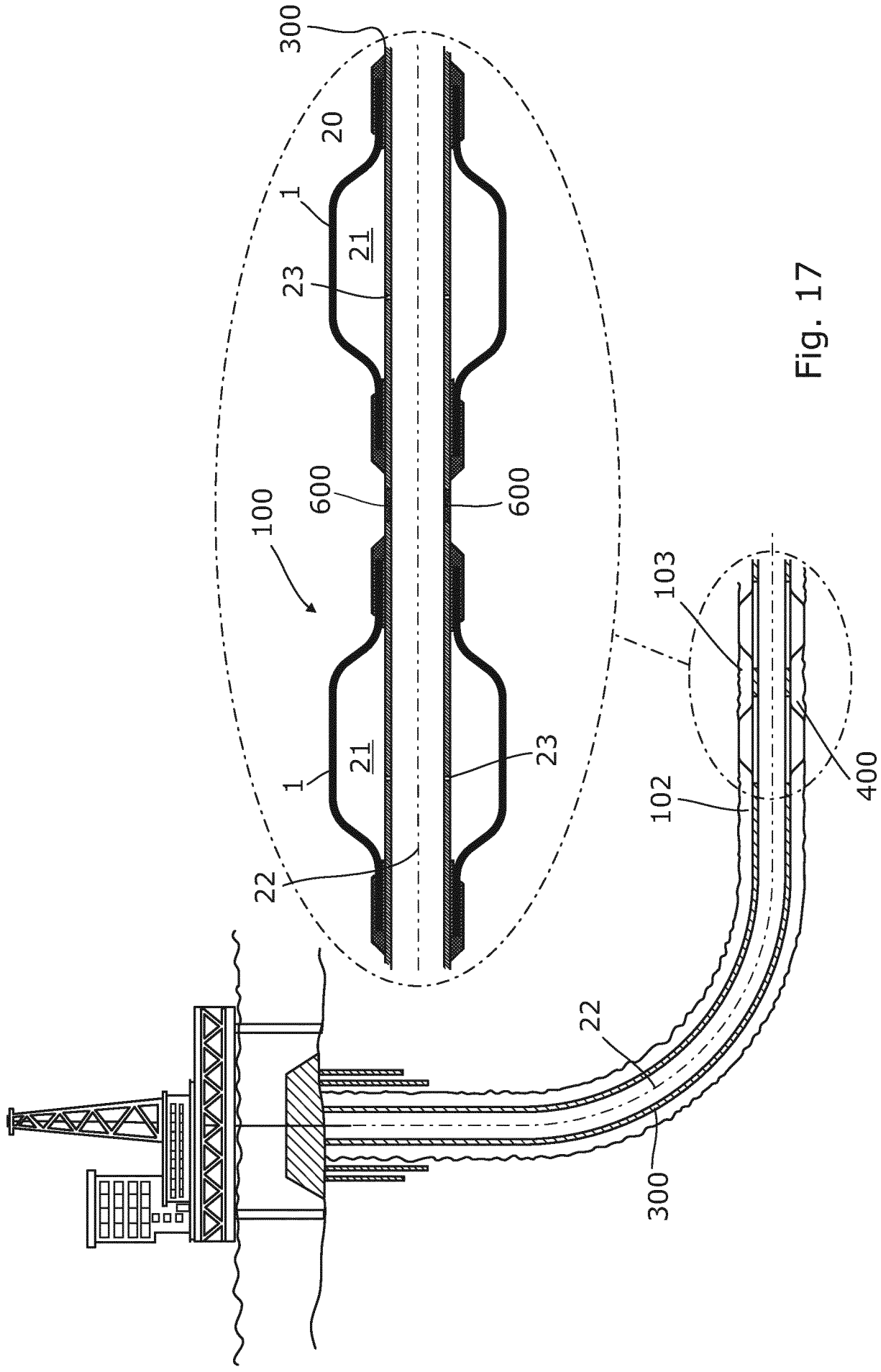

Fig. 17

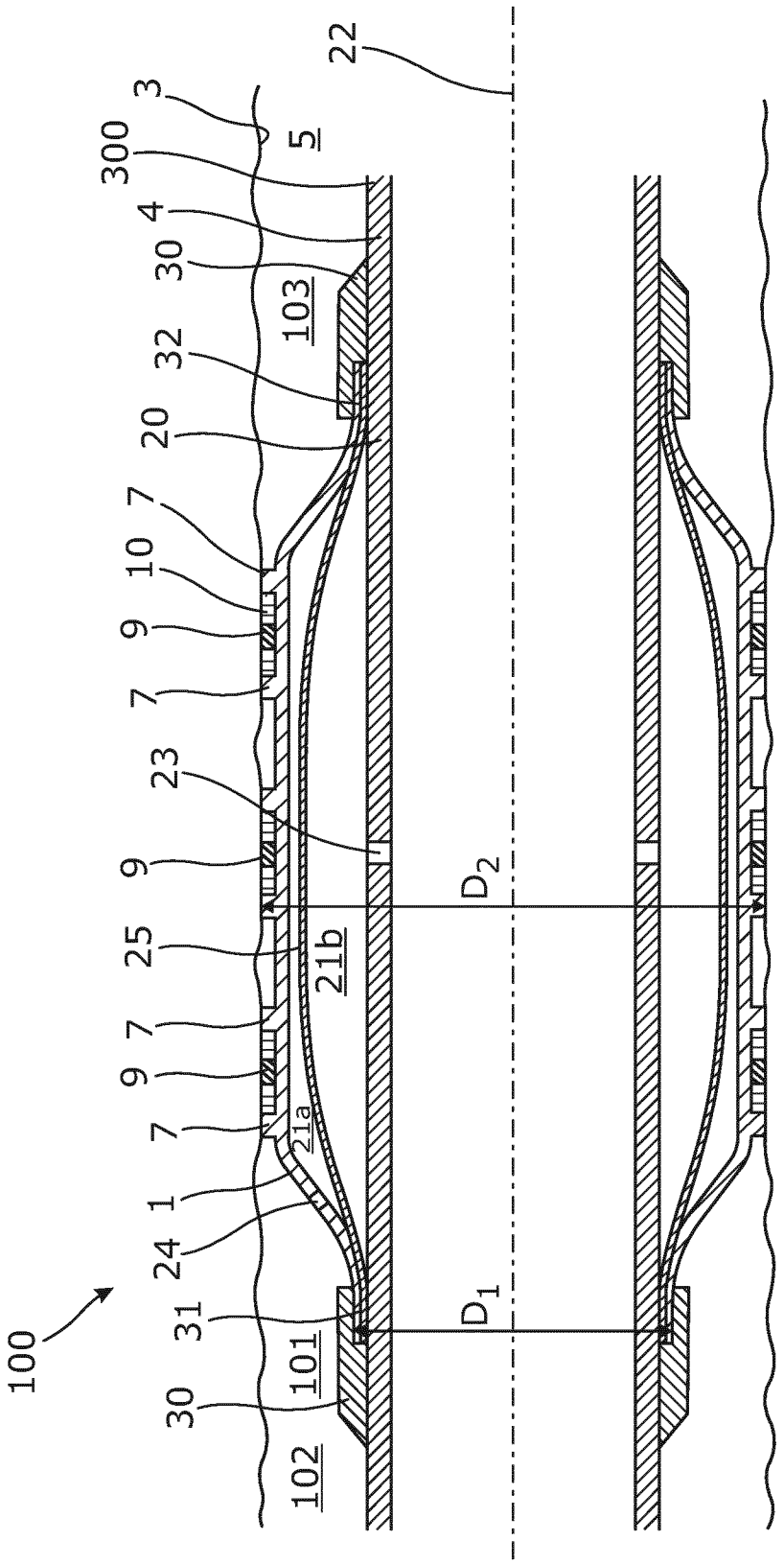
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Fig. 18

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/057369

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B43/10
ADD.

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

B. FIELDS SEARCHED

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

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	WO 2007/021975 A1 (BAKER HUGHES INC [US]; GARCIA DAVID A [US]) 22 February 2007 (2007-02-22) abstract figure 14 paragraphs [0002], [0003] paragraph [0025]	1-7,9, 10,13, 15,23-27 20,22 8,11,12, 14, 16-19,21
Y	WO 2006/012530 A1 (BAKER HUGHES INC [US]; EMERSON ALAN [US]) 2 February 2006 (2006-02-02) abstract figures 5,10,11,13	20,22

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 May 2014	26/05/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Wehland, Florian

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2014/057369

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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