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(54) System and method for providing a pressure seal

(57) A method of providing a pressure seal in an annular space (6) in a wellbore (1) formed in an earth formation (3), the space having a cross-section with an outer circumference, the method comprising; providing an expandable body (8) arranged around a tubular (5) in the wellbore, the expandable body having first and second ends along the tubular, identifying a high-pressure side and a low-pressure side along the wellbore; providing a pressure reinforcement device at least at a low-pressure end, selected from the first and second ends of the ex-

pandable body, which low-pressure end faces the low-pressure side of the wellbore, wherein the pressure reinforcement device (15) is a solid member of adjustable cross-section; adjusting the cross-section of the pressure-reinforcement device to the outer circumference of the annular space; expanding the expandable body from a contracted configuration to an expanded configuration so as to provide an annular seal, wherein the pressure reinforcement device contacts the low-pressure end of the expandable body in the expanded configuration.

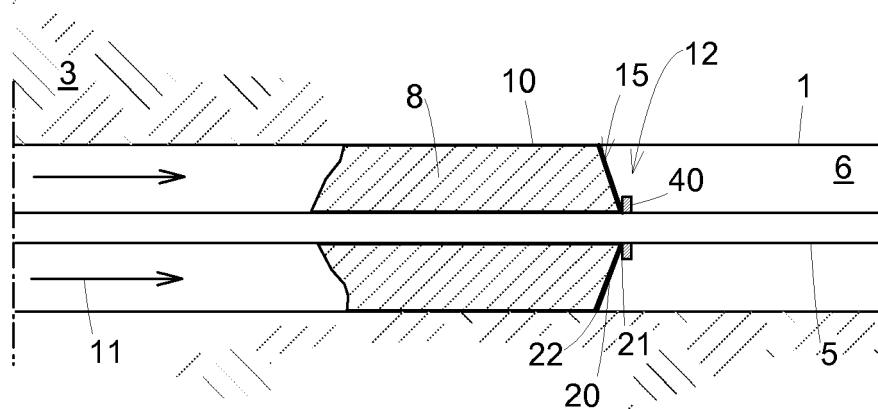


FIG. 2C

Description

[0001] The present invention relates to a system and method for providing a pressure seal in a wellbore formed in an earth formation.

[0002] In the context of production of fluids from a subsurface formation in the earth, such as a reservoir of hydrocarbon fluid, via a wellbore formed in the earth formation it can be desired to provide a seal in the wellbore, such as to prevent transfer of a selected fluid between the subsurface formation and the surface facility. Typically an annular seal around a tubular longitudinally extending in the wellbore is needed. Such an annular seal can be provided by an expandable body that extends around the tubular, e.g. a production tubular installed in the wellbore. The expandable body can for example be an inflatable packer, or a swellable body such as a swellable elastomer, or a gel-forming material. For example, a swellable elastomer bodies are known from WO 03/008756 or WO 2005/012686. A swellable body is swellable in a selected fluid, which can for example be aqueous or hydrocarbon based, e.g. water (brine), crude oil, drilling mud.

[0003] When the expandable body is extended against the surrounding wellbore wall, e.g. by inflating an inflatable packer or by contacting a swellable body with a selected fluid, it provides an annular seal.

[0004] In certain applications it is important that the annular seal can withstand a substantial pressure differential between the annular wellbore spaces at either end of the seal. For example, a high-pressure side can be the side at which fluid such as hydrocarbon fluid flows into the wellbore annulus from a surrounding earth formation. The high-pressure side can also be the side at which a fluid injection into the surrounding earth formation is conducted via the wellbore annulus.

[0005] There is a need for improved annular pressure seals, which can withstand higher differential pressures.

[0006] In accordance with the invention there is provided a method of providing a pressure seal in an annular space in a wellbore formed in an earth formation, the space having a cross-section with an outer circumference, the method comprising;

- providing an expandable body arranged around a tubular in the wellbore, the expandable body having first and second ends along the tubular;
- identifying a high-pressure side and a low-pressure side along the wellbore;
- providing a pressure reinforcement device at least at a low-pressure end, selected from the first and second ends of the expandable body, which low-pressure end faces the low-pressure side of the wellbore, wherein the pressure reinforcement device is a solid member of adjustable cross-section;
- adjusting the cross-section of the pressure-reinforcement device to the outer circumference of the annular space;

- expanding the expandable body from a contracted configuration to an expanded configuration so as to provide an annular seal, wherein the pressure reinforcement device contacts the low-pressure end of the expandable body in the expanded configuration.

[0007] The invention is based on the insight gained by applicant, that an expandable body in its expanded, i.e. sealing, configuration is typically deformable. Further it

10 has been recognized that the deformation under the influence of the pressure differential is a key limitation for the maximum pressure differential the seal can withstand. The deformation can be significantly minimized by providing a pressure-reinforcement device at the low-pressure side of the seal, and thus a seal with increased pressure rating than without the pressure-reinforcement device.

[0008] It is observed that WO 2006/121340 discloses a packer anchoring device for anchoring of an expandable annular packer to a normally tubular object by means

20 of a reinforcement and an expandable end ring for use in a borehole, in order to overcome problems with chemical bonding between an annular packer and a pipe. The expandable end ring has a cross-section in the shape of a right angle, wherein a first leg of the angle forms a disc perpendicular to the pipe it encircles, and the second leg forms a sleeve extending axially. The end ring is slit by a number of first radial slits extending from the inside, and a number of alternate second radial slits extending from the outside. A pressure or pressure differential in the wellbore is not discussed, and thus it is not disclosed to place the anchoring device at a low-pressure end. Even if that was done, the known packer anchoring device is not a pressure-reinforcement device, because its 30 deliberately weakened structure can fold backwards, away from the expanded packer.

[0009] In one embodiment the expandable body is selected from the group consisting of an inflatable packer, a swellable elastomer, a gel-forming material. These examples have in common that the expandable body is 40 deformable, or elastic, in its expanded configuration.

[0010] The swellable elastomer, also referred to as swellable rubber, can for example have a polymer matrix made from a polymer selected from the group consisting

45 of acrylonitrile butadiene rubber (e.g. NBR or HNBR), ethylene propylene monomer (EPDM), fluorocarbon and/or hydrofluorocarbon elastomers, of which examples are given hereinabove, butyl rubber, silicone rubber. A gel-forming material comprises a gel-forming component 50 selected from the group consisting of a layered silicate, an inorganic polymer, a superabsorbent, and swells and forms a gel when being contacted with a selected fluid, e.g. water and/or hydrocarbon oil.

[0011] In one embodiment the cross-section of the pressure-reinforcement device is adjusted to the outer circumference of the annular space before the expandable body is providing an annular seal. In this way it can engage well against the wellbore wall, and provide pres-

sure reinforcement from the moment that the seal is formed. With a swelling elastomer, for example, the seal is only gradually formed as the elastomer swells, and thus a reinforcement already at the initial sealing contact with the wellbore wall is provided.

[0012] In one embodiment the pressure-reinforcement device comprises a substantially frustoconical member having a top, and a base with relatively larger cross-section than the top, the base having an outer circumference that is adjusted or adjustable to the outer circumference of the space to be sealed, and wherein the base is arranged to face the expandable body. This is a particularly elegant, simple and cost-effective implementation of a pressure-reinforcement device. The substantially frustoconical shape allows the device to conform to the outer circumference of the space to be sealed, such as in an uncased open borehole or a cased borehole, and thus provides good support in this critical area for deformation of the expanded body. At the same time this shape provides a mechanically strong support for the expanded body, and a barrier against pressure from the base side, such as due to the swelling body. Pressure building up against the base side of the frustoconical member can press the base against the outer wall of the space to be sealed, thus further improving the seal in this critical area.

[0013] In one embodiment the frustoconical member is installed in the wellbore in a first configuration, in which the base has a first cross-section, and wherein the frustoconical member is moved to a second configuration, in which the base has a second cross-section larger than the first cross-section that is adjusted to the cross-section of the space to be sealed. In particular, in the second configuration the second cross-section of the base can be determined by an external radial inward force compensating a radial outward force exerted by the base. The second cross-section can be the cross-section of the space to be sealed. An example of a frustoconical member that can assume such first and second configurations is an umbrella-type member, wherein the release from the first configuration can be triggered by a suitable activating mechanism.

[0014] In one embodiment the frustoconical member in the first configuration is a resilient body under radial inward stress, and wherein it is moved to the second configuration by at least partially releasing the radial inward stress. Such an embodiment of the frustoconical member can for example be easily achieved when using a slit ring. The slit ring can be formed into a frustoconical shape of the first configuration, and for example releasably fixed in that configuration. When it was placed at the desired location in the wellbore, the fixation can be released, so that the base diameter/cross section increases and the base circumference pushes against the outer wall of the sealing space. In one embodiment, releasing the fixation can occur by opening of an adhesive connection under wellbore conditions, e.g. at a prevailing elevated temperature in the wellbore.

[0015] In one embodiment the frustoconical member

comprises a slit ring under radial inward stress. This is a particularly simple and cost-effective embodiment, which provides a resilient substantially frustoconical member of which the base diameter can be easily adjusted by adjusting radial inward force. The slit ring can have a single cut through the ring, or one or more partial slits starting at the larger diameter of the ring. For example, when a plane ring is cut open at one side, the ends formed by the cut can be slid one over the other, thereby deforming the ring out of the plane to form a substantially frustoconical shape. Preferably, the frustoconical member has a closed nappe when viewed in axial direction. The side wall or hull connecting the top and the base is referred to as nappe. This can be achieved with an inwardly deformed slit ring having an unobstructed outer diameter larger than the maximum diameter of the space to be sealed. The invention thus allows to provide pressure support to a material that is not a rubber, e.g. a gel-forming material.

[0016] In one embodiment the space in the wellbore is at a temperature of above 100 °C, in particular above 150 °C, more in particular above 200 °C, for at least part of the time that the system for sealing is in the wellbore. This can be during running into the well, or at a later point in time, in expanded or contracted state of the expandable body.

[0017] The invention moreover provides a system for providing a pressure seal in an annular space in a wellbore formed in an earth formation, the space having a cross-section with an outer circumference, the system comprising

- an expandable body arranged around a tubular, the expandable body having a first and second ends along the tubular, which expandable body is expandable from a contracted configuration to an expanded configuration; and
- a pressure reinforcement device for at least one of the first and second ends, the pressure reinforcement device comprising a substantially frustoconical member having a top, and a base with relatively larger cross-section than the top, the base having an outer circumference that is adjusted or adjustable to the outer circumference of the space to be sealed, and wherein the base is arranged to face the expandable body and to contact the expandable body when it is in the expanded configuration.

[0018] Some suitable features and embodiments of the frustoconical member have already been discussed hereinabove. Moreover, in one embodiment the frustoconical member at least at its base is under radial inward stress. This can be the case in a situation that the frustoconical member is run into the wellbore, where the base is radially squeezed to a smaller diameter than the wellbore. Also, the base of the member can be under radial inward stress when it has been adjusted to the wellbore wall. Thus it will exert an outward force against

the outer wall of the sealing space, conforming even better to that outer wall. The outer wall can for example be the open hole wall of the wellbore, or the inner wall of a casing. It is observed that in the packer-anchoring device known from WO 2006/121340 the end ring is under radial outward stress and has a tendency to retract from the borehole wall.

[0019] In one embodiment the frustoconical member is, at least at its base, resilient, the base having an unobstructed cross-section larger than the cross-section of the space to be sealed. This provides improved conforming of the base to the outer wall of the sealing space. The swollen body pushing against the base further improves the conformance.

[0020] In one embodiment the system further comprises a stop for preventing longitudinal movement of the pressure reinforcement device away from the expandable body. The stop can be provided at the top of the frustoconical member, preferably having a size or diameter larger than a top diameter of the frustoconical member. The stop can for example be an annular ring around the tubular. The stop can also be a connection to the tubular.

[0021] The pressure-reinforcement device can comprise one or more further substantially frustoconical members. For example, several slit rings arranged one behind the other can provide further improved pressure-reinforcement properties. The plurality of frustoconical members can be alike, or differ in one or more parameters. Parameters are for example the material from which the members are made, the thickness of the material, the dimensions such as the unobstructed base cross-section or diameter, resilient or elastic properties such as a spring constant.

[0022] The system can comprises two pressure-reinforcement devices at both the first and second ends. In this way pressure reinforcement is provided even if the pressure differential in the wellbore changes direction.

[0023] The method according to the invention can use any one of the systems according to the present invention.

[0024] The invention will now be further described by way of example and with reference to the drawings, wherein

Figures 1a and 1b schematically show a section of an open-hole wellbore provided with an expandable body around a tubular, before, and some time after expanding and under a pressure differential; respectively (not according to the invention);

Figures 2a through 2d schematically show a section of an open-hole wellbore provided with an expandable body, and at one end or both ends an pressure-reinforcement device according to the invention, in various stages;

Figures 3a and 3b show schematically a slit ring in unobstructed shape, and deformed into a substantially frustoconical shape, respectively.

[0025] Like reference numerals are used in the Figures to refer to the same or similar objects.

[0026] Reference is made to Figure 1a, showing a wellbore 1 extending, normally from surface, into the earth and penetrating a subsurface earth formation 3. In the wellbore 1 a tubular 5 is provided, which can for example be a production tubular for producing hydrocarbon fluid entering the wellbore at a production zone of the earth formation, and flowing via the production tubular to the surface of the earth. Sometimes it is desired to seal the annular space 6 around the tubular, so as to provide a pressure separation in the annulus 6, thereby also preventing fluid to flow along the annulus. A seal can be obtained by a packer. Figure 1a shows an expandable body 8, such as a swellable elastomer packer, in a contracted configuration, as it is run into the wellbore. Figure 1b shows the expandable body 8 in an expanded state, such as after inflating an inflatable packer or swelling a swellable elastomer packer. It has now extended to the outer wall 10 of the sealing space. The arrows 11 indicate a pressure differential acting on the seal from high to low pressure, with the high-pressure side being at the left of the drawing, and the low-pressure side at the right.

[0027] The drawing schematically shows that the elastic expanded body 8 deforms, in particular at the low pressure side. This deformation eventually leads to a loss of the seal if the pressure differential increases. The deformation of the packer will open channels for fluid, in particular along the outer wall of the annular space.

[0028] Figures 2a through 2d illustrate the system 12 and method of the present invention. Providing an expandable body arranged around a tubular in the wellbore has already been discussed with reference to Figure 1a. In addition, pressure-reinforcement device 15 is provided at a first end 17 of the expandable body 8, which is at the low-pressure side of the wellbore. The pressure-reinforcement device 15 is a solid member of adjustable cross-section. In this embodiment it comprises a substantially frustoconical member 20 having a top 21 and a base 22. The base 22, facing the expandable 8, has a larger cross-section than the top 21. Cross-section means with respect to the axis of the member, here also extension direction of the wellbore, horizontal in the drawing. The top and base suitably have a substantially circular cross-section, to optimally conform to a substantially circular (substantially cylindrical) wellbore obtained by rotary drilling, or e.g. to a casing in such wellbore. The cross-section and diameter at the top 21 is smaller than the cross-section and diameter at the base.

[0029] Figure 2a shows the expandable body in a contracted state like in Figure 1a. The pressure-reinforcement device is shown in a first configuration, in which the base has a first cross-section and diameter, smaller than the cross-section and diameter of sealing space, i.e. the maximum outer diameter of annular space 6.

[0030] In this example the frustoconical body is a slit ring as shown in Figures 3a and 3b.

[0031] Figure 3a schematically shows a ring 30 having

an outer circumference 31 defining an unobstructed diameter, and an inner circumference 32 defining an inner diameter. A cut 35 is provided through the ring 30. The cut is shown radially, but this is not required. The cut does not need fully cut through the ring as shown, it can for example be a partial slit starting at the outer circumference 31. It is possible to arrange 2,3,4 or more partial slits in the ring.

[0032] The ring is suitably made from a resilient material and has a thickness such that it can be deformed into a frustoconical shape as shown in a perspective view in Figure 3b. Figure 3a shows the ends 37a, 37b overlapping. It will be understood that the cut can have a certain width, but preferably the ends still overlap, so that the nappe is closed when viewed along the axis through top and base. The deformation shown in Figure 3b is elastic, and therefore the frustoconical member 20 is under radial inward stress and would return to or towards the unobstructed shape of Figure 3a if the radial stress was released. The radial stress can be maintained, for example, by a connection in the overlap zone 39. Such fixation is suitably releasable. For example, an epoxy resin or solder can be used in a adhesive, such as gluing, connection at surface temperatures, say below 100 °C or below 50 °C, wherein the materials are chosen such that the gluing connection will loosen at elevated temperatures in the well, at 100 °C or above, 150 °C or above, such as at 200 °C or above. The temperature in the wellbore will typically not exceed 400 °C. An alternative releasable fixation can be arranged in the form of a shear pin, that is selected such that the expanding body contacting the pressure-reinforcement device breaks the shear pin, preferably before the body is fully expanded or swollen and the seal is formed.

[0033] Returning to Figures 2a-2d, Figure 2a shows the pressure-reinforcement device 15 in a first, radially contracted, configuration. The radial inward force is then at least partially released, e.g. by allowing the gluing connection to disintegrate at elevated temperature in the well. The frustoconical member 20 thus springs to a second configuration as shown in Figure 2b. In Figure 2b the base 22 has a second cross section or diameter larger than the first cross-section or diameter as in Figure 2a, that conforms to the outer circumference or diameter of the space to be sealed. In this configuration the outer wall 10 now exerts a radial inward force compensating a radial outward force exerted by the base 22, seeking to assume its unobstructed diameter that is larger than the diameter of the wall 10. Resiliency of the base will conform the base to the cross-section of the wellbore 1, which is still regarded as a substantially frustoconical shape, but it will be understood that there can be deviations from a mathematical ideal shape.

[0034] In particular, it will be understood that a length of wellbore can be regarded as a substantially cylindrical shape. In a cross-section perpendicular to a length direction of the wellbore, the wellbore has typically substantially circular shape. Substantially circular means

that any two measurements of a diameter line dividing the cross-section in two areas of equal size, differ by 25% or less of the larger of the two measurements, in certain cases by 10% or less.

5 **[0035]** An ideal frustoconical shape is the shape of a conical frustum, i.e. a frustum created by slicing the top off a cone with the cut made parallel to its base, also referred to as truncated cone. The cone can be a generalized cone, which is the surface created by the set of 10 lines passing through a vertex and every point on a boundary. Typically the cone has substantially circular cross-section. Suitably a substantially frustoconical shape deviates in any dimension (a diameter, a height, a side length), by 25% or less, in certain cases by 10% 15 or less, from a value that would be calculated, assuming a mathematically ideal shape of a generalized cone, and typically also of a cone with circular base, from a measurement of one or more dimensions in selected directions.

20 **[0036]** In Figure 2b, the frustoconical member is expanded against the wellbore wall, thereby adjusting the cross-section of the pressure-reinforcement device to the outer circumference of the annular space. In this embodiment the adjusting is done before the expandable body 25 has formed a seal. Figure 2c shows the situation that the seal is formed. The expanded body 8 has grown by expansion, e.g. through swelling, and now presses against the pressure-reinforcement device and thereby also improves the seal between the base 22 and the wellbore 30. 1. Deformation of the expanded body towards the low-pressure side is effectively prevented, and thus the pressure differential that the seal can withstand is increased.

35 **[0037]** The maximum pressure differential before the seal is lost can for example be increased by at least 10%, in particular at least 30%, more in particular at least 50% such as at least 100%, based on the maximum pressure differential without the pressure-reinforcement device. Above 200%, such as 300% can be achieved.

40 **[0038]** A conventional swellable packer intended for use in relatively high pressure differentials can reach e.g. 35 MPa/m (i.e. ca 5000 psi; m is length of the seal) differential pressure rating. An increase by 300% would bring this rating to 105 MPa/m. Conventional swelling packers for such high pressure differentials only apply a 45 relatively small swelling ratio, i.e. swollen thickness in sealing condition divided by thickness before swelling, is applied, e.g. 1,1-1,25. A disadvantage with small swelling ratios is limited running clearance when installing in the wellbore. With the present invention, high pressure seals 50 can be provided with higher swelling ratios, e.g. 1,25-2, and thus improved running clearance.

55 **[0039]** Figures 2a-2d also show a stop for preventing longitudinal movement of the pressure-reinforcement device 15 away from the expandable body 8, in the form of ring 40. The ring is provided at the top of the frustoconical member 20, and has a diameter and cross-section larger than the diameter and cross-section of the top in radially contracted (Fig 2a) and expanded (Fig 2b,c) configura-

tion. An advantage of such a ring with a substantially frustoconical member is that also a good seal is formed between the top 21 and the ring 40, so that it is not required to separately seal or connect the top 21 to the tube 5, although it will be understood that this can still be done.

[0040] It will be understood that several, e.g. 2,3 or 4 frustoconical bodies like 20 can be arranged one behind the other along the tubular 5.

[0041] Figure 2d shows an embodiment in which two pressure-reinforcement devices 15 and 15a are provided at the first end 17 and the opposite second end of the expandable body. Pressure-reinforcement device 15a as shown here is essentially similar to pressure-reinforcement device 15, and designated with the same reference numerals with addition of an "a".

[0042] This is a particularly strong embodiment that can be used for high differential pressure ratings. The gel between the two pressure-reinforcement devices represents an incompressible fluid, so even at high swelling ratios or with gels high pressure differentials can be handled.

[0043] Two or more systems for sealing a space according to the invention can be provided, spaced apart along the tubular. Two such systems can provide a zonal isolation of an annular space in the wellbore.

[0044] The frustoconical member, such as from a slit ring, can be made for example from a metal such as galvanized steel, stainless steel, titania, but also of a synthetic material or composite, optionally reinforced.

[0045] Instead of a swellable elastomer as discussed hereinabove, even a gel-forming material can be used in the system and method of the invention as a swellable body to form a pressure seal. An example of a gel-forming material is a layered silicate that swells and forms a gel in water. Suitable layered silicates are sold by Rockwood Additives Limited under the trademark Laponite. Suitable gel-forming Laponite grades are e.g. grades RD, XLG, D, DF, XL21, HW, or LV. Relevant CAS Nos. of suitable Laponite materials are 53320-86-8 and 64060-48-6. Relevant EINECS Nos. of suitable Laponite materials are 258-476-2 and 285-349-9.

[0046] For example, a band or sleeve of gel-forming material containing Laponite can be made by putting Laponite powder in a mould and applying pressure until a solid Laponite band is formed. Such a band or sleeve represents the expandable body in its unexpanded state. Other components such as e.g. a filler or additives can be added in the moulding process.

[0047] Another suitable gel-forming material, when being contacted with water, is or comprises a superabsorbent, such as a polyacrylate and/or polyacrylamide based superabsorbent. The polyacrylate and/or polyacrylamide can be cross-linked. Suitable superabsorbents are sold by BASF under the trademark Luquasorb. Another suitable superabsorbent is sold by Imbibitive Technologies America Inc. (IMBTECH AMERICA) under the trademark AquaBiber.

[0048] Bands or sleeves of gel-forming material can be made from superabsorbents, e.g. Luquasorb or AquaBiber materials, by putting grinded superabsorbent in a mould and applying pressure thereby creating a solid band. Depending on the salinity of the surrounding formation or completion fluids between 1-50 w/w% of metal halides, based on the mass of superabsorbent, can be added. The metal halides are preferably NaCl or KC1. Other components such as e.g. a filler or additives can be added as well.

[0049] Suitable gel-forming material, when the selected fluid is or comprises oil, is e.g. an alkylstyrene copolymer, e.g. the material sold under the trademark Imbiber by Imbibitive Technologies America Inc. (IMBTECH AMERICA). The same band forming process as for superabsorbents Luquasorb can for example be used.

[0050] The gel-forming material is suitably not free-flowing, before it is contacted with the selected fluid. For example, the gel-forming material can be solid, highly viscous, or thixotropic. Thixotropic materials do not freely flow, but flow when pressure is applied, i.e. show a behaviour like toothpaste. The gel-forming material does not contain a substantial quantity of a solvent, e.g. less than 20 wt%, or less than 5 wt%, in particular no solvent.

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Claims

1. A method of providing a pressure seal in an annular space in a wellbore formed in an earth formation, the space having a cross-section with an outer circumference, the method comprising;

- providing an expandable body arranged around a tubular in the wellbore, the expandable body having first and second ends along the tubular,
- identifying a high-pressure side and a low-pressure side along the wellbore;
- providing a pressure reinforcement device at least at a low-pressure end, selected from the first and second ends of the expandable body, which low-pressure end faces the low-pressure side of the wellbore, wherein the pressure reinforcement device is a solid member of adjustable cross-section;
- adjusting the cross-section of the pressure-reinforcement device to the outer circumference of the annular space;
- expanding the expandable body from a contracted configuration to an expanded configuration so as to provide an annular seal, wherein the pressure reinforcement device contacts the low-pressure end of the expandable body in the expanded configuration.

2. The method according to claim 1, wherein the expandable body is selected from the group consisting

of an inflatable packer, a swellable elastomer, a gel-forming material.

3. The method according to claim 1 or 2, wherein the cross-section of the pressure-reinforcement device is adjusted to the outer circumference of the annular space before the expandable body is providing an annular seal.

4. The method according to any one of claims 1-3, wherein the pressure-reinforcement device comprises a substantially frustoconical member having a top, and a base with relatively larger cross-section than the top, the base having an outer circumference that is adjusted or adjustable to the outer circumference of the space to be sealed, and wherein the base is arranged to face the expandable body.

5. The method according to claim 4, wherein the frustoconical member is installed in the wellbore in a first configuration, in which the base has a first cross-section, and wherein the frustoconical member is moved to a second configuration, in which the base has a second cross-section larger than the first cross-section that is adjusted to the cross-section of the space to be sealed.

6. The method according to claim 4 or 5, wherein the frustoconical member in the first configuration is a resilient body under radial inward stress, and wherein it is moved to the second configuration by at least partially releasing the radial inward stress.

7. The method according to any one of claims 4-6, wherein the frustoconical member comprises a slit ring under radial inward stress.

8. A system for providing a pressure seal in an annular space in a wellbore formed in an earth formation, the space having a cross-section with an outer circumference, the system comprising

- an expandable body arranged around a tubular, the expandable body having a first and second ends along the tubular, which expandable body is expandable from a contracted configuration to an expanded configuration; and
- a pressure reinforcement device for at least one of the first and second ends, the pressure reinforcement device comprising a substantially frustoconical member having a top, and a base with relatively larger cross-section than the top, the base having an outer circumference that is adjusted or adjustable to the outer circumference of the space to be sealed, and wherein the base is arranged to face the expandable body and to contact the expandable body when it is in the expanded configuration.

9. The system according to claim 8, wherein the frustoconical member at least at its base is under radial inward stress.

5 10. The system according to claim 8 or 9, wherein the frustoconical member is movable from a first configuration, in which the base has a first cross-section, to a second configuration, in which the base has a second cross-section larger than the first cross-section.

10 11. The system according to claim 10, and wherein in the second configuration the second cross-section of the base is determined by an external radial inward force compensating a radial outward force exerted by the base.

15 12. The system according to any one of claims 8-11, wherein the frustoconical member is, at least at its base, resilient, the base having an unobstructed cross-section larger than the cross-section of the space to be sealed.

20 13. The system according to any one of claims 8-12, wherein the system further comprises a stop for preventing longitudinal movement of the pressure reinforcement device away from the expandable body.

25 14. The system according to any one of claims 8-13, wherein the expandable body is elastical in its expanded configuration, in particular wherein the expandable body comprises at least one of an inflatable packer, a swellable elastomer, and a gel-forming material.

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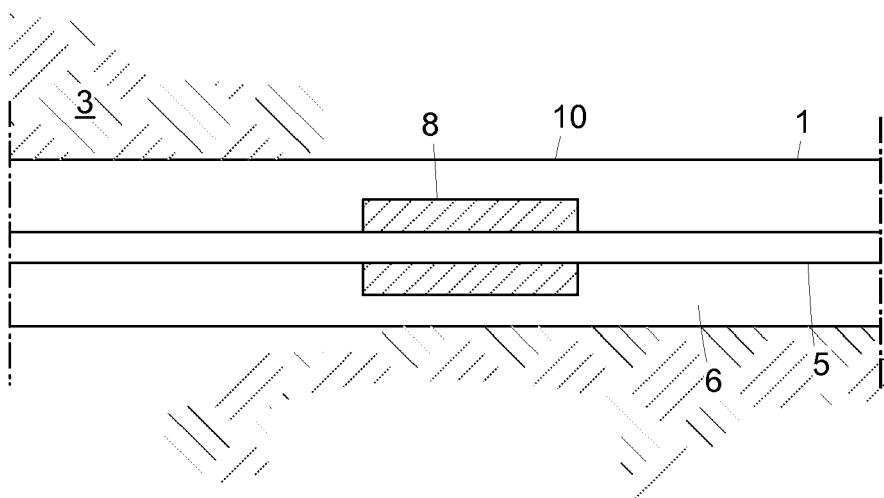


FIG. 1A

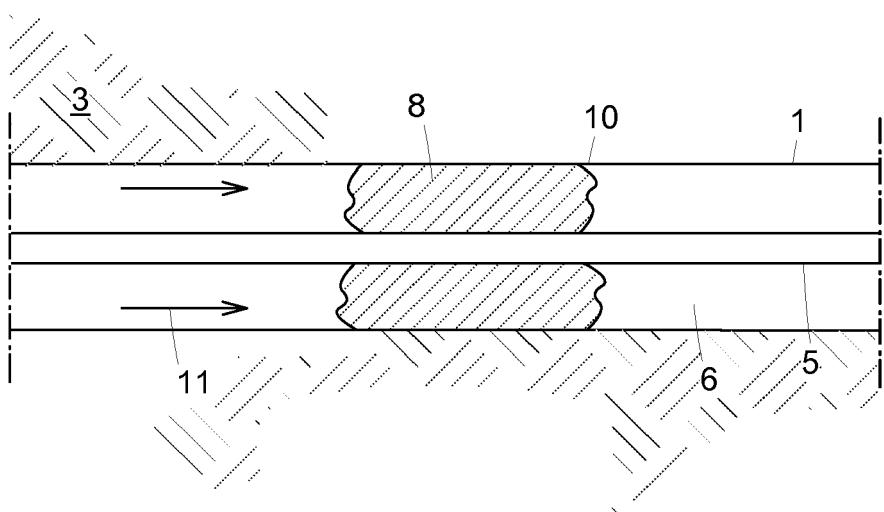
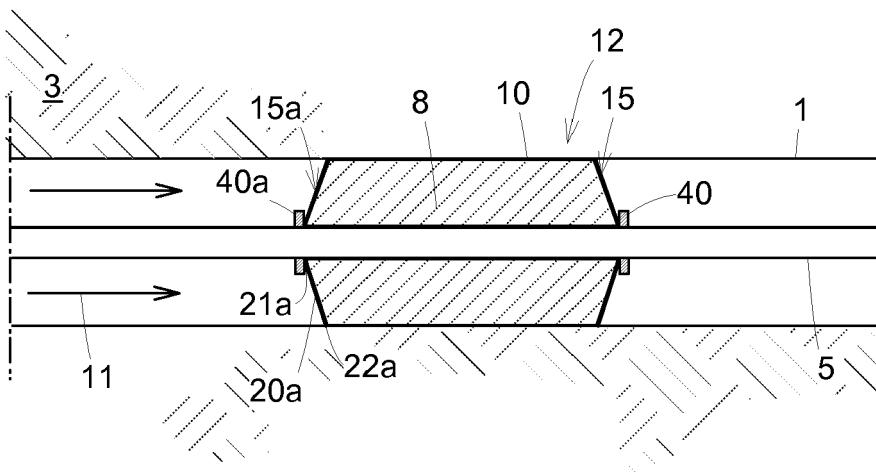
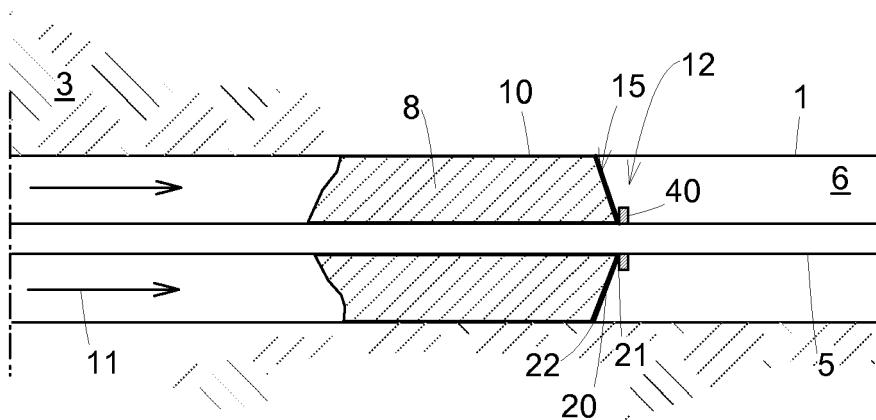
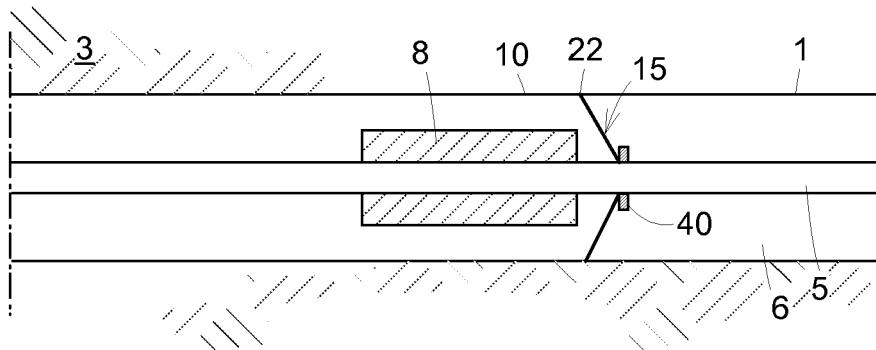
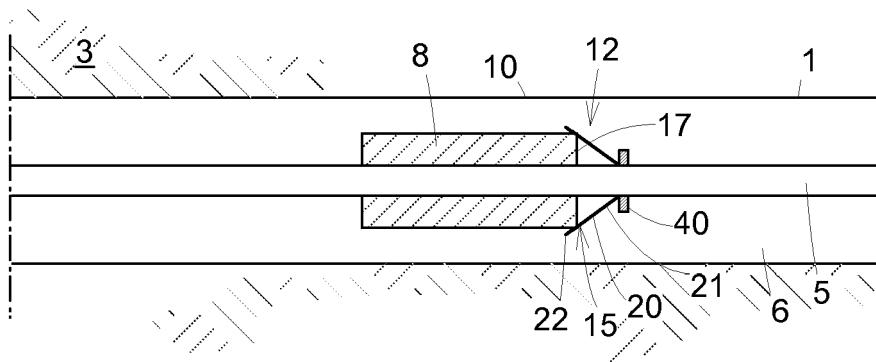


FIG. 1B



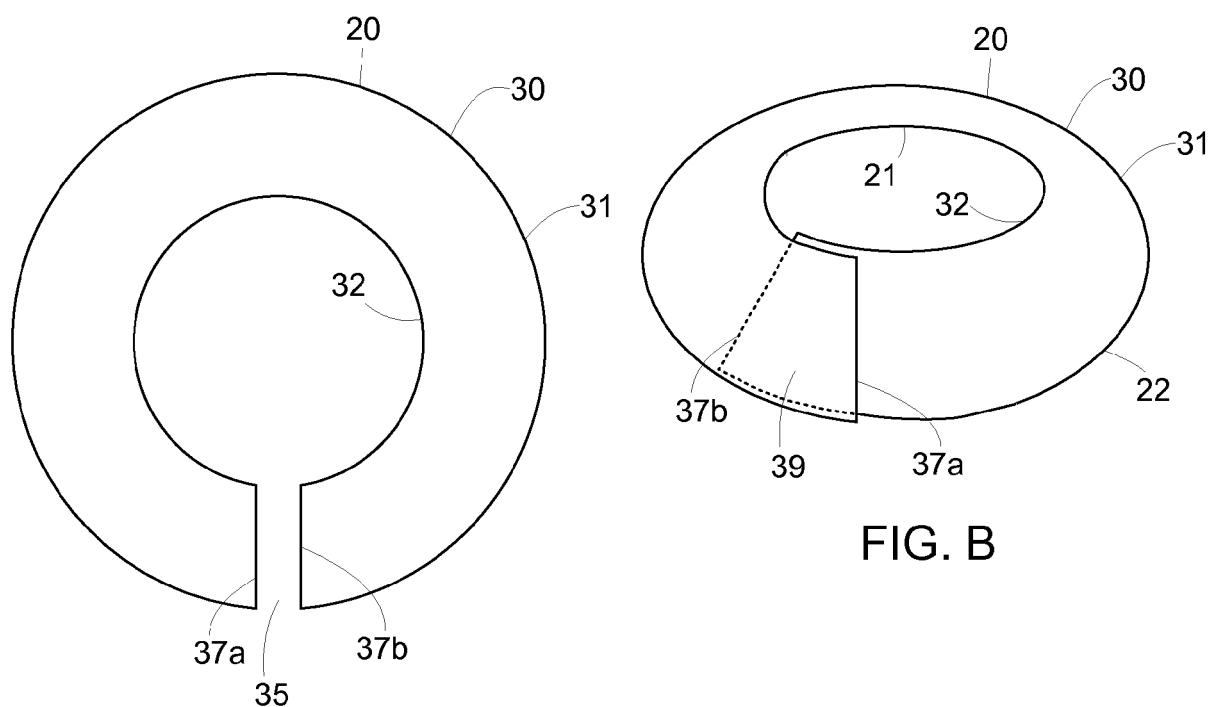


FIG. 3A

FIG. B



EUROPEAN SEARCH REPORT

Application Number

EP 10 19 6481

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (IPC)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	US 2010/288486 A1 (KUTAC ANDREW [US]) 18 November 2010 (2010-11-18) * paragraphs [0013], [0014], [0018]; figure 3 *	1,2,4,5, 8,10,13, 14	INV. E21B33/12
X	US 2009/255690 A1 (CONNER NICHOLAS S [US] ET AL) 15 October 2009 (2009-10-15) * sentence 3, paragraph 18; figures 1, 2 * * last sentence, paragraph 18 *	8,10,13	
X	GB 2 321 918 A (HALLIBURTON ENERGY SERV INC [US]) 12 August 1998 (1998-08-12) * page 15, lines 13-17; figures 4, 5 * * page 17, lines 16-17 * * page 18, lines 12-16 *	8,10,13	
X	US 5 226 492 A (SOLAECHE P JOSE M [VE] ET AL) 13 July 1993 (1993-07-13) * column 3, lines 7-9, 19-20, 39-41, 55-60; figures 2, 3 *	8,10,13	
A	US 5 676 384 A (CULPEPPER JESS L [US]) 14 October 1997 (1997-10-14) * figures 7-9 *	1-14	E21B
A	WO 02/46573 A1 (WEATHERFORD LAMB [US]; HARDING RICHARD PATRICK [GB]; ZIMMERMAN PATRICK) 13 June 2002 (2002-06-13) * figures 2, 4 *	1-14	
The present search report has been drawn up for all claims			
2	Place of search Munich	Date of completion of the search 13 May 2011	Examiner Georgescu, Mihnea
CATEGORY OF CITED DOCUMENTS <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons </p> <p>& : member of the same patent family, corresponding document</p>			

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ON EUROPEAN PATENT APPLICATION NO.

EP 10 19 6481

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on. The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

13-05-2011

Patent document cited in search report		Publication date		Patent family member(s)		Publication date
US 2010288486	A1	18-11-2010	NONE			
US 2009255690	A1	15-10-2009	NONE			
GB 2321918	A	12-08-1998	US 5857520 A		12-01-1999	
US 5226492	A	13-07-1993	NONE			
US 5676384	A	14-10-1997	NONE			
WO 0246573	A1	13-06-2002	AU 2088502 A CA 2427017 A1 DE 60106294 D1 EP 1339944 A1 US 2004036225 A1 US 2002070503 A1		18-06-2002 13-06-2002 11-11-2004 03-09-2003 26-02-2004 13-06-2002	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 03008756 A [0002]
- WO 2005012686 A [0002]
- WO 2006121340 A [0008] [0018]