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(54) Sealing material for annular barriers

(57) The present invention relates to an annular barrier for providing zone isolation between a first zone and a second zone in a borehole or a casing downhole, said annular barrier having a circumference and an outer face and comprising an annular seal comprising a sealing material having a bundle of strands wherein at least one strand comprises graphite and/or carbon.

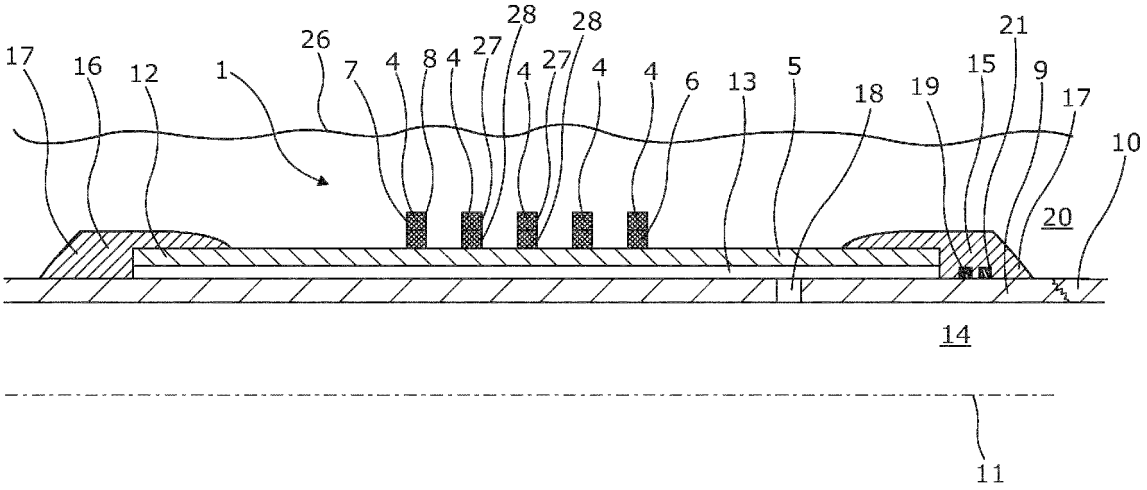

Fig. 1

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Description

Field of the invention

[0001] The present invention relates to an annular barrier for providing zone isolation between a first zone and a second zone in a borehole or a casing downhole.

Background art

[0002] Annular barriers or packers downhole often comprise external sealing material, such as elastomeric circumferential rings, to improve the sealing ability of the annular barrier when expanded to abut the inner wall of the casing or borehole.

[0003] When expanding the annular barriers or packers, the sealing material is expanded accordingly and the sealing ability is decreased and the sealing ability of the elastomeric material is furthermore decreased when subjected to the harsh environment downhole, such as high temperatures and pressure, and also different kinds of acid.

[0004] Annular barriers may be part of the completion for many years without being expanded, while the elastomeric seals are continuously subjected to the harsh environment and disintegrates and thus deteriorates over that time so that when expanded, the sealing ability of the elastomeric material may be lost.

Summary of the invention

[0005] 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 seal for annular barriers capable of withstanding the harsh environment downhole, such as high temperatures, high pressure and acid, over a period of time of approximately 10 to 20 years.

[0006] 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 zone isolation between a first zone and a second zone in a borehole or a casing downhole, said annular barrier having a circumference and an outer face and comprising an annular seal comprising a sealing material having a bundle of strands wherein at least one strand comprises graphite and/or carbon.

[0007] In one embodiment, the sealing material may cover less than 60% of the outer face, preferably less than 40% of the outer face, more preferably less than 30% of the outer face.

[0008] Also, the sealing material of the annular seal may extend around the outer face of the annular barrier.

[0009] Moreover, a cross-sectional shape of the annular seal may substantially be a triangle, a square, a pentagon, a hexagon, or a shape having more sides.

[0010] Further, the sealing material may be wound around the outer face of the annular barrier with x windings, where x > 1.0.

[0011] x may be between 1.0 and 2.0, preferably between 1.1 and 1.7 and more preferably between 1.2 and 1.5.

[0012] Additionally,the annular seal may have an elongated shape and two ends and may extend around the outer face of the annular barrier.

[0013] In one embodiment, the ends may overlap.

[0014] Furthermore, the annular barrier may comprise several annular seals.

[0015] Also, the overlap may extend over at least 10% of the circumference of the annular barrier, preferably at least 15% of the circumference, more preferably at least 30%, and even more preferably at least 40% of the circumference.

[0016] Moreover, the strands may abut each other.

[0017] In addition, the bundle and/or the strands may be coated with a second material selected from the group of metal, polymers, teflon, rubber or a combination thereof.

[0018] Further, the strands may be twisted around each other, braided, or may form a yarn.

[0019] Also, the strands may enclose a core.

[0020] The annular barrier according to the present invention may furthermore comprise a tubular part for mounting as part of the well tubular structure, said tubular part having a longitudinal axis, an expandable sleeve surrounding the tubular part and defining a space being in fluid communication with an inside of the tubular part, each end of the expandable sleeve being connected with the tubular part, and an aperture for letting fluid into the space to expand the sleeve.

[0021] In one embodiment, the annular barrier may be a packer arranged to seal against an inner surface of a well tubular structure.

[0022] The annular barrier as described above may further comprise adhesive between the outer face and the annular seal.

[0023] The present invention further relates to a downhole annular seal comprising:

- a sealing material having at least one strand comprising graphite and/or carbon.

[0024] Also, the present invention relates to a downhole system comprising a well tubular structure and at least one annular barrier as described above, wherein the annular barrier comprises a tubular structure mounted as part of the well tubular structure.

[0025] The downhole system as described above may further have a tool comprising isolation means isolating an isolated part of the inside of the tubular part outside the aperture to pressurise the isolated part of the inside and the space to expand the expandable sleeve.

[0026] Said tool may further comprise a pumping device for pumping fluid from the inside of the tubular part

being outside the isolated part and into the isolated part to expand the expandable sleeve.

[0027] Additionally, the present invention relates to a manufacturing method for manufacturing a annular barrier as described above, comprising the steps of:

- winding the sealing material around the outer face of the annular barrier to form the annular seal,
- fastening the sealing material by providing adhesive between the sealing material and outer face of the annular barrier.

[0028] Finally, the present invention relates to an application method of providing an annular barrier in a casing or borehole, comprising the steps of:

- inserting an annular barrier in the casing or borehole having x windings of sealing material around the outer face, where x > 1.0,
- expanding the annular barrier so that the annular barrier has y windings of sealing material around the outer face, wherein x > y.

[0029] Said sealing material may have substantially the same length before and after expansion of the annular barrier.

Brief description of the drawings

[0030] The invention and its many advantages will be described in more detail below with reference to the accompanying schematic drawings, which for the purpose of illustration show some non-limiting embodiments and in which

Fig. 1 shows an annular barrier according to the invention in its unexpanded condition,

Fig. 2 shows the annular barrier of Fig. 1 in its expanded condition,

Fig. 3 shows another embodiment of the annular barrier,

Fig. 4 shows yet another embodiment of the annular barrier,

Fig. 5 shows en expanded view of part of Fig. 4 in which the annular barrier is unexpanded,

Fig. 6 shows en expanded view of part of Fig. 4 in which the annular barrier is expanded,

Figs. 7a-11b shows different embodiments of the annular seal seen in a cross-sectional view and in a side view, and

Fig. 12 shows a downhole system.

[0031] All the figures are highly schematic and not necessarily to scale, and they show only those parts which are necessary in order to elucidate the invention, other parts being omitted or merely suggested.

Detailed description of the invention

[0032] Fig. 1 shows an annular barrier 1 for providing zone isolation between a first zone 2 and a second zone 3 in a borehole 20 as illustrated in Fig. 2. The annular barrier may also be set for providing zone isolation between a first zone 2 and a second zone 3 in a casing downhole, e.g. when arranging a production casing within an intermediate casing. The annular barrier 1 has a circumference and an outer face 5 and comprises several annular seals 4, each made of a sealing material 6 having a bundle 7 of strands 8 wherein at least one strand comprises graphite and/or carbon. In this way, the seals of the annular barrier can withstand very high temperatures such as up to 650°C and a high pressure such as up to 450 bar downhole. Seals of graphite or carbon are also capable of withstanding hot steam, or other gasses, lyes, and acid, such as sulphur and nitride. Known elastomeric seals are capable of withstanding such harsh downhole conditions over a longer period of time, such over a time span of 10 to 20 years as they dissolve or crack.

[0033] The annular barrier of Fig. 1 comprises a tubular part 9 for mounting as part of the well tubular structure 10 having a longitudinal axis 11 and mounted as part of a well tubular structure 10 for e.g. the production casing. The annular barrier 1 has an expandable sleeve 12 surrounding the tubular part and defining a space 13 being in fluid communication with an inside 14 of the tubular part. Each end 15, 16 of the expandable sleeve is connected with the tubular part in connection parts 17, and the tubular part has an aperture 18 for letting fluid into the space 13 to expand the sleeve. One end 15 is slidably connected with the tubular part 9 and seals 19 are arranged in grooves 21 of the connection part 17 and the other end 16 is fixedly connected with the tubular part 9. In the following,the annular barriers will be disclosed as an annular barrier having the expandable sleeve and the tubular as just described, but the annular barrier may also be a packer set between a first tubular 22 and second tubular 23 as shown in Fig. 3, where projections 24 presses the annular seal 4 against an inner face 25 of the second tubular 23.

[0034] As can be seen in Fig. 1, the sealing material of the annular seal extends around the outer face of the annular barrier for one annular seal 4. The annular seal has an elongated shape and two ends 27, 28 and the ends overlap so that one end 27 is arranged outside the other end 28 of the annular seal 4. The sealing material is wound around the outer face of the annular barrier with x windings, where x > 1.0. x is 1.0 if the ends 27, 28 face each other and x > 1.0 if one end 27 is arranged outside the other end 28 of the annular seal 4 and lies in two layers at least partly around the outer face. x is between

1.0 and 2.0 in Fig. 1 illustrating the annular barrier in its unexpanded position, x is preferably between 1.1 and 1.7 and more preferably between 1.2 and 1.5. In the unexpanded condition, the overlap extends over at least 10% of the circumference of the annular barrier, preferably at least 15% of the circumference, more preferably at least 30%, and even more preferably at least 40% of the circumference. The overlap depends on how much the outer diameter of the annular barrier is to be increased during the expansion and thus depends on the differences in the circumference before and after expansion.

[0035] When expanding the annular barrier 1, the sleeve 12 presses against the inner face 26 of the borehole 20 as shown in Fig. 2, pressing the annular seals against the inner face 26 and thus squeezing the annular seals in between the sleeve and the inner face. As the sleeve expands, the sealing material unwinds so that the ends 27, 28 of the annular seal 4 no longer overlap as shown in Fig. 2.

[0036] In order to hold the sealing material in place during insertion of the annular barrier down through the well, the annular barrier further comprises adhesive between the outer face and the sealing material of the annular seal. The overlapping end 27 arranged outside the innermost end 28 may also be adhered to the other end. After expansion, the annular seal needs no longer to be adhered to the outer face as it is squeezed in between the sleeve and the inner face 25.

[0037] In Figs. 1 and 2, the sealing material covers less than 40% of the outer face, and covers, in Fig. 4, preferably less than 30% of the outer face, more preferably less than 20% of the outer face.

[0038] In Fig. 4, the annular seals 4 are arranged in external safety sleeves 37 fastened to the expandable sleeve 12 by a first connection 38 and a second connection 39. In Fig. 4, the annular barrier 1 is shown in its expanded condition and in Fig. 5, an expanded view of one of the external safety sleeves 37 of the annular barrier is shown in an unexpanded condition of the annular barrier. Five annular seals are arranged on the outer face of the annular barrier being on the outer face of the external safety sleeve 37. In the unexpanded condition, the ends 27, 28 of the annular seals 4 overlap as shown in Fig. 5. The external sleeve has a trapezoidal cross-sectional shape holding the annular seals 4 closely together. In Fig. 6, the annular barrier has been expanded and the annular seals 4 have been unwound so that the ends 27, 28 thereof no longer overlap. In Fig. 6, fluid from one isolation zone has entered an opening 30 in the external safety sleeve 37 and presses the annular seals even further against the inner face 25 of the borehole 20.

[0039] As can be seen in Figs. 1-6, the cross-sectional shape of the annular seal is substantially square, but may, in another embodiment, have another shape such as a triangular shape, a pentagonal shape, a hexagonal shape, or a shape having more sides.

[0040] In Figs. 7a-11b,the different embodiments of the annular seal are shown. In Figs. 7a, 8a, 9a, 10a and 11a,the cross-section of the annular seal is shown, and Figs. 7b, 8b, 9b, 10b and 11b show the annular seal from a side. In Figs. 7a and 7b, bundle 7 of strands 8 is wound or braided together by means of another material 40 into a yarn in which the four strands lie straight along the longitudinal extension of the yarn so that they are substantially unbent. In Fig. 8a, the bundle 7 of strands 8 in which the strands 8 are braided itself forms the yarn-like pattern shown in Figs. 8a and 8b. In Fig. 9a, the bundle 7 of strands 8 are wound or braided together by means of another material 40 into a yarn pattern 41 and the strands form a core 42. In Fig. 10a, the bundle 7 of strands 8 are wound or braided around a core 42 of another material. In Fig. 11a, the bundle 7 of strands 8 are twisted forming a coiling pattern 43 and the strands abut each other.

[0041] In Figs. 7a and 9a, the other material 40 may be a material selected from the group of metal, polymers, teflon, rubber or a combination thereof. The bundle 7 of strands 8 may be coated with a second material selected from the group of metal, polymers, teflon, an elastomeric material, silicone, or natural or synthetic rubber or a combination thereof. In this way, the sealing ability of the annular seal is substantially increased.

[0042] Fig. 12 shows a downhole system 100 comprising a well tubular structure 10 and two annular barriers having a tubular part 9 mounted as part of the well tubular structure 10. The downhole system 100 may further have a tool comprising isolation means isolating an isolated part of the inside 14 of the tubular part outside the aperture 18 to pressurise the isolated part of the inside 14 and the space 13 to expand the expandable sleeve 12. The tool may further comprise a pumping device for pumping fluid from the inside of the tubular part being outside the isolated part and into the isolated part to expand the expandable sleeve.

[0043] When manufacturing an annular barrier 1, the expandable sleeve 12 is fastened in the connection parts 17 and the sealing material is wound around the outer face of the annular barrier to form the annular seal. The sealing material is fastened to the outer face by providing adhesive between the sealing material and the outer face of the annular barrier. The annular barrier is then inserted into the casing or borehole having x windings of sealing material around the outer face, where $x > 1.0$, and when the annular barrier is subsequently expanded, the annular barrier has y windings of sealing material around the outer face, wherein $x>y$.

[0044] The sealing material of each annular seal has substantially the same length before and after expansion of the annular barrier and in this way, the strands are not broken into several pieces which would ruin the sealing ability of the annular seal. Graphite and carbon are not very bendable materials, but when they are being wound, some kind of flexibility is then built into the annular seal 4.

[0045] When one end 27 of the annular seal overlaps the other end 28 and the expandable sleeve 12 is expanded, the strands 8 may unwind themselves slightly

so that the strands of one end 27 lie in between the strands of the other end 28 of the annular seal, and the annular seal in that section is thus wider than in other sections of the annular seal.

[0046] An annular barrier may also be called a packer or similar expandable means. The well tubular structure can be the production tubing or casing or a similar kind of tubing downhole in a well or a borehole. The annular barrier can be used both in between the inner production tubing and an outer tubing in the borehole or between a tubing and the inner wall of the borehole. A well may have several kinds of tubing and the annular barrier of the present invention can be mounted for use in all of them.

[0047] A valve may be arranged in the aperture 18 and the valve may be any kind of valve capable of controlling flow, such as a ball valve, butterfly valve, choke valve, check valve or non-return valve, diaphragm valve, expansion valve, gate valve, globe valve, knife valve, needle valve, piston valve, pinch valve, or plug valve. The aperture may be arranged opposite a connection part and the connection part may have a fluid channel fluidly connecting the aperture and the space 13.

[0048] The expandable sleeve may be an expandable tubular metal sleeve that is a cold-drawn or hot-drawn tubular structure.

[0049] When the expandable sleeve 12 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 12 has an outside diameter and is capable of expanding to an at least 10% larger diameter, preferably an at least 15% larger diameter, more preferably an at least 30% larger diameter than that of an unexpanded sleeve.

[0050] Furthermore, the expandable sleeve 12 has a wall thickness which is thinner than a length 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.

[0051] The expandable sleeve 12 of the annular barrier 1 may be made of metal, polymers, an elastomeric material, silicone,or natural or synthetic rubber.

[0052] In order to increase the thickness of the sleeve 12, additional material may be applied (not shown) onto the expandable sleeve, e.g. by adding welded material onto the outer face.

[0053] In another embodiment, the thickness of the sleeve 12 is increased by fastening a ring-shaped part onto the sleeve (not shown).

[0054] In yet another embodiment, the increased thickness of the sleeve 12 is facilitated using a varying thickness sleeve 12 (not shown). To obtain a sleeve of varying thickness, techniques such as rolling,extrusion or die-casting may be used.

[0055] 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 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.

[0056] 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 oilcontaining fluid, etc. Gas, oil, and water fluids may thus all comprise other elements or substances than gas, oil, and/or water, respectively.

[0057] By a casing is meant any kind of pipe, tubing, tubular, liner, string etc. used downhole in relation to oil or natural gas production.

[0058] In the event that the tool is not submergible all the way into the casing, a downhole tractor can be used to push the tools all the way into position in the well. A downhole tractor is any kind of driving tool capable of pushing or pulling tools in a well downhole, such as a Well Tractor®. A downhole tractor may have wheels on arms projecting from a tool housing of the tractor, or driving belts for moving the tractor forward in the well.

[0059] Although the invention has been described in the above in connection with preferred embodiments of the invention, it will be evident for a person skilled in the art that several modifications are conceivable without departing from the invention as defined by the following claims.

Claims

1. An annular barrier (1) for providing zone isolation between a first zone (2) and a second zone (3) in a borehole (20) or a casing downhole, said annular barrier having a circumference and an outer face (5) and comprising an annular seal (4) comprising a sealing material (6) having a bundle (7) of strands (8) wherein at least one strand comprises graphite and/or carbon.

2. An annular barrier according to claim 1, wherein the sealing material is wound around the outer face of the annular barrier with x windings, where $x > 1.0$.

3. An annular barrier according to claim 1 or 2, wherein the annular seal has an elongated shape and two ends (27, 28) and extends around the outer face of the annular barrier.

4. An annular barrier according to claim 3, wherein the ends overlap.

5. An annular barrier according to claim 4, wherein the

overlap extends over at least 10% of the circumference of the annular barrier, preferably at least 15% of the circumference, more preferably at least 30%, and even more preferably at least 40% of the circumference.

6. An annular barrier according to any of the preceding claims, wherein the bundle and/or the strands are coated with a second material selected from the group of metal, polymers, teflon, rubber or a combination thereof.

7. An annular barrier according to any of the preceding claims, wherein the strands are twisted around each other, braided, or forms a yarn.

8. An annular barrier according to any of the preceding claims, wherein the strands enclose a core.

9. An annular barrier according to any of the preceding claims, wherein the annular barrier comprises a tubular part (9) for mounting as part of the well tubular structure (10), said tubular part having a longitudinal axis (11), an expandable sleeve (12) surrounding the tubular part and defining a space (13) being in fluid communication with an inside (14) of the tubular part, each end (15, 16) of the expandable sleeve being connected with the tubular part, and an aperture (18) for letting fluid into the space to expand the sleeve.

10. An annular barrier according to any of the preceding claims, further comprising adhesive between the outer face and the annular seal.

11. A downhole annular seal comprising:

- a sealing material having at least one strand comprising graphite and/or carbon.

12. A downhole system comprising a well tubular structure and at least one annular barrier according to any of claims 1-10, wherein the annular barrier comprises a tubular structure mounted as part of the well tubular structure.

13. A manufacturing method for manufacturing a annular barrier according to any of the claims 1-10, comprising the steps of:

- winding the sealing material around the outer face of the annular barrier to form the annular seal,
- fastening the sealing material by providing adhesive between the sealing material and outer face of the annular barrier.

14. An application method of providing an annular barrier in a casing or borehole, comprising the steps of:

- inserting an annular barrier in the casing or borehole having x windings of sealing material around the outer face, where $x > 1.0$,
- expanding the annular barrier so that the annular barrier has y windings of sealing material around the outer face, wherein $x > y$.

15. An application method according to claim 14, wherein the sealing material has substantially the same length before and after expansion of the annular barrier.

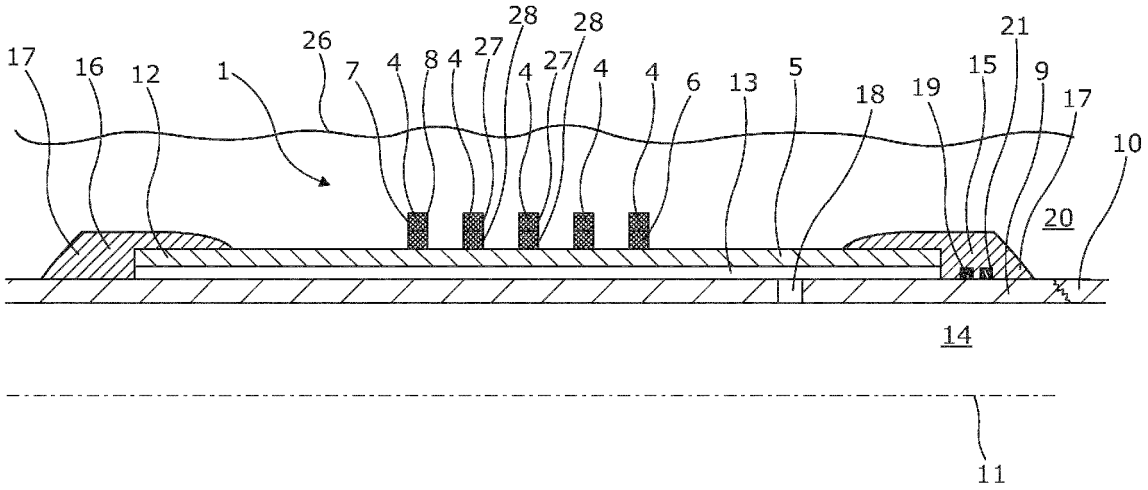


Fig. 1

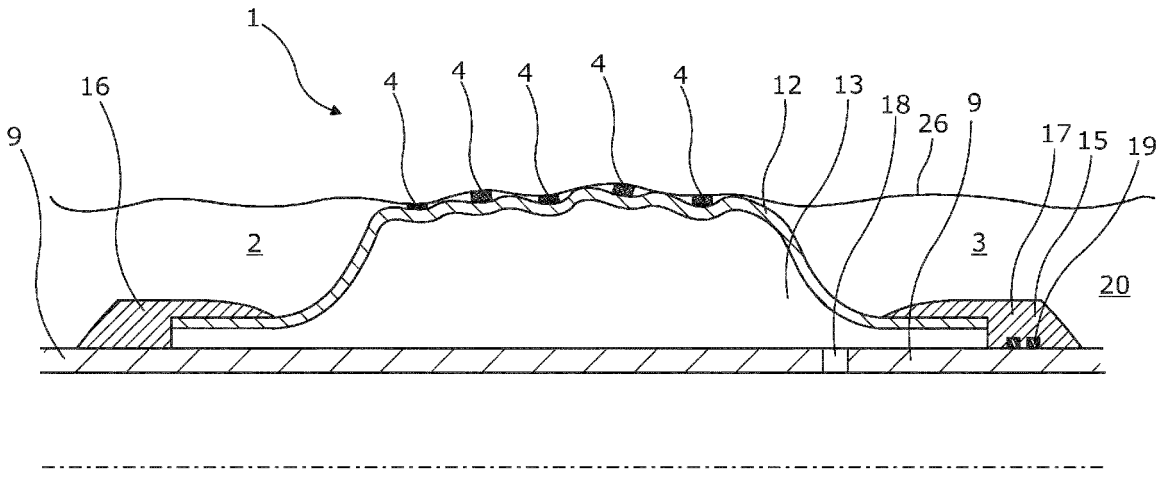


Fig. 2

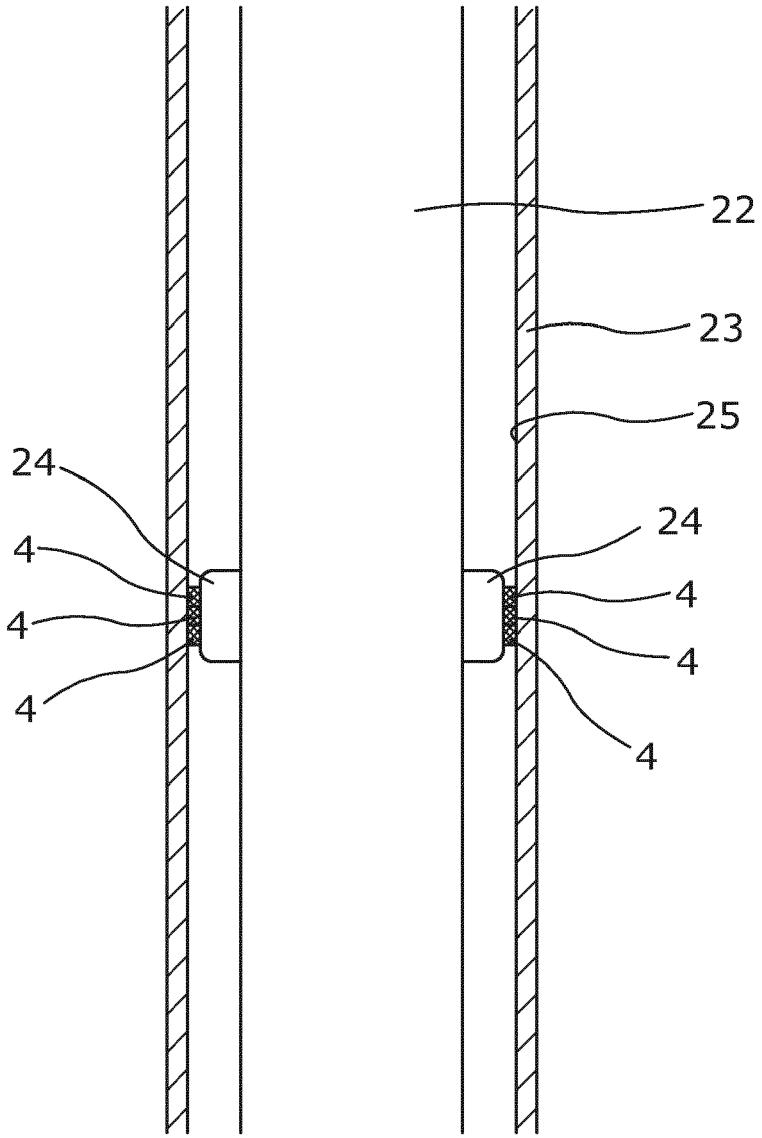


Fig. 3

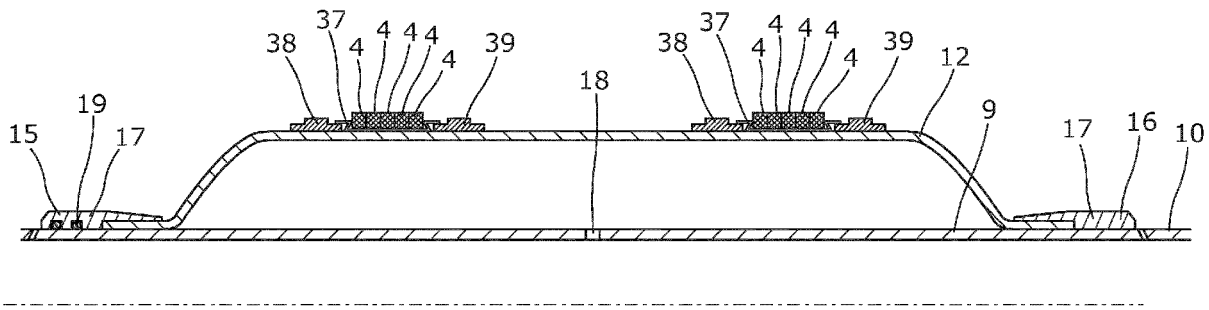


Fig. 4

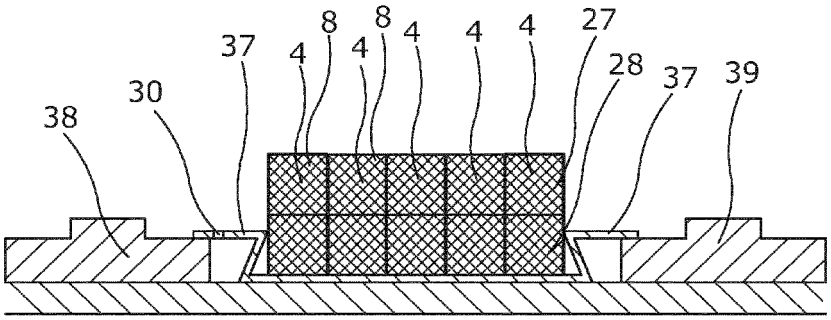


Fig. 5

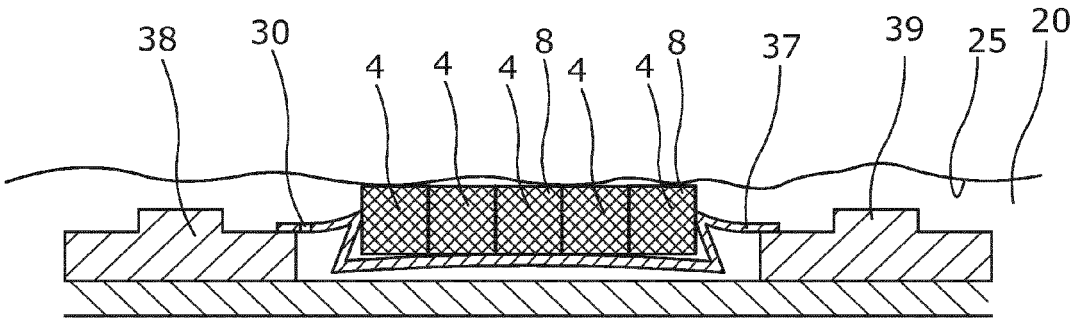


Fig. 6

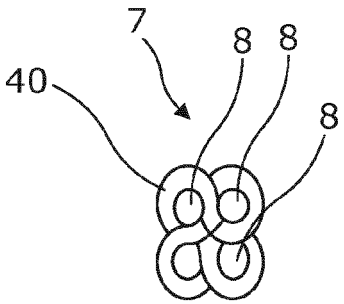


Fig. 7a

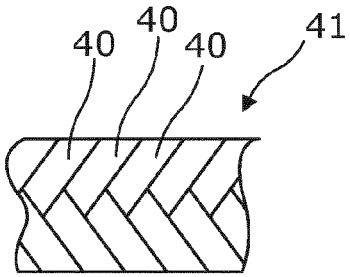


Fig. 7b

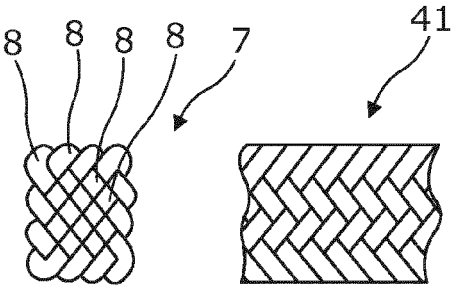


Fig. 8a

Fig. 8b

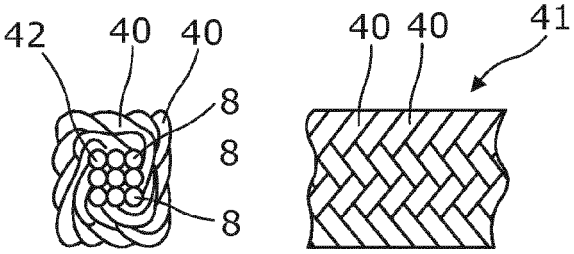
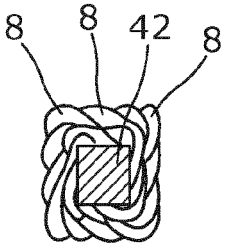


Fig. 9a

Fig. 9b



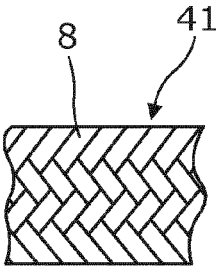


Fig. 10a

Fig. 10b

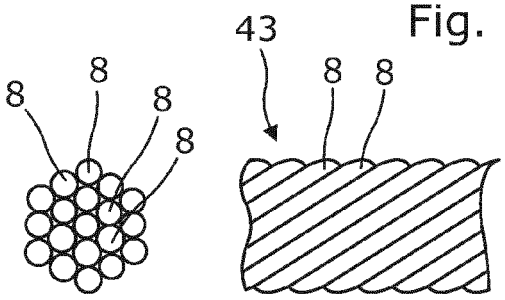


Fig. 11a

Fig. 11b

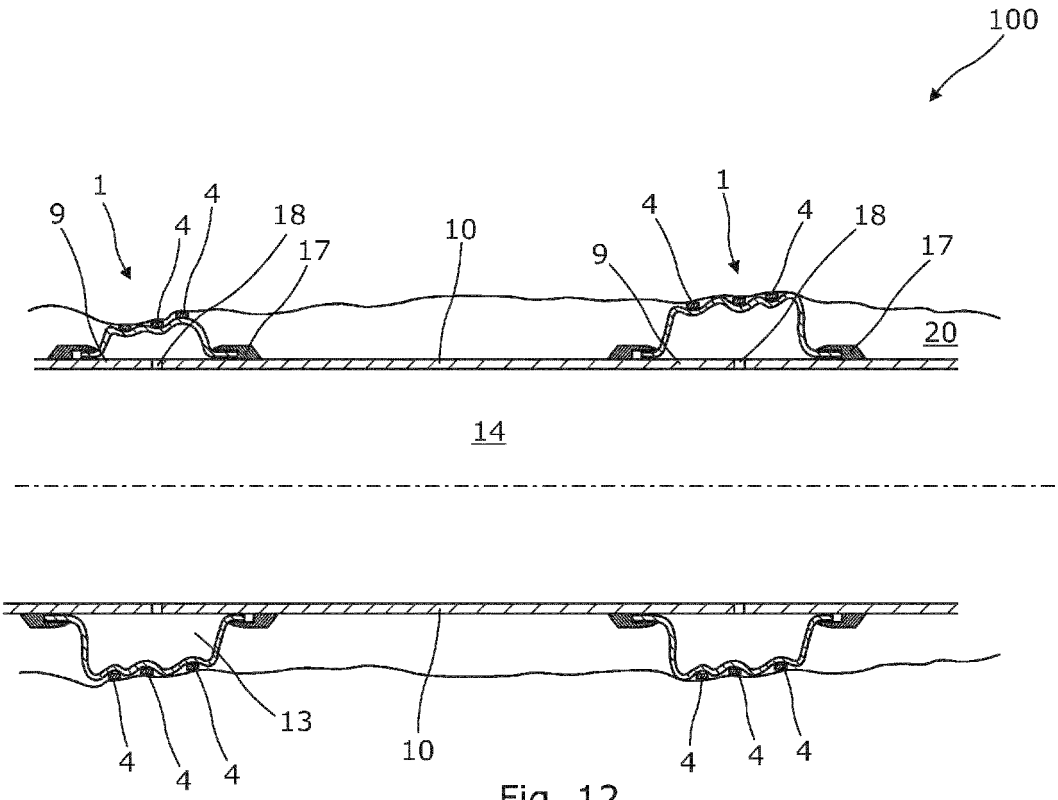


Fig. 12

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EUROPEAN SEARCH REPORT

Application Number
EP 11 18 7092

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 507 341 A (ESLINGER DAVID M [US] ET AL) 16 April 1996 (1996-04-16) * column 3, line 30 - line 34; claims 1-4; figures 1-5 * -----	1-15	INV. E21B33/127
X	GB 2 458 557 A (SCHLUMBERGER HOLDINGS [VG]) 30 September 2009 (2009-09-30) * page 5, line 9 - line 11; figure 2 * -----	11	
X	US 4 730 670 A (KIM YUNG J [US]) 15 March 1988 (1988-03-15) * column 8, line 60 - column 9, line 10; figures 1e, 9 * -----	11	
X	US 4 753 444 A (JACKSON ALAN T [US] ET AL) 28 June 1988 (1988-06-28) * column 2, line 59 - column 3, line 33; claims 1,14; figures 1,2 * -----	11	
A	US 4 532 169 A (CARLEY EARL P [US]) 30 July 1985 (1985-07-30) * column 18, line 28 - line 57 * -----	1-15	TECHNICAL FIELDS SEARCHED (IPC) E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	11 June 2012	Strømmen, Henrik

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