

AN ANNULAR BARRIER HAVING A FLEXIBLE CONNECTIONField of the invention

The present invention relates to an annular barrier for providing a barrier
5 between a casing and a borehole or between a casing and a surrounding casing.

Background art

In wellbores, annular barriers are used for different purposes, such as for
10 providing a barrier for flow between an inner and an outer tubular structure or
between an inner tubular structure and the inner wall of the borehole. The
annular barriers are mounted as part of the well tubular structure. An annular
barrier has an inner wall surrounded by an annular expandable sleeve. The
expandable sleeve is typically made of an elastomeric material, but may also be
15 made of metal. The sleeve is fastened at its ends to the inner wall of the annular
barrier.

In order to seal off a zone between an inner and an outer tubular structure or a
well tubular structure and the borehole, a second annular barrier is used. The
20 first annular barrier is expanded on one side of the zone to be sealed off, and the
second annular barrier is expanded on the other side of that zone, and in this
way, the zone is sealed off.

When expanded, the expandable sleeve of the annular barriers is connected with
25 the tubular part of the annular barrier by means of a slidable end and a fixed
end. However, the slidable end has shown not to be sufficiently tight for all
downhole conditions.

Summary of the invention

30 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 having no sliding end or at least an
improved sliding end connecting the expandable sleeve with the tubular.

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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 providing a barrier between a casing and a borehole or between a casing and a surrounding casing, comprising:

- a tubular part for forming part of the casing, having an axial extension,
- an expandable metal sleeve connected with and surrounding the tubular part and defining an expandable space, and
- an opening fluidly connected with the expandable space for letting fluid from within the tubular part to the expandable space to expand the sleeve,

wherein the annular barrier further comprises a tubular metal element connecting the sleeve with the tubular part, having an extension in the axial extension and a first end part connected with the tubular part and a second end part connected with the expandable sleeve, and

wherein the first end part is arranged closer to the opening along the axial extension of the tubular part than the second end part.

In some downhole environments, pressure and temperature are very high which makes it very difficult to use packers having an elastomeric expandable sleeve.

In the present solution, the expandable sleeve is made of metal, and when such more rigid material is expanded, the design of the annular barrier has to be changed so that the expandable metal sleeve does not crack during expansion which would destroy its sealing ability. In prior art solutions, the expandable sleeve is connected to the tubular part via at least one sliding end having elastomeric seals, which, similarly to packers having an elastomeric expandable sleeve, are unsuitable for use in some downhole wells.

By having a tubular metal element connecting the sleeve with the tubular part, where the first end part of the tubular metal element is connected with the tubular part, and the second end part is connected with the expandable sleeve, the sleeve can be expanded without substantially thinning. This is due to the fact that the tubular metal element is flexing, hence providing the sleeve with an additional flexing ability. If the sleeve was just bent at its ends, the bend would unbend, which would generate an extremely high stress in the connection between the sleeve and the tubular part, resulting in a crack in the connection to the tubular part and hence a leaking annular barrier. By having the tubular metal element fastened so that the first end part is arranged closer to the opening

along the axial extension of the tubular part than the second end part, the element seeks to keep the angle between the tubular metal element and the tubular part at a minimum during expansion of the annular barrier.

5 In an embodiment, the sleeve may be made of metal.

Moreover, the tubular metal element may be made as a separate element.

Also, the first end part may be connected to the tubular part and the second end
10 part may be connected to the expandable sleeve.

The tubular metal element may be without bends in an unexpanded condition of the annular barrier.

15 Further, the first end part of the tubular element may be welded to the tubular part and/or the second end part of the tubular element may be welded to the sleeve.

In an embodiment, the first end part of the tubular element may be welded to
20 the tubular part so that the welded connection faces the space.

Furthermore, the tubular element may have an intermediate part between the first end part and the second end part, not connected to the sleeve and the tubular part.

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Said intermediate part may be unconnected to the sleeve and the tubular part.

By having an intermediate part which is unconnected to the sleeve and the tubular part, the intermediate part is free to move and thus bend or be squeezed
30 together.

Furthermore, the intermediate part of the tubular element may be separate from the sleeve and the tubular part.

35 Additionally, the intermediate part may be corrugated.

Moreover, the intermediate part may be corrugated in the axial extension.

In addition, the corrugated intermediate part may comprise a series of parallel ridges and furrows, and a distance may be arranged between each ridge and each furrow in the axial extension.

- 5 During expansion of the sleeve, the corrugated intermediate part is compressed in the axial extension. Hereby, the distance between each ridge and each furrow is reduced, thereby reducing the length of the corrugated intermediate.

10 In an embodiment, the intermediate part may have a length in the axial extension, and the intermediate part may be more compressible in the axial extension than the sleeve, causing the length of the intermediate part to reduce as the sleeve is expanded.

15 Moreover, the intermediate part may comprise a first surface facing the tubular part and a second surface facing the sleeve, at least one of the surfaces comprising circumferential recesses.

20 Furthermore, the second surface may comprise a plurality of circumferential recesses extending from the second surface downwards into the intermediate part.

25 When the sleeve is expanded, the second end part is pulled upwards in the axial extension towards the opening, whereby the intermediate part, due to the circumferential recesses in the second surface, will start to bend in a radial extension away from the tubular part, causing a reduction in the length of the intermediate part.

30 In addition, the tubular element may have an initial length in an unexpanded state of the annular barrier and an expanded length in an expanded state of the annular barrier, the expanded length being shorter in the axial extension than the initial length.

Moreover, the tubular element may be made of a material which is more flexible than that of the expandable sleeve.

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In an embodiment of the invention, the intermediate part may have a first modulus of elasticity in the axial extension, and the sleeve may have a second

modulus of elasticity in the axial extension, the first modulus of elasticity being lower than the second modulus of elasticity.

Furthermore, the first modulus of elasticity may be 10% lower than the second modulus of elasticity, preferably 25% lower, more preferably 40% lower.

Additionally, the first end part of the tubular element may be welded to the tubular part and/or the second end part of the tubular element may be welded to the sleeve.

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Moreover, the sleeve may have two ends, each end being connected with the tubular part by means of a tubular element.

In addition, the sleeve may comprise a first end connected with the tubular part.

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The annular barrier may further comprise a second tubular element connecting a second end of the sleeve with the tubular part, having an extension in the axial direction and a first end part connected with the tubular part and a second end part connected with the second sleeve end, the first end part being arranged closer to the opening along the axial extension of the tubular part than the second end part.

In an embodiment, the sleeve may have a first end and a second end, the first sleeve end being connected to the tubular element and the second sleeve end being connected to the tubular part.

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The present invention furthermore relates to an annular barrier system comprising a casing and at least one annular barrier as described above, wherein the tubular part may form part of the casing.

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The annular barrier system may further comprise an inflow control section comprising a tubular part forming part of the casing and an opening in the tubular part of the inflow control section for letting fluid from a surrounding reservoir into the casing.

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Furthermore, an inflow control valve may be arranged in the opening of the inflow control section.

Finally, the invention relates to a method for providing a barrier between a casing and a borehole or between a casing and a surrounding casing by means of the annular barrier described above, comprising the step of:

- letting fluid from within a tubular part via an opening in the tubular part to an expandable space of the annular barrier to expand an expandable sleeve of the annular barrier,
- whereby a second end part of a tubular element during the expansion of the sleeve is pressed towards a first end part of the tubular element, the first end part being arranged closer to the opening along an axial extension of the tubular part than the second end part, causing a reduction of a length of the tubular element in an axial extension.

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 view of an annular barrier in its unexpanded condition,

Fig. 2 shows a cross-sectional view of the annular barrier of Fig. 1 in its expanded condition,

Fig. 3 shows a cross-sectional view of another annular barrier in its unexpanded condition,

Fig. 4 shows a cross-sectional view of the annular barrier of Fig. 3 in its expanded condition,

Fig. 5 shows a cross-sectional view of yet another annular barrier in its unexpanded condition,

Fig. 6 shows a cross-sectional view of the annular barrier of Fig. 5 in its expanded condition,

Fig. 7 shows a cross-sectional view of yet another annular barrier in its unexpanded condition having circumferential sealing elements,

Fig. 8 shows a cross-sectional view of the annular barrier of Fig. 7 in its expanded condition,

Fig. 9 shows a cross-sectional view of the annular barrier system,

Fig. 10 shows a cross-sectional view of yet another annular barrier having serrations in its unexpanded condition,

Fig. 11 shows a cross-sectional view of the annular barrier of Fig. 10 in its expanded condition,

Fig. 12 shows a cross-sectional view of an annular barrier having only one tubular element in its unexpanded condition, and

Fig. 13 shows a cross-sectional view of the annular barrier of Fig. 12 in its expanded condition.

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

An annular barrier 1 shown in Fig. 1 is used for being expanded in an annulus 2 between a well tubular structure 3 and an inside wall 4 of a borehole 5 downhole to provide zone isolation between a first zone 8 and a second zone 12 of the borehole 5, as shown in Figs. 2 and 9. The tubular structure 3 may be a production casing or a liner. The annular barrier 1 comprises a tubular part 6 mounted as part of the well tubular structure 3 by means of a threaded connection 40. The tubular part 6 has an axial extension along a longitudinal axis 14 coaxial with the longitudinal axis of the well tubular structure 3. The annular barrier 1 comprises an expandable metal sleeve 7 surrounding the tubular part 6 and defining a space 13 which is in fluid communication with an inside 15 of the tubular part 6. The annular barrier 1 further comprises an opening 11 fluidly

connected with the expandable space 13 for letting fluid from within the tubular part 6 to the space for expanding the sleeve 7. The annular barrier 1 also comprises a tubular metal element 20 connecting the metal sleeve 7 with the tubular part 6 of metal. The tubular metal element 20 has an extension in the axial extension of the tubular part, and a first end part 21 of the tubular metal element is connected with the tubular part, and a second end part 22 of the tubular element is connected with the expandable metal sleeve 7. As can be seen, the first end part 21 is arranged closer to the opening 11 along the axial extension of the tubular part 6 than the second end part 22. Each end 9, 10 of the expandable metal sleeve 7 is connected with the tubular part 6 via the tubular metal element 20.

In Fig. 1, the annular barrier 1 comprises both a first tubular metal element 20A and a second tubular metal element 20B. The first tubular metal element 20A connects a first end 9 of the expandable metal sleeve 7 with a second end part 22 of the tubular metal element 20 and a first end part 21 of the tubular metal element 20 with the tubular part 6. The second tubular metal element 20B connects a second end 10 of the expandable metal sleeve with the second end 22 of the second tubular metal element 20B. Furthermore, the first end part 21 of the second tubular metal element 20B is connected with the tubular part 6.

The annular barrier 1 has an opening 11 for letting fluid into the expandable space 13 to expand the metal sleeve 7. The opening 11 is arranged in the tubular part 6 so that the fluid is let directly into the expandable space 13 when the tubular part 6 and the casing are pressurised to expand the expandable metal sleeve 7 of the annular barrier. The expandable metal sleeve 7 is typically expanded by pressurising the well tubular structure 3 from the top of the well, which allows for expansion of several annular barriers at the same time. A valve may also be arranged in the aperture, such as a one-way valve.

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The annular barrier 1, i.e. both the tubular part, the sleeve and the tubular element, is made of metal. When expanding a metal sleeve using pressurised fluid, the amount of force needed is substantially higher than when using an elastomeric sleeve. When expanding, the length of the sleeve 7 shrinks along the longitudinal axis 14, and in prior art solutions, at least one end needs to be sliding in relation to the tubular part to avoid substantial thinning of the

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expandable sleeve 7. Having a slidable end with seals entails a substantial risk of leakage, which may prevent expansion of the sleeve 7.

5 By having an annular barrier 1 where the first end part 21 of the tubular metal element 20 connected to the tubular part 6 is arranged closer to the opening 11 along the axial extension of the tubular part than the second end part 22 connected to one end 9 of the metal sleeve, a flexible connection between the tubular part and the expandable metal sleeve 7 is provided. Thus, a flexible connection is provided since the tubular element 20 bends or compresses itself to
10 compensate for the axial shrinkage of the expandable metal sleeve 7 when the sleeve is expanded.

In some wells downhole, the environment is harsh in that pressure and temperature are very high and acid may be present, which makes it very difficult
15 to use packers having an elastomeric expandable sleeve. In the present solution, the expandable sleeve is a metal sleeve, and when such more rigid material is expanded, the design of the annular barrier has to be changed compared to known solutions so that the expandable metal sleeve does not crack during expansion which would destroy its sealing ability. By having a tubular metal
20 element connecting the sleeve with the tubular part, the sleeve can be expanded without substantially thinning. This is due to the fact that the tubular metal element is flexing, hence providing the sleeve with the required flexing ability. If the sleeve was just bent at its ends, the bend would unbend, which would generate an extremely high stress in the connection between the sleeve and the
25 tubular part, resulting in a crack during expansion of the barrier in the connection to the tubular part and hence a leaking annular barrier. The rigidity of the tubular metal element keeps the angle between the tubular metal element and the tubular part in the connection there between at a minimum, and the connection does therefore not crack during expansion.

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In Fig. 1, the tubular metal element 20 comprises an intermediate part 18 arranged between the first end part 21 and the second end part 22. The intermediate part 18 is not connected to the sleeve 7 and the tubular part 6. In Fig. 2, the sleeve 7 of the annular barrier 1 is expanded, and the ends 9, 10 of the sleeve move outwards away from the tubular part 6 to make up for the axial shrinkage of the sleeve.
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In Figs. 3 and 4, the connection of the tubular elements 20A, 20B and the tubular part 6 is arranged closer to the opening 11 than in the solution of Figs. 1 and 2. In this way, the expandable metal sleeve 7 may be expanded to an even larger overall diameter than the solution of Figs. 1 and 2 as the tubular metal element 5 20 compensates and connects the sleeve with the tubular part 6 by also extending outwards.

In Fig. 5, the intermediate part 18 is corrugated in the axial extension, and the tubular element 20 thus has corrugations 23 when seen in cross-section. In Fig. 10 6, the intermediate part 18 of the tubular metal element 20 has been compressed during expansion of the expandable metal sleeve 7. In Fig. 5, the tubular metal element 20 has an initial length L_i which is reduced during expansion to fit the shorter length of the expanded metal sleeve 7. After expansion, the tubular metal element 20 has a length L_{ex} which is shorter than 15 the initial length L_i . In this way, no sliding annular barrier ends are needed to compensate for the shorter length of the sleeve in its expanded state. In Figs. 5 and 6, the intermediate part 18 is more compressible in the axial extension than the sleeve, meaning that the length of the intermediate part is reduced as the sleeve 7 is expanded. The corrugations 23 are pressed together, as shown in Fig. 20 5.

The intermediate part 18 comprises a first surface 30 facing the tubular part 6 and a second surface 31 facing the sleeve 7. In Fig. 7, both surfaces 30, 31 comprise circumferential recesses 32. In Fig. 8, the sleeve has been expanded, 25 and the recesses are pressed together so that the length L_{ex} of the tubular element is shorter than when the annular barrier is in the unexpanded state, as shown in Fig. 7.

As shown in Fig. 7, the annular barrier 1 has an outer face 28 and circumferential 30 sealing elements 25 connected with the outer face by means of tubular ring elements 26. When the expandable sleeve 7 is expanded, the tubular ring elements 26 hinder free expansion of the metal sleeve 7, as shown in Fig. 8, and the sleeve forms smaller corrugations 27 during expansion, thereby strengthening the sleeve, causing the collapse rating of the annular barrier to 35 increase.

In Fig. 1, the tubular element 20 is made of a material which is more flexible than that of the expandable sleeve 7, so that the tubular metal element is more flexible than the expandable metal sleeve. Being more flexible, the tubular element 20 bends outwards so as to compensate for the shorter length of the expandable metal sleeve 7 in the axial extension. Thus, the intermediate part 18 may have a first modulus of elasticity in the axial extension and the sleeve 7 may have a second modulus of elasticity in the axial extension, the first modulus of elasticity being lower than the second modulus of elasticity. The first modulus of elasticity is 10% lower than the second modulus of elasticity, preferably 25% lower, more preferably 40% lower.

As can be seen in Figs. 1-8, the first end part 21 of the tubular metal element 20 is welded to the tubular part 6, as indicated by reference no. 41 in Fig. 2, and the second end part 22 of the tubular metal element 20 is welded to the metal sleeve 7, as indicated by reference no. 42 in Fig. 2. Welding is an easy way to join two tubular parts, and it provides for a sufficiently tight connection. The first end part 21 of the tubular metal element 20 is welded together with the tubular part 6 of metal, and the expandable metal sleeve is subsequently arranged so that it surrounds the tubular part 6 and the tubular metal element 20, and the second end part of the tubular metal element 20 are welded together with the expandable metal sleeve 7.

As mentioned, the outer face and second surface facing the sleeve of the tubular element 20 may have recesses, as shown in Fig. 10. During expansion of the expandable sleeve 7, the recesses are reduced, and the tubular element 20 bends outwards as the expandable sleeve 7 is expanded. The expandable sleeve also moves outwards and shortens in length. However, the sleeve has a curved cross-sectional shaped since it is welded to and prevented from free expansion by the tubular element, as shown in Fig. 11.

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In Figs. 12 and 13, the annular barrier 1 comprises only one tubular metal element 20. In Fig. 12, the annular barrier 1 is in its unexpanded state, and in Fig. 13, the annular barrier is in its expanded condition. The first sleeve end 9 is connected to the second end part 22 of the tubular metal element 20, and the first end part 21 of the tubular metal element is connected to the tubular part. The second end 10 of the metal sleeve 7 is connected directly to the tubular part, meaning that the second sleeve end 10 is connected to the tubular part without

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any tubular elements. Hereby, one end of the expandable metal sleeve 7 is fixedly connected directly with the tubular part, and the other end is intermediately connected with the tubular part by means of the tubular metal element 20. In this way, it is possible to avoid a slidable end slidably fastening the sleeve 7 to the tubular part.

A valve may be arranged in the opening of the tubular part 6. The valve may be a one-way valve so that the fluid injected into the space is trapped in the space 13, after which the tubular part and the well tubular structure 3, also called a casing, are no longer pressurised to expand the expandable sleeve 7.

The invention further relates to an annular barrier system 100, shown in Fig. 9, comprising a casing and at least one annular barrier, wherein the tubular part forms part of the casing.

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The annular barrier system 100 may further comprise an inflow control section 120 comprising a tubular part forming part of the casing and an opening 121 in the tubular part of the inflow control section for letting fluid from a surrounding reservoir into the casing. An inflow control valve 122 may be arranged in the opening of the inflow control section 120.

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The annular barrier system 100 further comprises a tool (not shown) having an isolation means isolating a part of the inside of the tubular part opposite the opening to pressurise the isolated part of the inside of the tubular part, and thus the space 13, to expand the sleeve 7. The isolation means may be an inflatable elastomeric element or a metal packer. The tool further comprises a pumping device for pumping fluid from the inside of the tubular part 6 opposite the isolated part into the isolated part to expand the expandable sleeve 7. The annular barrier system 100 may also have several annular barriers 1.

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When the expandable sleeve 7 of the annular barrier 1 is expanded, the diameter of the sleeve is expanded from its initial unexpanded diameter to a larger diameter. The expandable sleeve 7 has an outside diameter D (shown in Fig. 1) and is capable of expanding to a diameter which is at least 10% larger, preferably at least 15% larger, more preferably at least 30% larger than that of an unexpanded sleeve.

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Furthermore, the expandable sleeve 7 has a wall thickness t (shown in Fig. 1) which is thinner than a length L (shown in Fig. 1) of the expandable sleeve, the thickness preferably being less than 25% of the length, more preferably less than 15% of the length, and even more preferably less than 10% of the length.

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The fluid used for expanding the expandable sleeve may be any kind of well fluid present in the borehole surrounding the tool and/or the well tubular structure 3. Also, the fluid may be cement, gas, water, polymers, or a two-component compound, such as powder or particles mixing or reacting with a binding or
10 hardening agent. Part of the fluid, such as the hardening agent, may be present in the cavity between the tubular part and the expandable sleeve before injecting a subsequent fluid into the cavity.

By fluid or well fluid is meant any kind of fluid that may be present in oil or gas
15 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.

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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
25 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 (1) for providing a barrier between a casing (3) and a borehole (5) or between a casing and a surrounding casing, comprising:
 - 5 - a tubular part (6) for forming part of the casing, having an axial extension,
 - an expandable metal sleeve (7) connected with and surrounding the tubular part and defining an expandable space (13), and
 - an opening (11) fluidly connected with the expandable space for letting fluid from within the tubular part to the expandable space to expand the sleeve,
- 10 wherein the annular barrier further comprises a tubular metal element (20, 20A) connecting the sleeve with the tubular part, having an extension in the axial extension and a first end part (21) connected with the tubular part and a second end part (22) connected with the expandable sleeve, and
- 15 wherein the first end part is arranged closer to the opening along the axial extension of the tubular part than the second end part.
2. An annular barrier according to claim 1, wherein the tubular metal element is made as a separate element, and subsequently the first end part is connected to the tubular part and the second end part is connected to the expandable
- 20 sleeve.
3. An annular barrier according to claim 2, wherein the tubular metal element is without bends in an unexpanded condition of the annular barrier.
- 25 4. An annular barrier according to any of the preceding claims, wherein the first end part of the tubular element is welded to the tubular part and/or the second end part of the tubular element is welded to the sleeve.
5. An annular barrier according to any of the preceding claims, wherein the
- 30 first end part of the tubular element is welded to the tubular part so that the welded connection faces the space.
6. An annular barrier according to any of the preceding claims, wherein the tubular element has an intermediate part (18) between the first end part and the
- 35 second end part, not connected to the sleeve and the tubular part.

7. An annular barrier according to claim 6, wherein the intermediate part is corrugated.
8. An annular barrier according to claim 6 or 7, wherein the intermediate part
5 has a length in the axial extension and the intermediate part is more compressible in the axial extension than the sleeve, causing the length of the intermediate part to reduce as the sleeve is expanded.
9. An annular barrier according to any of claims 6-8, wherein the intermediate
10 part comprises a first surface (30) facing the tubular part and a second surface (31) facing the sleeve, at least one of the surfaces comprising circumferential recesses (32).
10. An annular barrier according to any of the preceding claims, wherein the
15 tubular element is made of a material which is more flexible than that of the expandable sleeve.
11. An annular barrier according to any of the preceding claims, wherein the
20 sleeve has two ends (9, 10), each end being connected with the tubular part by means of a tubular element.
12. An annular barrier system comprising a casing and at least one annular
25 barrier according to any of the preceding claims, wherein the tubular part forms part of the casing.
13. An annular barrier system according to claim 12, further comprising an
inflow control section (120) comprising a tubular part forming part of the casing and an opening (121) in the tubular part of the inflow control section for letting
30 fluid from a surrounding reservoir into the casing.
14. An annular barrier system according to claim 13, wherein an inflow control
valve (122) is arranged in the opening of the inflow control section.
15. A method for providing a barrier between a casing and a borehole or
35 between a casing and a surrounding casing by means of an annular barrier according to any of claims 1 to 11, comprising the step of

- letting fluid from within a tubular part via an opening in the tubular part to an expandable space of the annular barrier to expand an expandable sleeve of the annular barrier,
- 5 whereby a second end part of a tubular element during the expansion of the sleeve is pressed towards a first end part of the tubular element, the first end part being arranged closer to the opening along an axial extension of the tubular part than the second end part, causing a reduction of a length of the tubular element in an axial extension.

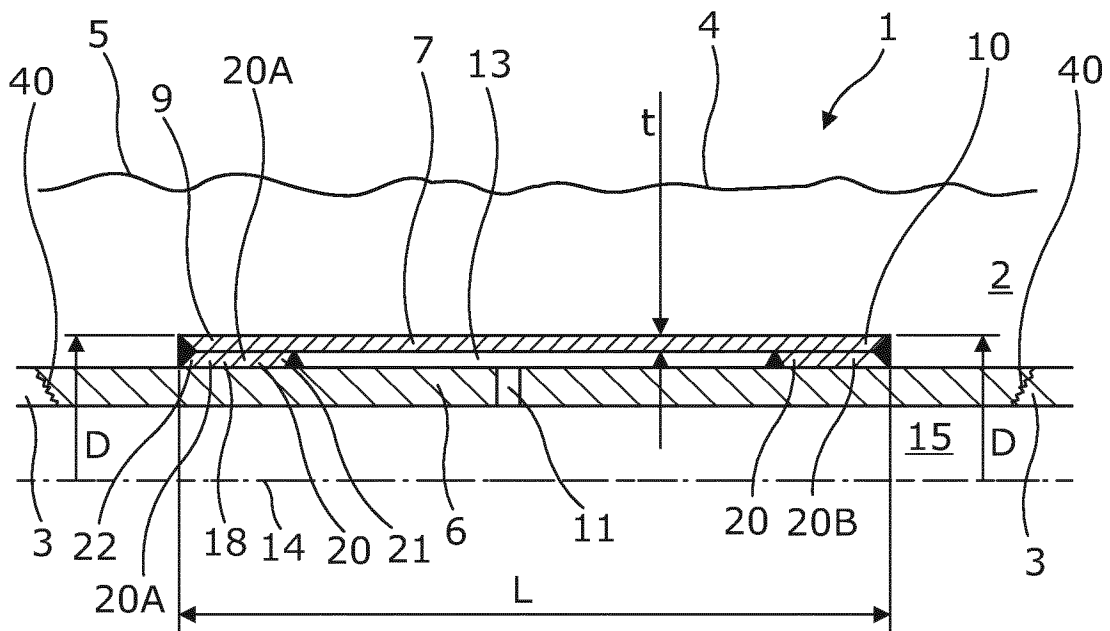


Fig. 1

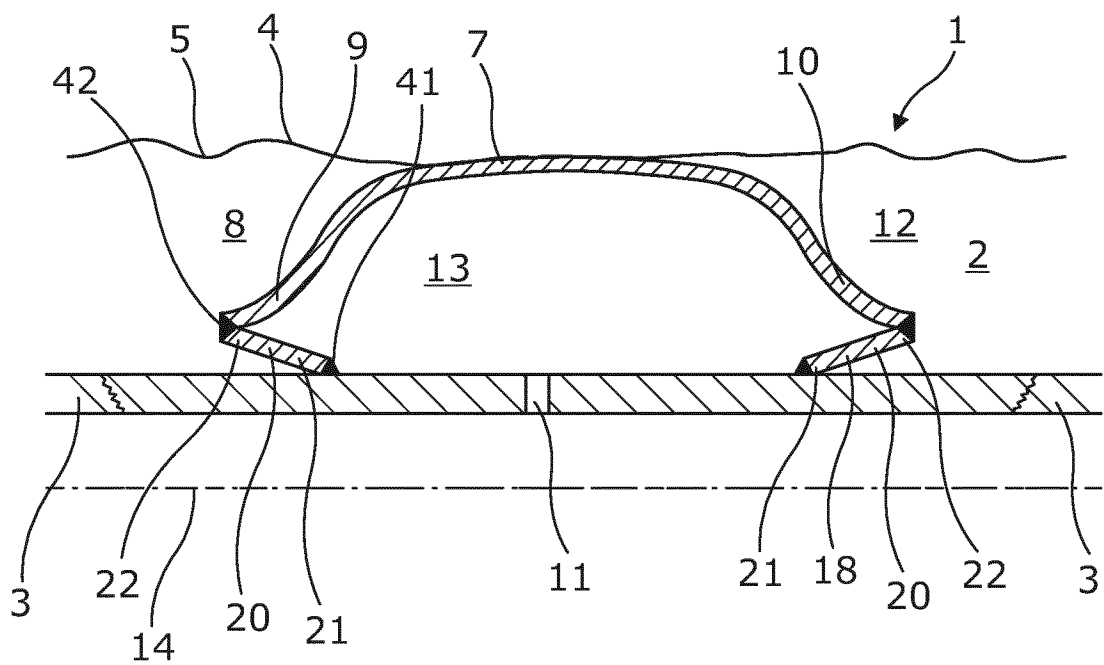


Fig. 2

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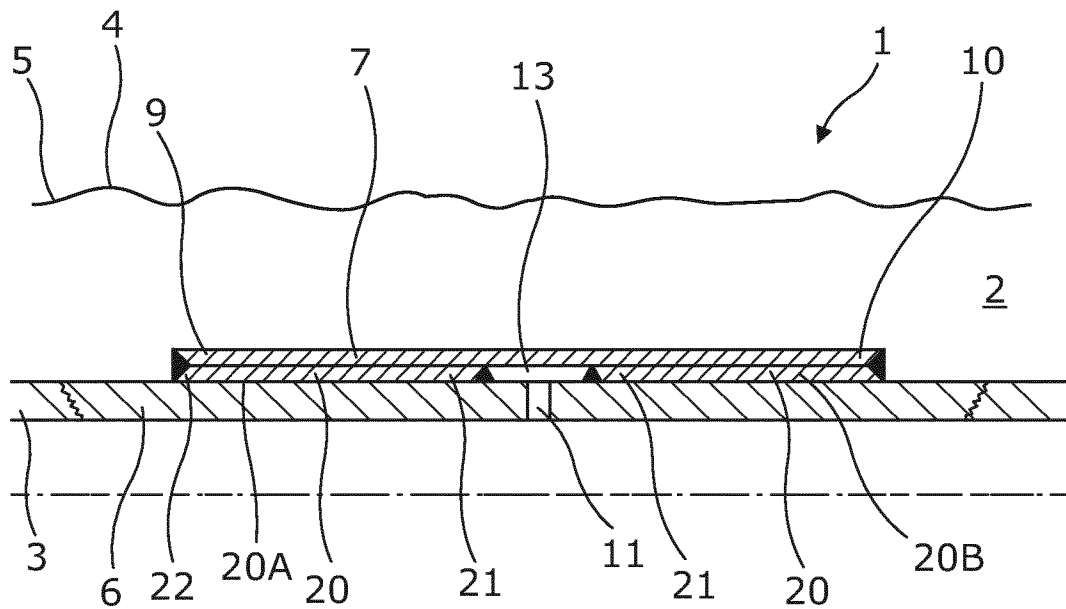


Fig. 3

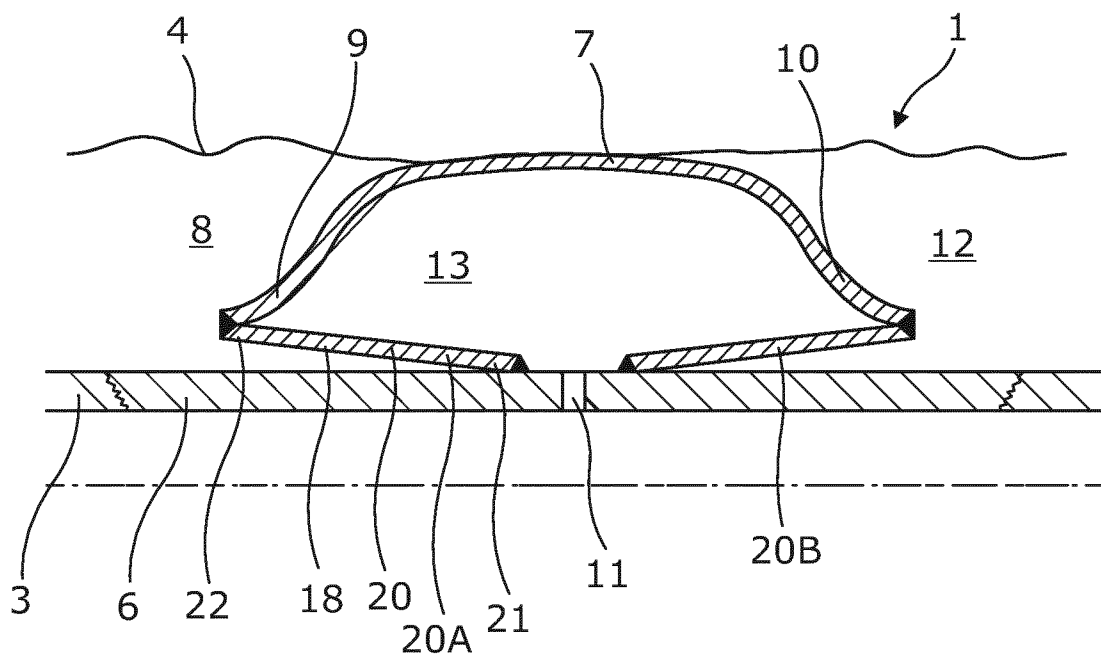


Fig. 4

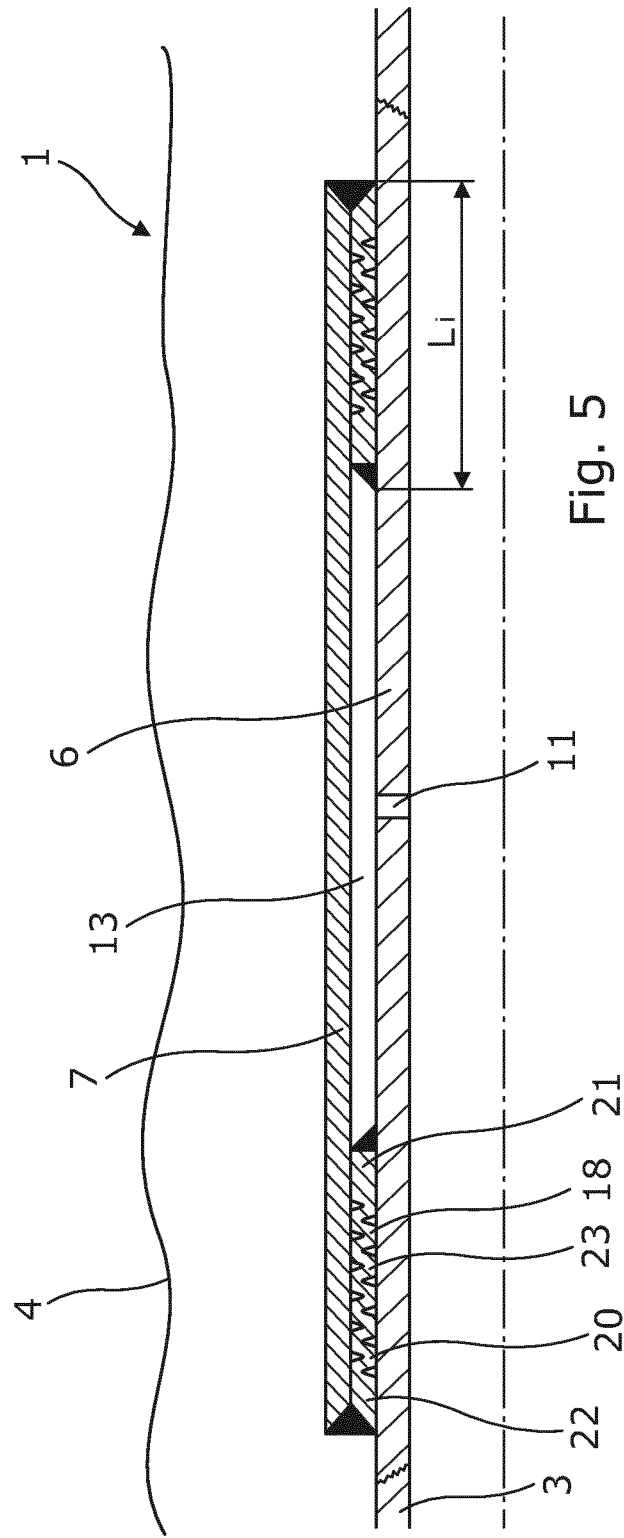


Fig. 5

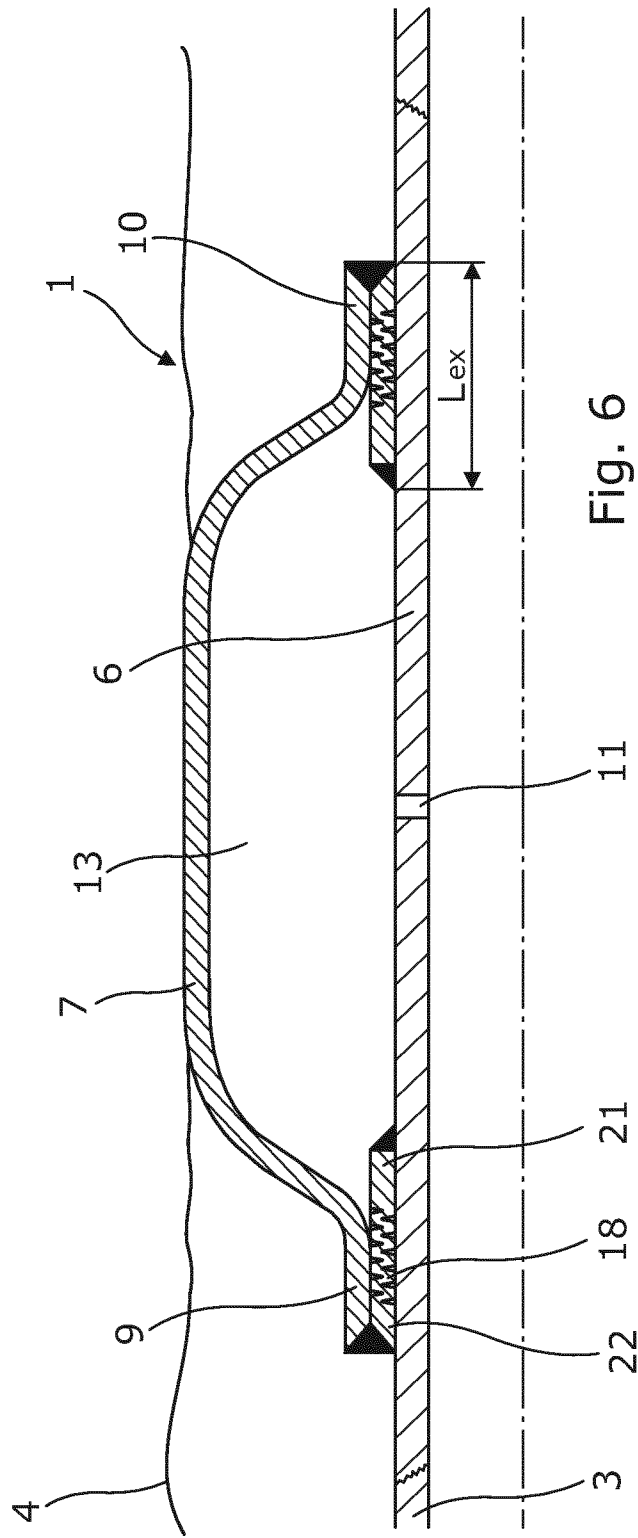


Fig. 6

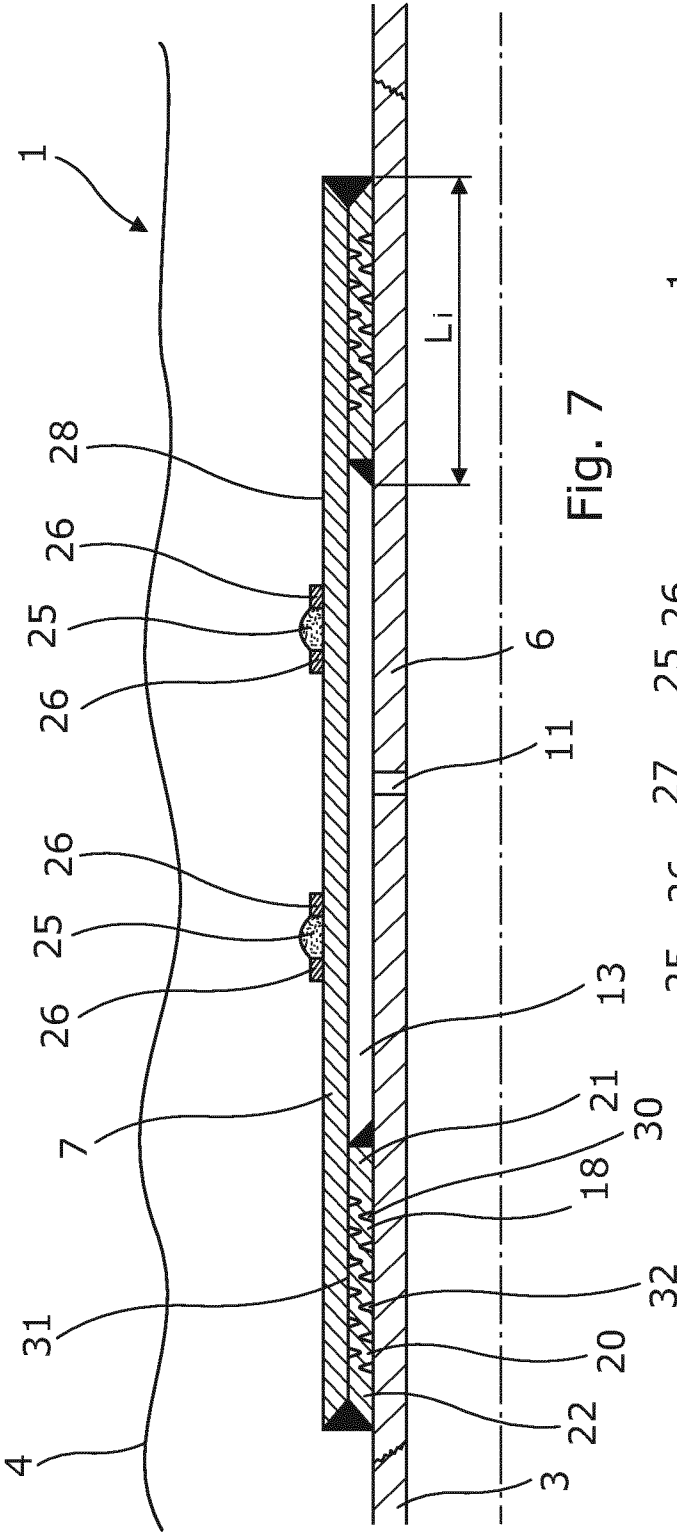


Fig. 7

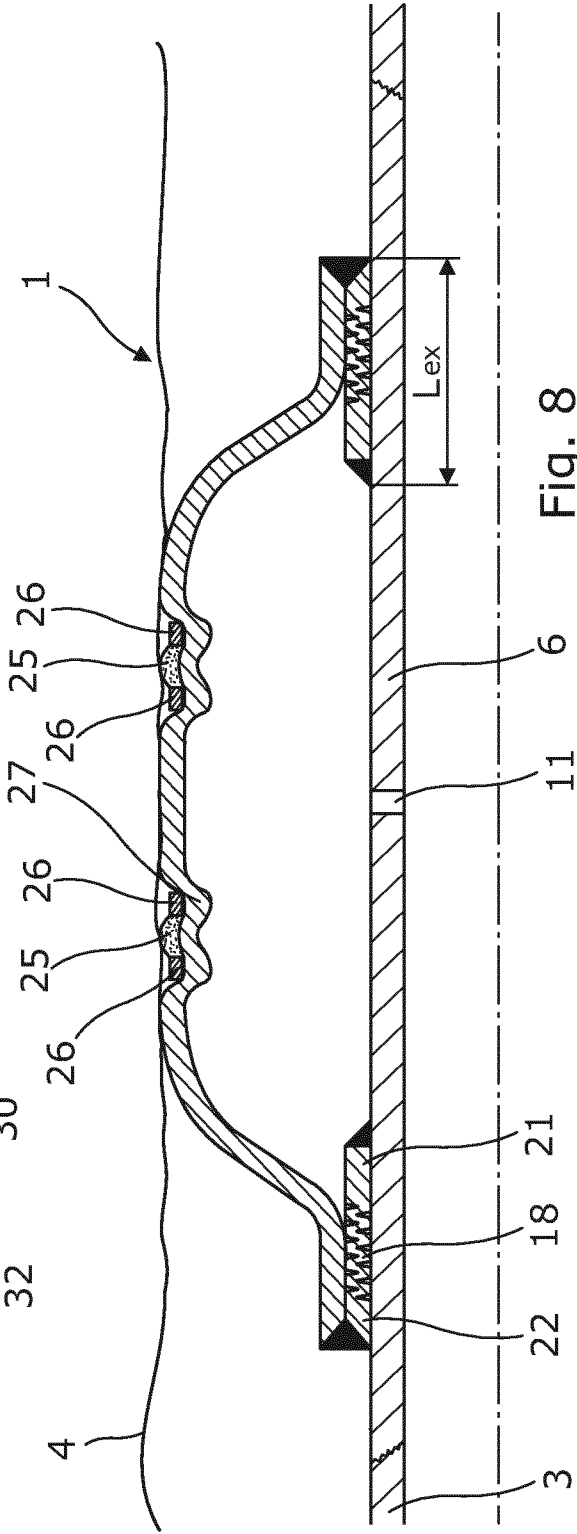


Fig. 8

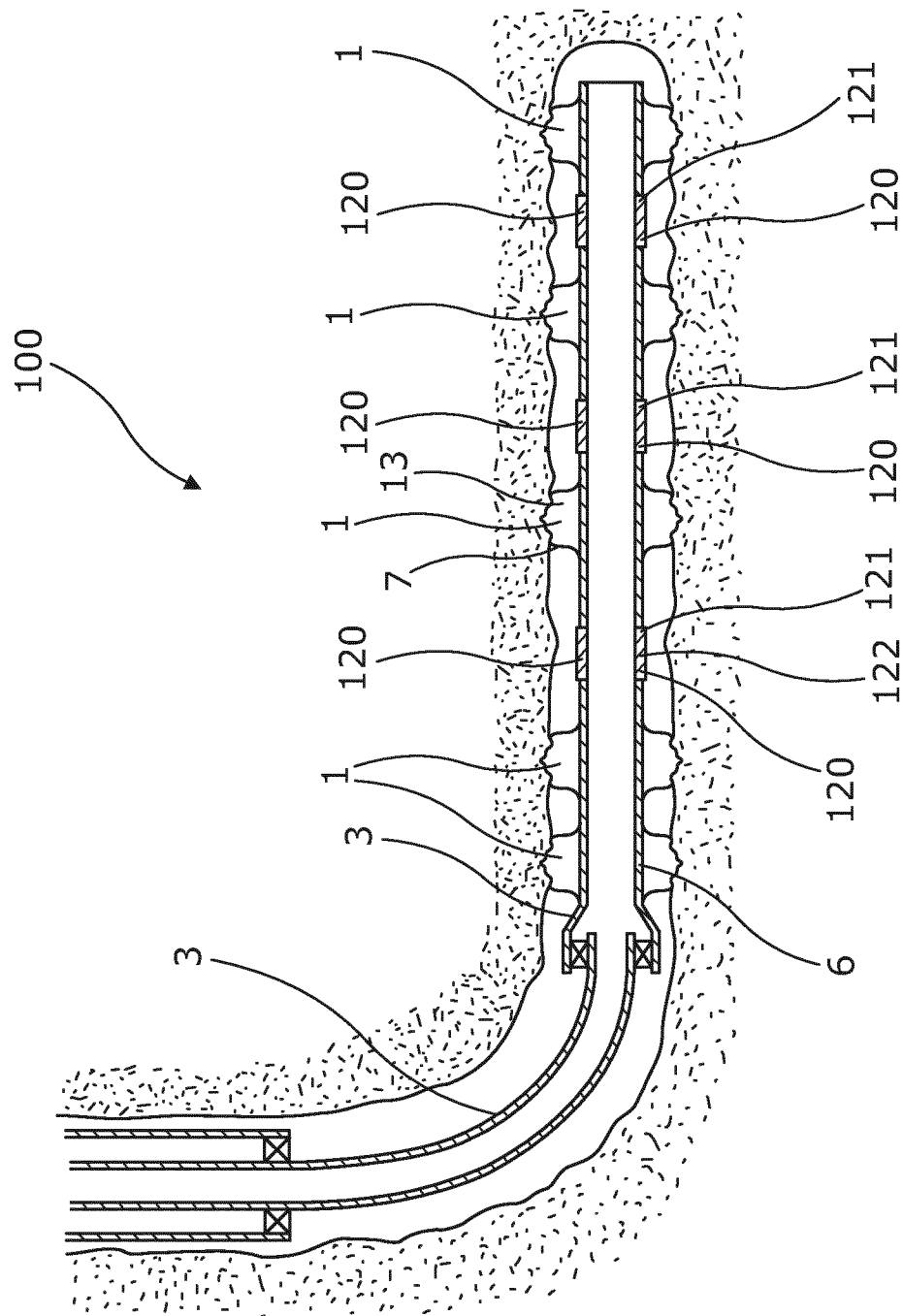
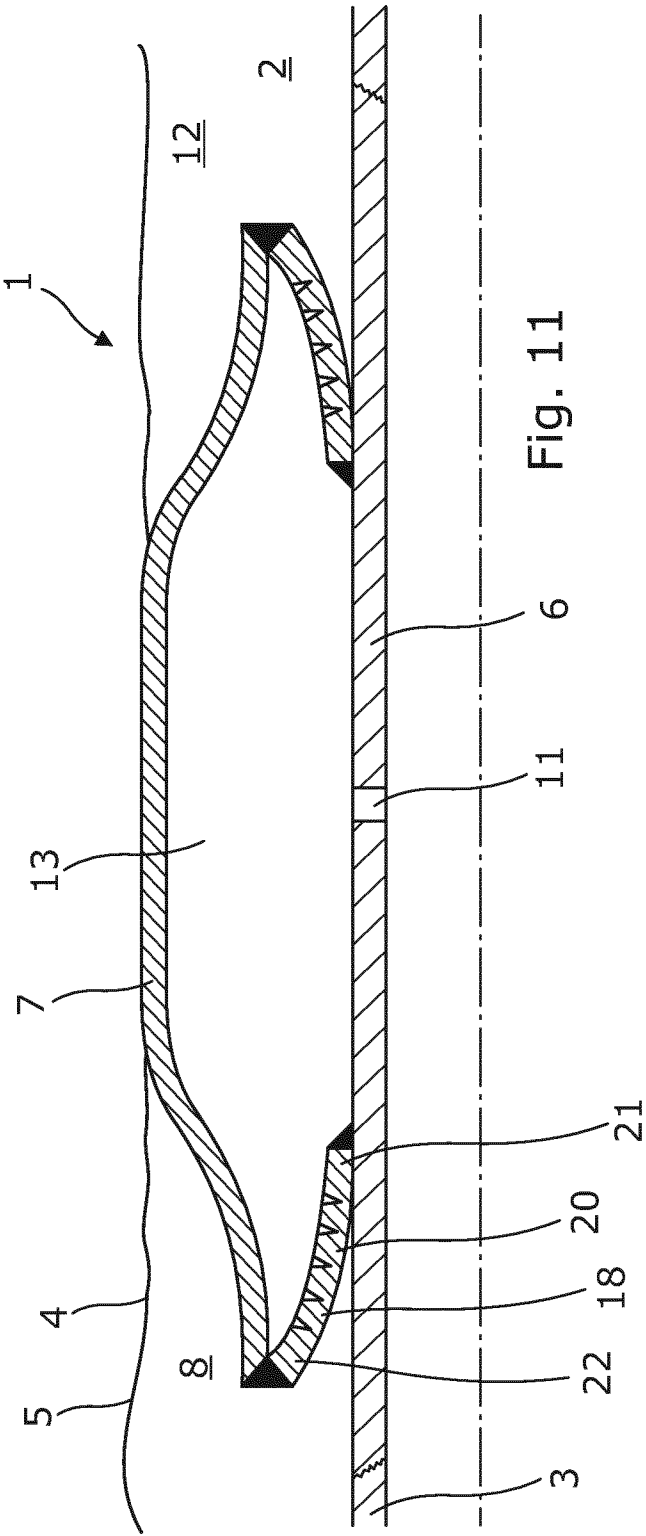
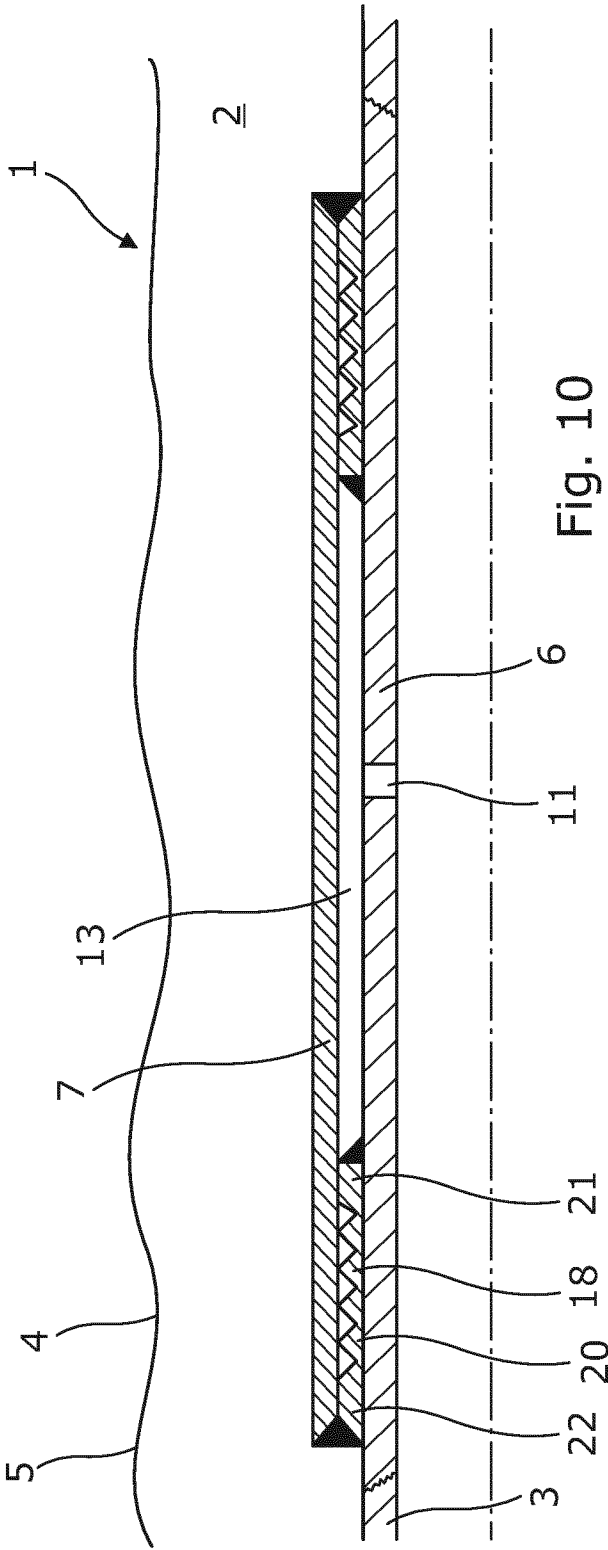


Fig. 9



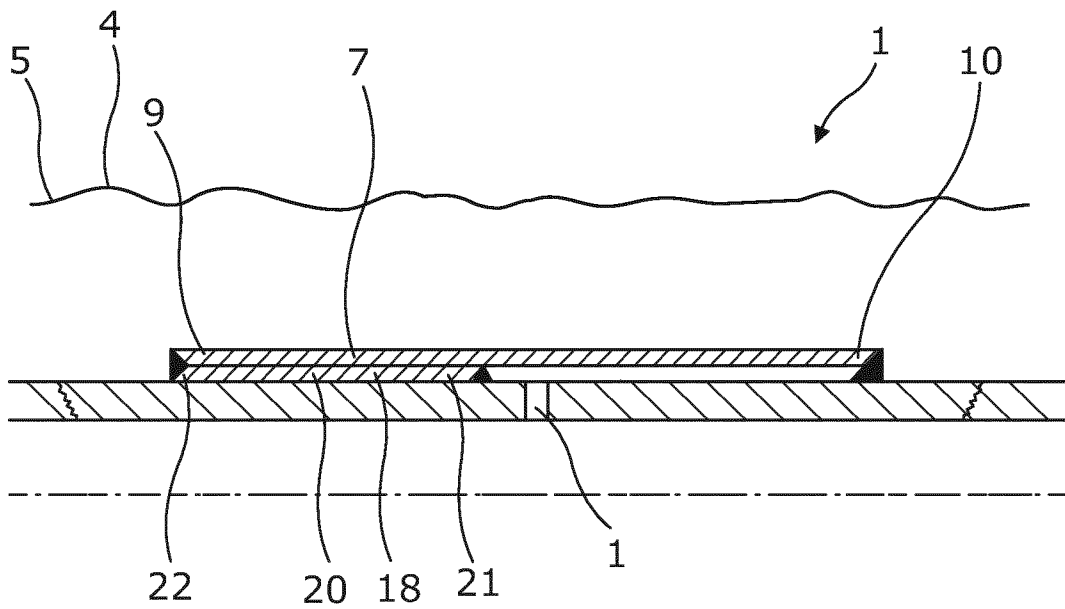


Fig. 12

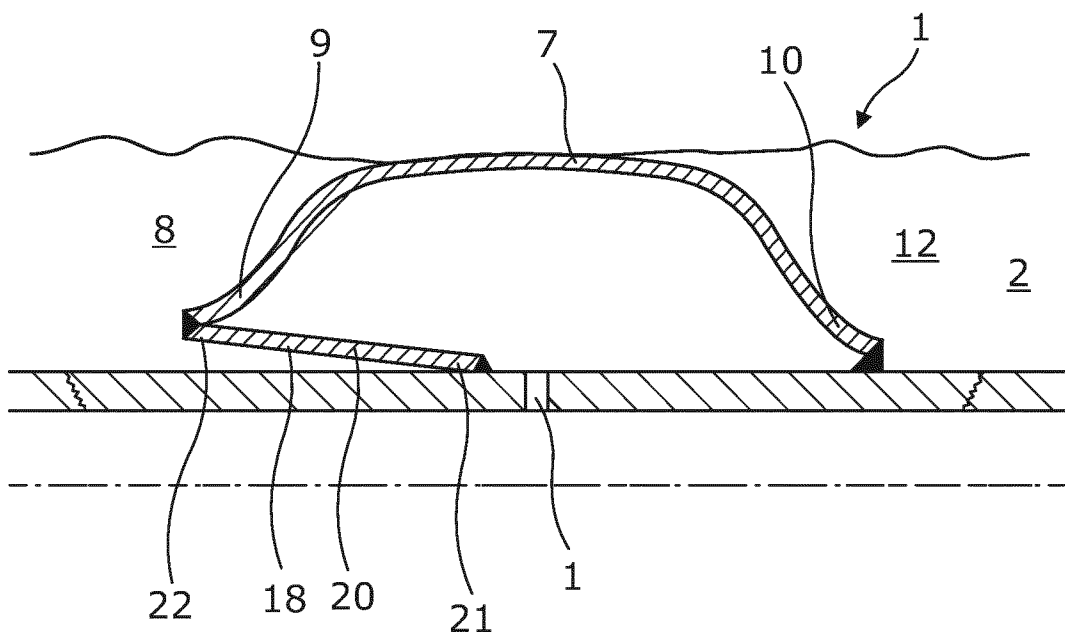


Fig. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/056470

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B33/127
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	WO 2011/042492 A1 (WELLTEC AS [DK]; HALLUNDBAEK JOERGEN [DK]; HAZEL PAUL [GB]; ANDERSEN T) 14 April 2011 (2011-04-14) bellows; page 21, lines 9-11; figures 9,10,11,13,17 page 18, line 16 - page 21, line 7 the whole document	1-15
X,P	EP 2 479 376 A1 (WELLTEC AS [DK]) 25 July 2012 (2012-07-25) the whole document New Priority date corresponding to filing date ----- -/--	1



Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search

14 May 2013

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INTERNATIONAL SEARCH REPORT

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PCT/EP2013/056470

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