

DOWNHOLE ANNULAR BASE STRUCTURE

Field of the invention

The present invention relates to a downhole setting tool for setting an annular base structure in a well having a first well part with a casing string and a second well part without a casing string. The present invention also relates to a downhole sealing system for sealing off a zone in an open hole well and to a setting method for setting an annular base structure in a well.

Background art

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A well sometimes has a cased part and an un-cased part, the un-cased part also being referred to as an open hole well. Most often the production zone in which the hydrocarbon-containing fluid flows out of the reservoir is arranged in the open hole part of the well. Eventually, the production zone will produce too much water, such as in the case of a water breakthrough, and there is thus a need to shut off the production zone in the open hole part of the well. Since the open hole part has a diameter which is larger than that of the cased part, it may be difficult to set an annular sealing structure to isolate the production zone.

Summary of the invention

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It is an object of the present invention to wholly or partly overcome the above disadvantages and drawbacks of the prior art. More specifically, it is an object to provide an improved downhole sealing element and sealing system, rendering it possible to seal off an open hole production zone through a cased well part.

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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 a downhole setting tool for setting an annular base structure in a well having a first well part with a casing string and a second well part without a casing string, the second well part having an inner diameter which is larger than that of the casing string, comprising:

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- a tool body having a tool axis, a first end, a second end and an outer face, and
- an annular base structure comprising:

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- a first end part having an indentation in an inner face, in which indentation a sealing means is arranged so that the first end part is slidable in relation to the tool body along the longitudinal extension,
- a second end part having an indentation in an inner face, and
- 5 - an expandable centre part having a wall thickness which is smaller than the wall thicknesses of the first and second end parts,
- a release element engaging the indentation for maintaining the second end part to the tool body along the longitudinal extension during positioning and/or expansion, the first and second end parts abutting the outer face of the tool body
- 10 and hence defining a space between the centre part and the tool body.

The tool body may comprise a fluid channel with an outlet in fluid communication with the space for expanding the annular base structure by means of pressurised fluid.

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Also, the release element may project from the inner face of the second end part.

Moreover, the release element may engage a radial bore arranged in the second end of the tool body for maintaining the second end part to the tool body during

20 positioning and/or expansion.

The downhole annular base structure may further comprise an expandable element having a wall thickness which is larger than that of the centre part, the expandable element having a first end and second end and being adapted to be

25 arranged on an outer face of the centre part.

Further, the expandable element may be made of a material which is more flexible than the material of the centre part.

30 Moreover, the centre part may be made of metal, such as steel.

Further, the first and second end parts may be made of metal, such as aluminium.

35 Additionally, the second end part may comprise sealing means.

Furthermore, the expandable element may comprise a plurality of annular elements arranged in succession of each other in the longitudinal extension.

Said annular elements may be made of different materials.

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Moreover, the release element may comprise a charge for detonation.

Further, the release element may be a shear pin.

10 The centre part may be connected with the first and second end parts by means of welding, such as friction welding.

Also, the first end part and/or the second end part may have a tapering extension.

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Moreover, the expandable element and the annular base structure may be arranged in succession along the tool axis.

20 Furthermore, the tool body may comprise a piston which is movable along the tool axis for pressing on the first end of the expandable element to arrange the expandable element on the outer face of the centre part.

Said piston may be arranged circumferencing the tool body.

25 Also, the tool body may comprise a groove extending along the tool axis on the outer face, and the piston may comprise a projecting element adapted for engaging the groove.

In addition, the piston may be arranged in the tool body.

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Further, the tool body may comprise a second fluid channel in fluid communication with the piston.

35 Additionally, a second piston may be arranged in the fluid channel in the second end of the tool body opposite the second end part, the second piston having a cavity for reception of the release element when the second piston is in a second position, providing the cavity opposite the release element.

Moreover, the second piston may comprise two end discs having a first diameter, the two end piston parts being arranged with a mutual distance and being connected by an intermediate piston rod having a diameter which is smaller than the first diameter, creating the cavity.

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The second piston may have an outer face and the cavity may be arranged in the outer face.

Furthermore, sealing means may be arranged between the second piston and the fluid channel.

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Said sealing means may be arranged in an indentation in the fluid channel or in an indentation arranged in the second piston.

Also, a spring may be arranged upstream of the second piston for ensuring that the second piston is pressed into the second position.

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Additionally, a shear disc may be arranged downstream of the second piston in the fluid channel.

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Further, the expandable element may comprise friction enhancing elements of for instance embedded tungsten carbide, rock, stone, etc.

The downhole setting tool may further comprise an annular support arranged between the expandable element and the annular base structure.

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The annular support may be made of a material which is less flexible than that of the expandable element.

Also, the annular support may be made of Polytetrafluoroethylene (PTFE).

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The downhole setting tool as described above may further comprise a pump for pressurising fluid supplied through the fluid channel.

Moreover, the downhole setting tool as described above may further comprise a fluid chamber in fluid communication with the pump.

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Furthermore, the fluid chamber may comprise a chamber piston dividing the chamber into a first chamber part and second chamber part, the first chamber part comprising fluid and being in fluid communication with the pump.

5 In addition, the second chamber part may comprise a spring.

Further, the second chamber part may be in fluid communication with well fluid.

Also, the second chamber part may comprise a gas, such as nitrogen, propane or
10 the like.

The downhole setting tool as described above may further comprise a milling tool for removing the end parts of the annular base structure.

15 Additionally, the downhole setting tool as described above may further comprise an acid chamber.

Moreover, the downhole setting tool as described above may further comprise a machining tool for removing the end parts of the annular base structure.

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Furthermore, the downhole setting tool as described above may comprise a driving unit for propelling the tool and the annular base structure forward in the well.

25 The present invention also relates to a downhole sealing system for sealing off a zone in an open hole well, comprising

- a first and a second annular base structure set by the downhole setting tool as described above, the annular base structures being set and expanded with a mutual distance, and

30 - a tubular element having a first and a second tubular end and being arranged between the two annular base structures, so that the first tubular end at least partly overlaps the first annular base structure, and the second tubular end at least partly overlaps the second annular base structure, the tubular element having an outer face,

35 wherein the tubular element is expanded so that the outer face abuts against an inner face of the annular base structures.

Further, the present invention relates to a downhole sealing system for sealing off a zone in an open hole well, comprising

- a first and a second annular base structure as described above set by the downhole setting tool as described above, the annular base structures being set and expanded with a mutual distance,
- a tubular element having a first and a second tubular end and being arranged between the two annular base structures, so that the first tubular end at least partly overlaps the first annular base structure, and the second tubular end at least partly overlaps the second annular base structure, the tubular element having an outer face, and
- two packers arranged between the annular base structures and the tubular element.

Finally, the present invention relates to a setting method for setting an annular base structure as described above in a well having a first well part with a casing string and a second well part without a casing string, the second well part having an inner diameter which is larger than that of the casing string, said setting method comprising the steps of:

- arranging the annular base structure on the tool body of the downhole setting tool as described above,
- moving the setting tool through the casing string until the annular base structure is arranged in the second well part,
- pressurising the fluid channel,
- expanding the annular base structure,
- releasing the tool body from the second end part, and
- retracting the setting tool,

wherein the step of releasing the tool body from the second end part is performed before, during or after the expansion step.

- In said method, before the expansion step the expandable element may be arranged on the outer face of the centre part.

Also, the setting method described above may comprise the step of removing the end parts.

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Said step of removing the end parts may be performed by milling or by means of acid.

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
5 illustration show some non-limiting embodiments and in which

Fig. 1 shows a cross-sectional view of a downhole annular base structure,

Fig. 2 shows a setting tool in a well,
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Fig. 3 shows a cross-sectional view of the downhole annular base structure,

Fig. 4 shows a cross-sectional view of the setting tool,

15 Fig. 5 shows an enlarged cross-sectional view of the setting tool of Fig. 4,

Fig. 6 shows an enlarged cross-sectional view of another setting tool,

Fig. 7 shows part of a setting tool pushing an expandable element onto an
20 expandable centre part before expanding the same,

Fig. 8 shows another setting tool arranged in a well,

Fig. 9 shows another downhole annular base structure,
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Fig. 10 shows a sealing system in an open hole, and

Fig. 11 shows another sealing system in an open hole.

30 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

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Fig. 1 shows a downhole annular base structure 1 for being set downhole in an open hole part of a well in order to provide an annular base structure or a sealing

structure abutting against an inner face of the open hole. The downhole annular base structure 1 is arranged around a tool body 5 of a downhole setting tool, defining a space 26 being annular. The downhole annular base structure 1 is set by means of the downhole setting tool 10 (shown in Fig. 2) arranged partly in a
5 cased well part 2 and partly in an un-cased open hole part 3 in a well 4. The downhole annular base structure 1 of Fig. 1 has a longitudinal extension and comprises a first end part 6 having an indentation 7 in an inner face 8, in which indentation a sealing means 9 is arranged for sealing the space 26. The downhole annular base structure 1 comprises a second end part 11 which also has an
10 indentation 12 in an inner face 14, and an expandable centre part 15 connected with the first and second end parts. The expandable centre part 15 has a wall thickness 16 which is smaller than the wall thicknesses of the first and second end parts and is therefore capable of being expanded more easily than the first and second end parts.

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The first end part is slidable in relation to the tool body along the longitudinal extension and the sealing means provides a sealing ability and seals the space 26. The second end part 11 comprises a release element 17 engaging the indentation 12 for maintaining the second end part to the tool body along the
20 longitudinal extension during positioning and/or expansion. In this way, the second end part is maintained in its position along the longitudinal extension, and the first end part is sliding towards the second end part as the centre part is expanded. The two end parts will, due to their increased thickness, stay unexpanded in the radial direction. As can be seen in Fig. 1, the tool 10 has a
25 tool body 5 which together with the centre part and the end parts enclose the space 26. In order to expand the centre part, fluid is ejected through an outlet 42 in the tool body, and hence the space is pressurised.

In Fig. 2, the setting tool 10 is shown in a well. The downhole annular base structure 1 is fastened to the second end 24 of the tool body 5 so that the
30 downhole annular base structure 1 is not dropped when passing the vertical part of the well. The downhole annular base structure 1 extends into the second and open hole part 2 of the well, and part of the setting tool 10 is still in the cased part of the well. The setting tool 10 is connected and powered through a wireline
35 43. The setting tool is operated from surface or may be programmed to be self-operable. The setting tool uses pressurised fluid for expanding the downhole annular base structure 1, which is provided by a pump 44 driven by a motor 45

and an electronic section 46. The tool 10 further comprises a fluid control section 47 to control the pressurisation of the downhole annular base structure 1.

As shown in Fig. 3, the downhole annular base structure comprises an expandable element 18 arranged outside the outer face 22 of the centre part. The expandable element 18 has a wall thickness 19 which is larger than that of the centre part 15 and is made of a material which is more flexible than that of the centre part, so that the expandable element 18 is able to compensate for an uneven open hole. The expandable element has a first end 20 and a second end 21 and is adapted to be arranged on an outer face 22 of the centre part by the tool, which is shown in Fig. 2. In Fig. 2, the expandable element 18 and the centre part are arranged in succession along the longitudinal extension, and a piston 30 is adapted to push the expandable element onto the outer face of the centre part before expanding the downhole annular base structure 1, so that the expandable element abuts the inner wall of the open hole.

The centre part is made of metal, such as steel, and the first and second end parts are made of metal, such as aluminium. The first and second end parts are substantially more rigid and taper towards the centre part from a base facing the tool body, as shown in Fig. 3. The first and second end parts 6, 11 have indentations 7 comprising a sealing element 9 to seal the space to be pressurised. The centre part 15 is arranged between the first and second end parts and may be connected with the first and second end parts by means of welding, such as friction welding.

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The release element 17 projects from the inner face 14 of the second end part 11. The release element 17 engaging the indentation 12 also engages a radial bore 27 arranged in the second end 24 of the tool body for maintaining the second end part 11 to the tool body during positioning and/or expansion. The downhole annular base structure 1 is released when the pressurised fluid in the fluid channel 28 in the tool body 5 presses a second piston 37 arranged in the fluid channel towards the second end 24 of the tool body. As the second piston moves, a cavity 39 in the piston is moved to be opposite the releasing element 17, and the releasing element enters into the cavity 39 and out of engagement with second end part 11 of the downhole annular base structure 1. In order to move the piston, a shear disc 51 arranged in front or upstream of the second piston 37 must be broken. A reception bore 38 for reception of the releasing

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element is arranged in front of the shear disc, and when the second piston is in a second position arranging the cavity 39 opposite the release element 17, the second piston 37 is arranged in that reception bore.

- 5 In another embodiment, the second piston comprises two end piston parts having a first diameter, and the two end piston parts are arranged with a mutual distance and connected by an intermediate piston rod having a diameter which is smaller than the first diameter, creating the cavity.
- 10 As shown in Fig. 3, sealing means 73 is arranged between the second piston and the fluid channel. The sealing means is arranged in an indentation in the indentation arranged in the second piston. A spring 68 may be arranged upstream of the second piston for ensuring that the second piston is pressed into the second position.
- 15 Fig. 4 shows a part of the setting tool in cross-section in which the expandable element 18 is shown before it is to be pushed onto the expandable centre part 15. The tool comprises a piston 30 which is movable along the tool axis for pressing on the first end 20 of the expandable element to arrange the expandable element on the outer face of the centre part. The piston is arranged circumferencing the tool body 5 and is forced towards the second end 24 of the tool body 5 by means of pressurised fluid in a second fluid channel 36. The pressurised fluid in the second fluid channel is indicated by the number "1", and the pressurised fluid flowing in the other fluid channel for expanding the downhole annular base structure 1 is indicated by the number "2". The piston has a flange 53 abutting the expandable element 18 and the tool body so that fluid from the second fluid channel 36 is pressed into an expandable space 55 between a flange 54 of the tool body and the flange 53.
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- 30 As shown in details in Fig. 5, the tool body comprises a groove 33 extending along the tool axis, and the piston comprises a projecting element 32 adapted for engaging the groove. As the fluid presses the piston towards the second end of the tool body, the projecting element 32 prevents the piston from sliding off the tool body when the projecting element abuts the end of the groove. When the projecting element 32 abuts the second end of the groove 33. In Fig. 5, the projecting element is closest to the first end of the groove. When the expandable
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element has been arranged outside the centre part, the fluid control section shown in Fig. 2 lets the fluid into main fluid channel 28 (shown in Fig. 1) and expansion of the centre part can be initiated.

5 In Fig. 6, the piston 30 is arranged in the tool body 5. The piston has a first piston part 63 arranged in the second fluid channel 36 and connected with a second piston part 64 by a piston rod. The second piston part 64 is arranged outside the second fluid channel and abuts the expandable element 18. The first piston part 63 is annular and is arranged in an annular fluid channel being the
10 second fluid channel 36. The first piston part divides the second fluid channel 36 in a first channel part 61 and a second channel part 62. The fluid is let from the pump into the first channel part 61, forcing the first part 63 of the piston to move and thereby forcing the second piston part to press onto the expandable element 18.

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In order to force the expandable element 18 fully onto the expandable centre part, the piston may have a slotted end flange 66 as shown in Fig. 7. The slotted end flange 66 is in Fig. 7 shown in its expanded position, in which the expandable element has been pushed fully onto the centre part. An annular support 52 is
20 arranged between the expandable element 18 and the slotted end flange, so that the slotted end flange does not dig into the expandable element. The annular support is made of a material which is less flexible than that of the expandable element, and may thus be made of Polytetrafluoroethylene (PTFE) or similar material which is better than the material of the expandable element, e.g. it may
25 be made of rubber, to even out the pressure applied to it by the slotted end flange.

The expandable element may comprise friction-enhancing elements of for instance embedded tungsten carbide, rock, stone, etc. in order to obtain a more
30 firm grip into the inner wall of the open hole.

As shown in Fig. 8, the annular support 52 may also be arranged between the expandable element 18 and the annular base structure 1, so that the expandable element does not rupture when forced onto the centre part. The setting tool 10
35 further comprises a fluid chamber 67 in fluid communication with the pump 44. The fluid chamber comprises a chamber piston dividing the chamber into a first chamber part and second chamber part, the first chamber part comprising fluid

and being in fluid communication with the pump. The second chamber part may comprise a spring and be filled with a gas, such as nitrogen, propane or the like or be in fluid communication with well fluid.

- 5 The setting tool may further comprise a driving unit 48, such as a downhole tractor shown in Fig. 8. The setting tool may further comprise an acid chamber so that after expansion of the centre part, the first and second end parts are removed by injecting acid into the well. The first and second end parts may also be removed by a machining tool 69, such as a milling tool or drilling tool. The
10 machining tool 69 is arranged in front of the downhole annular base structure 1.

In Fig. 9, the expandable element comprises a plurality of annular elements 18' arranged in succession of each other in the longitudinal extension. Hereby, the annular elements are made of different materials having different characteristics,
15 such as resistance to high temperatures, high pressure, acid, etc.

The release element may comprise a charge for detonation or be a shear pin.

Fig. 10 shows a downhole sealing system for sealing off a zone in an open hole well and comprises a first and a second downhole annular base structure set by
20 the downhole setting tool. The annular base structures are set and expanded with a mutual distance, and a tubular element 41 has a first and a second tubular end and is arranged between the two annular base structures, so that the first tubular end overlaps the first annular base structure, and the second tubular end
25 overlaps the second annular base structure, the tubular element having an outer face. In Fig. 10, the tubular element is expanded so that the outer face abuts an inner face of the annular base structures. In Fig. 11, packers are arranged between the tubular element 41 and the downhole annular base structures so that the tubular element does not need to be expanded.

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The annular base structure according to the present invention may be set by a setting method for setting an annular base structure as described above in a well having a first well part with a casing string and a second well part without a casing string, the second well part having an inner diameter which is larger than
35 that of the casing string.

This method comprises the steps of arranging the annular base structure on the tool body of the downhole setting tool as described above, moving the setting tool through the casing string until the annular base structure is arranged in the second well part, pressurising the fluid channel, expanding the annular base structure, releasing the tool body from the second end part and then retracting the setting tool.

The step of releasing the tool body from the second end part is performed before, during or after the step of expanding. In this method, before the step of expanding, the expandable element is arranged on the outer face of the centre part. The setting method may also comprise the step of removing the end parts, which may be performed by milling or by means of acid.

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

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

In the event that the tool is not submergible all the way into the casing, a downhole tractor can be used to push the tool all the way into position in the well. The downhole tractor may have projectable arms having wheels, wherein the wheels contact the inner surface of the casing for propelling the tractor and the tool forward in the casing. A downhole tractor is any kind of driving tool capable of pushing or pulling tools in a well downhole, such as a Well Tractor®.

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.

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Claims

1. A downhole setting tool (10) for setting an annular base structure (1) in a well having a first well part with a casing string and a second well part without a casing string, the second well part having an inner diameter which is larger than that of the casing string, comprising:
- a tool body (5) having a tool axis, a first end (23), a second end (24) and an outer face (25), and
 - an annular base structure (1) comprising:
 - a first end part (6) having an indentation (7) in an inner face (8), in which indentation a sealing means (9) is arranged so that the first end part is slidable in relation to the tool body along the longitudinal extension,
 - a second end part (11) having an indentation (12) in an inner face (14), and
 - an expandable centre part (15) having a wall thickness (16) which is smaller than the wall thicknesses of the first and second end parts,
 - a release element (17) engaging the indentation (12) for maintaining the second end part to the tool body along the longitudinal extension during positioning and/or expansion, the first and second end parts (6, 11) abutting the outer face of the tool body and hence defining a space (26) between the centre part (15) and the tool body (5).
2. A downhole setting tool according to claim 1, wherein the tool body (5) comprises a fluid channel (28) with an outlet (42) in fluid communication with the space (26) for expanding the annular base structure by means of pressurised fluid.
3. A downhole setting tool according to any of the preceding claims, wherein the release element (17) projects from the inner face (14) of the second end part (11).
4. A downhole setting tool according to any of the preceding claims, wherein the release element engages a radial bore (27) arranged in the second end (24) of the tool body for maintaining the second end part (11) to the tool body during positioning and/or expansion.

5. A downhole setting tool according to any of the preceding claims, wherein the downhole annular base structure further comprises an expandable element (18) having a wall thickness (19) which is larger than that of the centre part (15), the expandable element having a first end (20) and second end (21) and
5 being adapted to be arranged on an outer face (22) of the centre part.

6. A downhole setting tool according to claim 5, wherein the expandable element (18) is made of a material which is more flexible than the material of the centre part (15).
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7. A downhole setting tool according to claim 5 or 6, wherein the expandable element comprises a plurality of annular elements (18') arranged in succession of each other in the longitudinal extension.

8. A downhole setting tool according to claims 5, 6 or 7, wherein the expandable element and the annular base structure are arranged in succession along the tool axis.
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9. A downhole setting tool according to any of the preceding claims, wherein the tool body comprises a piston (30) which is movable along the tool axis for pressing on the first end of the expandable element to arrange the expandable element on the outer face of the centre part.
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10. A downhole setting tool according to claim 9, wherein the piston is arranged circumferencing the tool body.
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11. A downhole setting tool according to claim 9 or 10, wherein the tool body comprises a groove extending along the tool axis on the outer face, and the piston comprises a projecting element adapted for engaging the groove.
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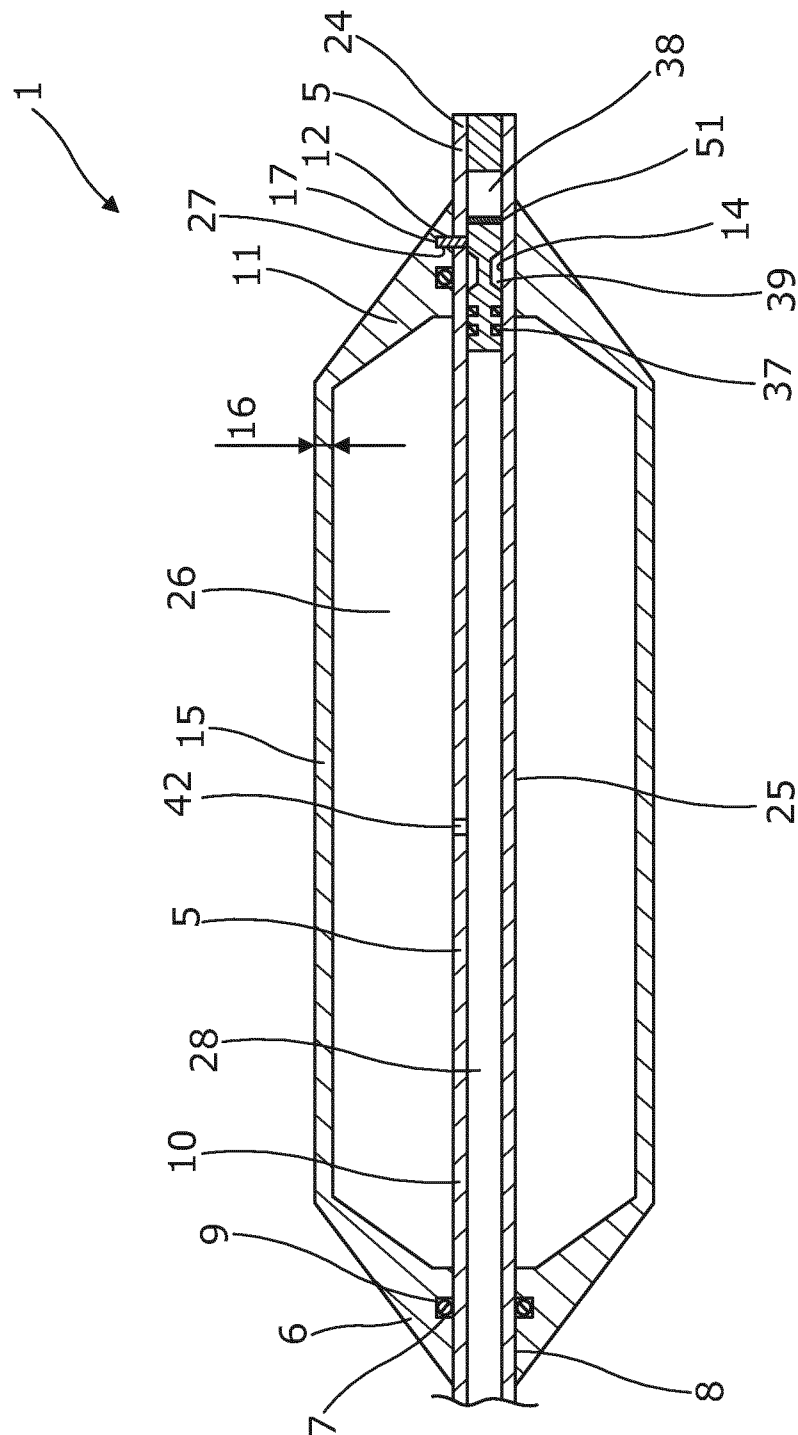
12. A downhole setting tool according to any of claims 9-11, wherein the piston is arranged in the tool body.

13. A downhole setting tool according to any of claims 9-12, wherein the tool body may comprise a second fluid channel in fluid communication with the piston.
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14. A downhole setting tool according to any of claims 9-13, wherein a second piston (37) is arranged in the fluid channel in the second end of the tool body opposite the second end part, the second piston having a cavity (39) for reception of the release element when the second piston is in a second position,
5 providing the cavity opposite the release element.
15. A downhole setting tool according to any of the claims 2-14, further comprising a pump for pressurising fluid supplied through the fluid channel.
- 10 16. A downhole setting tool according to claim 15, further comprising a fluid chamber in fluid communication with the pump.
- 15 17. A downhole setting tool according to any of the preceding claims, further comprising a machining tool for removing the end parts of the annular base structure.
18. A downhole setting tool according to any of the preceding claims, further comprising a driving unit for propelling the tool and the annular base structure forward in the well.
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19. A downhole sealing system for sealing off a zone in an open hole well, comprising:
- a first and a second annular base structure set by the downhole setting tool according to any of claims 1-18, the annular base structures being set and
25 expanded with a mutual distance, and
- a tubular element having a first and a second tubular end and being arranged between the two annular base structures, so that the first tubular end at least partly overlaps the first annular base structure, and the second tubular end at least partly overlaps the second annular base structure, the tubular element
30 having an outer face,
wherein the tubular element is expanded so that the outer face abuts against an inner face of the annular base structures.
20. A downhole sealing system for sealing off a zone in an open hole well,
35 comprising:

- a first and a second annular base structure set by the downhole setting tool according to any of claims 1-19, the annular base structures being set and expanded with a mutual distance,
- a tubular element having a first and a second tubular end and being arranged
5 between the two annular base structures, so that the first tubular end at least partly overlaps the first annular base structure, and the second tubular end at least partly overlaps the second annular base structure, the tubular element having an outer face, and
- two packers arranged between the annular base structures and the tubular
10 element.

21. A setting method for setting an annular base structure in a well having a first well part with a casing string and a second well part without a casing string, the second well part having an inner diameter which is larger than that of the
15 casing string, said setting method comprising the steps of:
- arranging the annular base structure on the tool body of the downhole setting tool according to any of the claims 1-19,
 - moving the setting tool through the casing string until the annular base structure is arranged in the second well part,
 - 20 - pressurising the fluid channel,
 - expanding the annular base structure,
 - releasing the tool body from the second end part, and
 - retracting the setting tool,
- wherein the step of releasing the tool body from the second end part is
25 performed before, during or after the expansion step.



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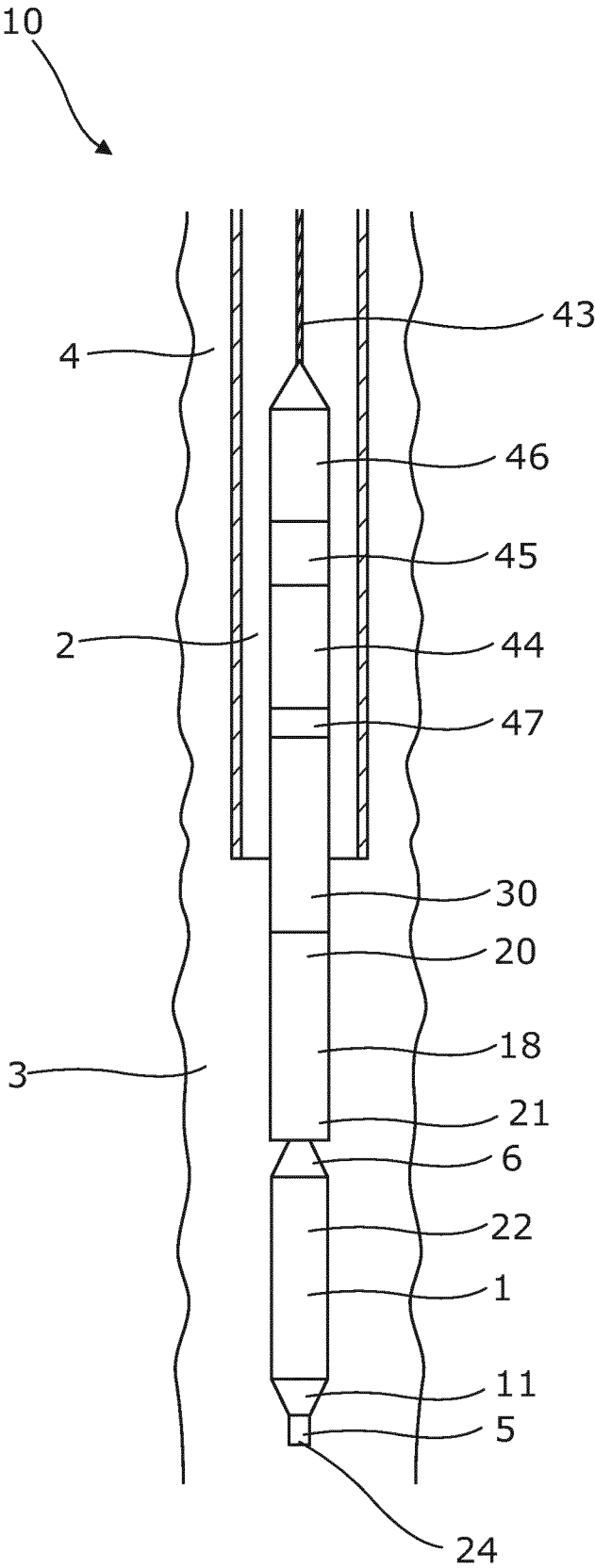
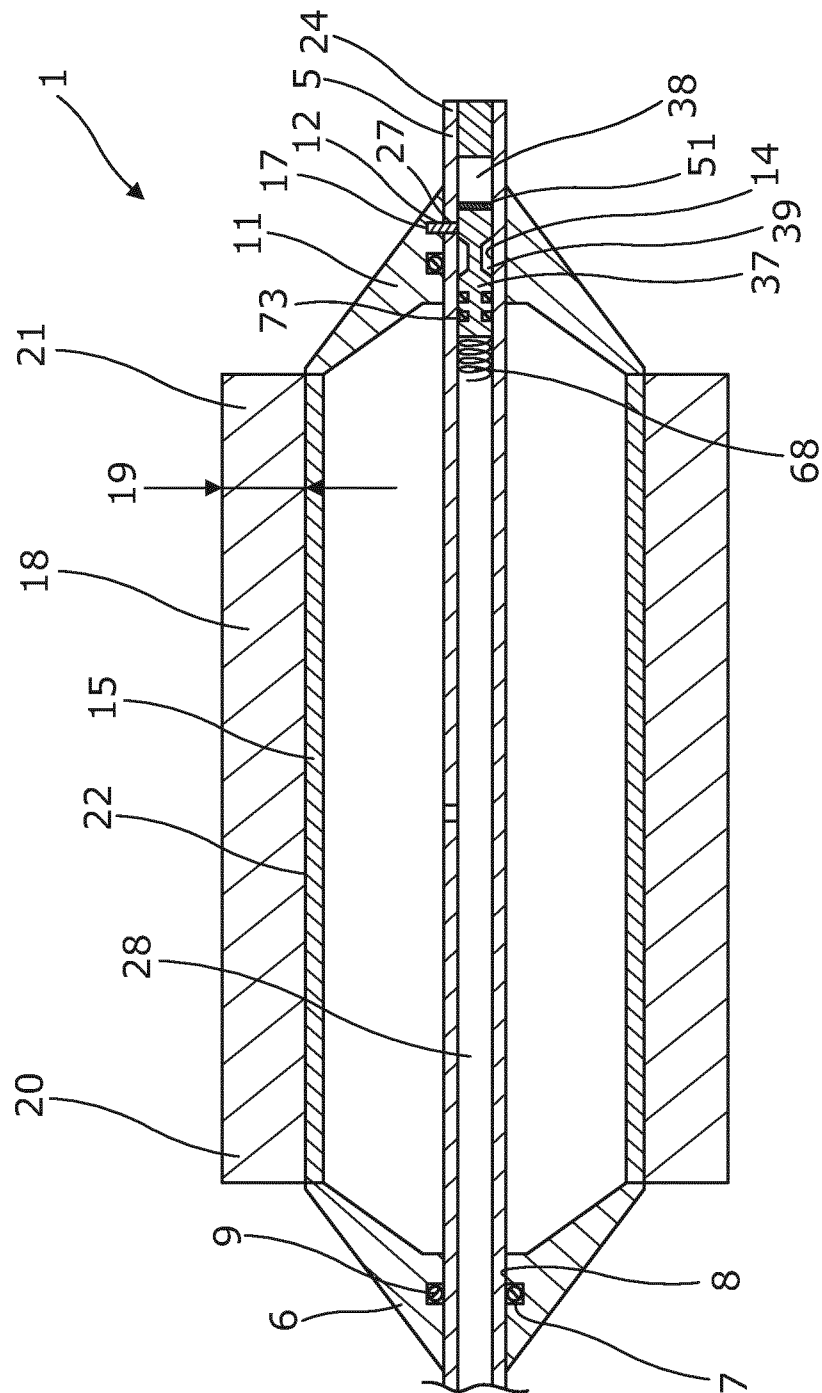


Fig. 2



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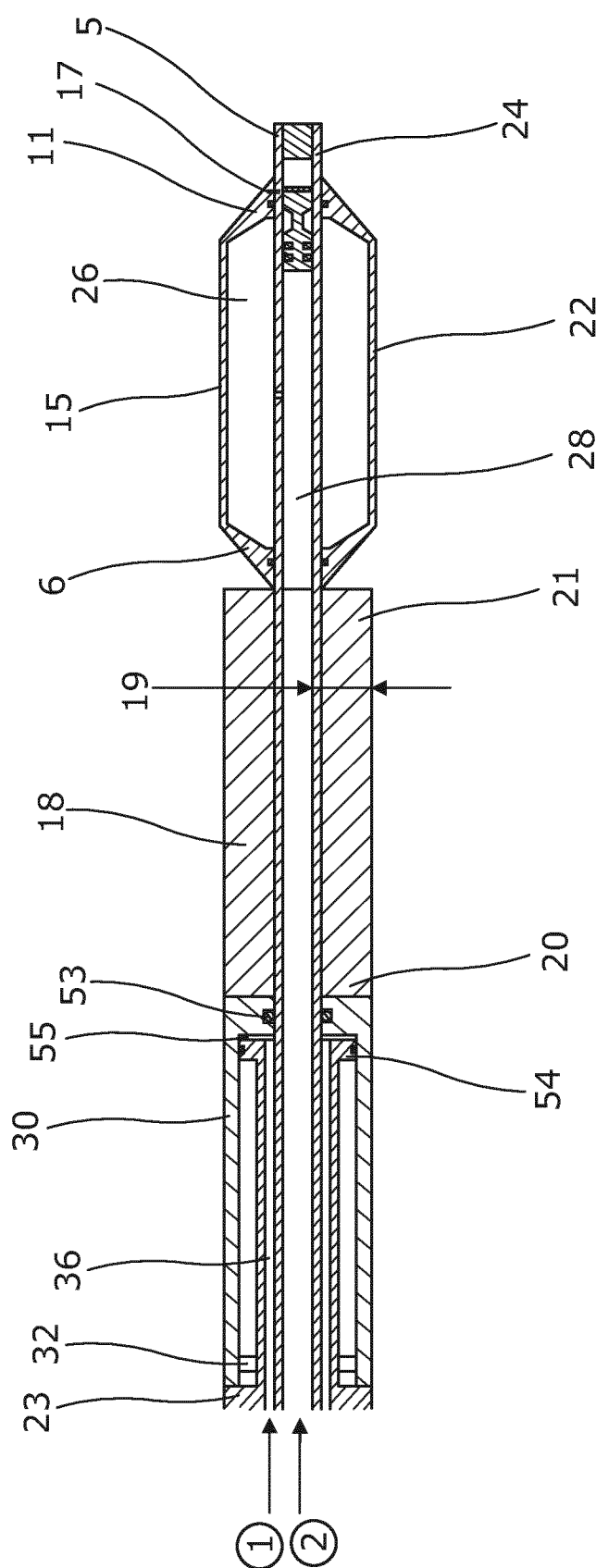


Fig. 4

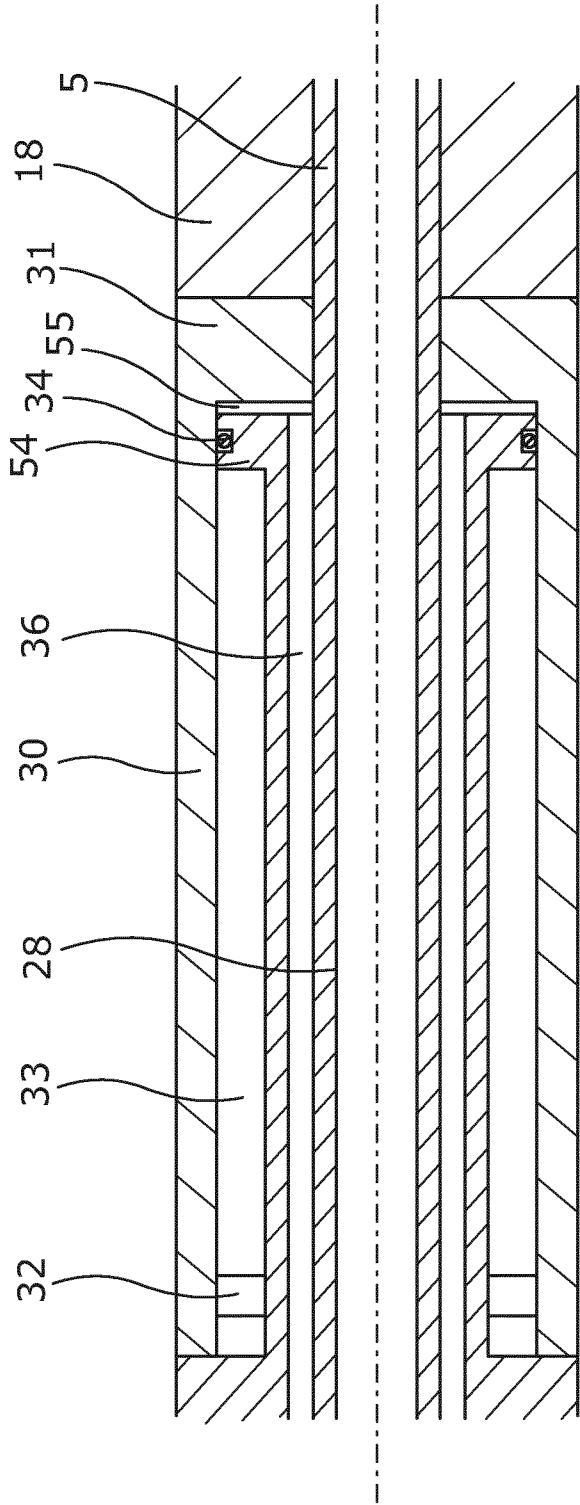


Fig. 5

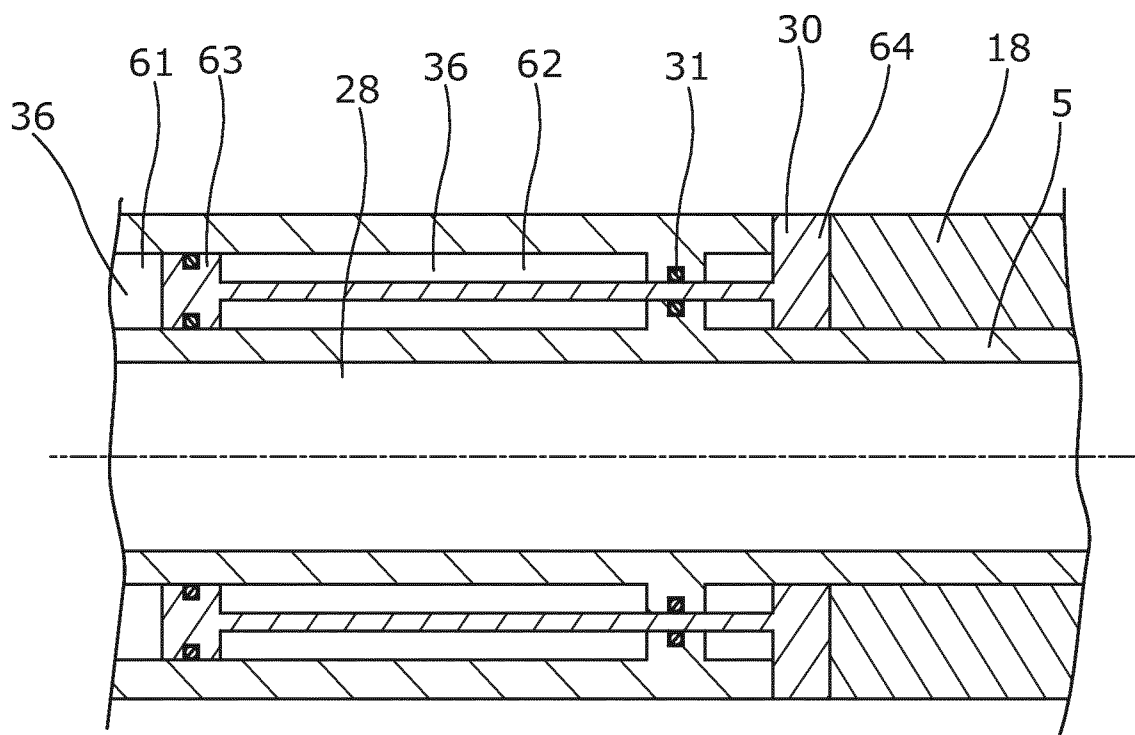


Fig. 6

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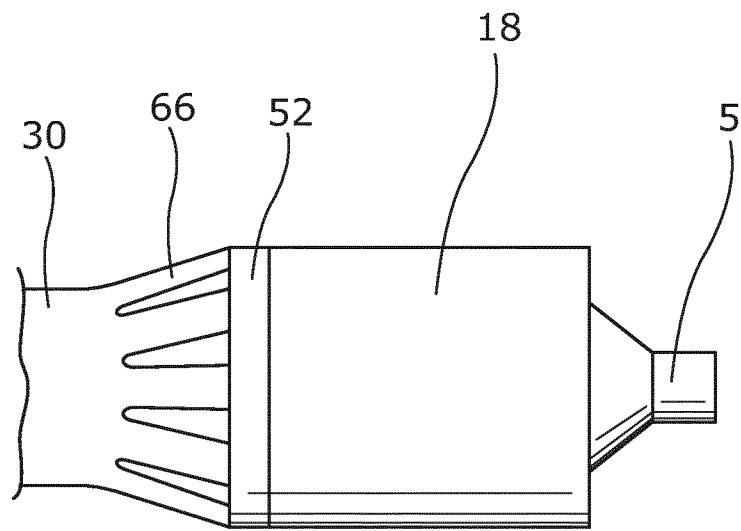


Fig. 7

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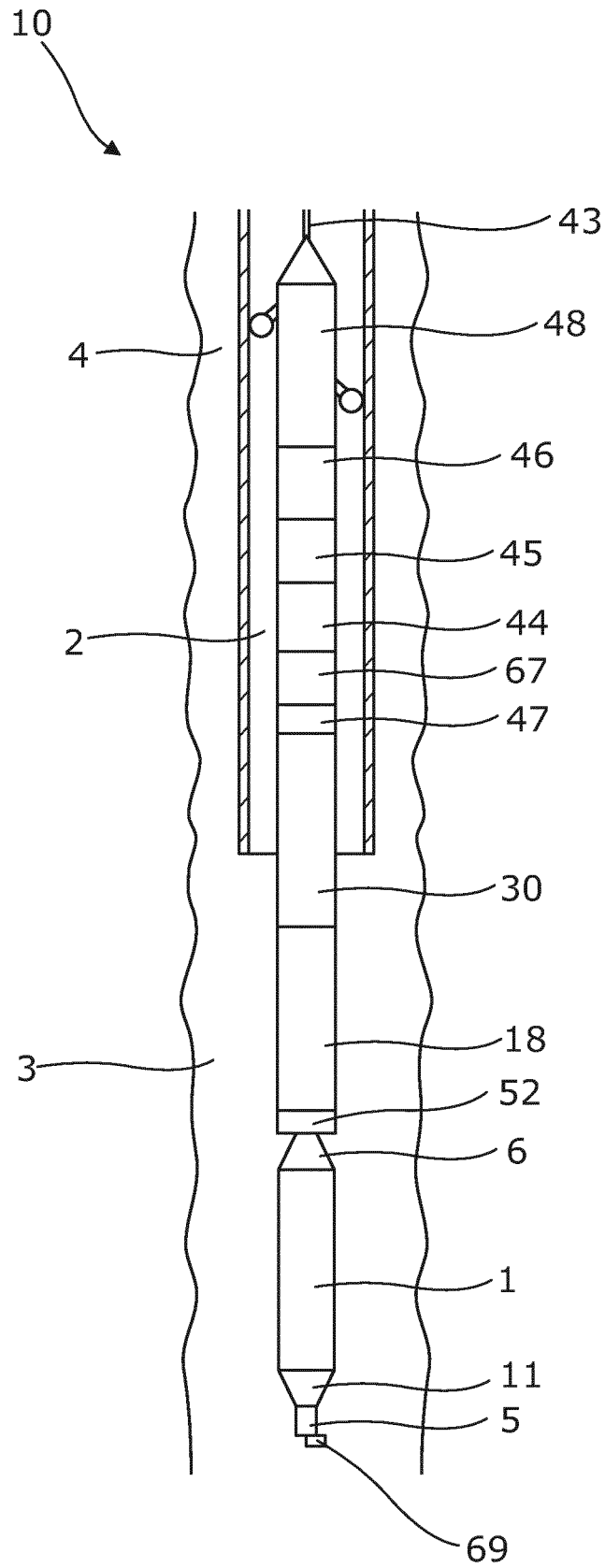


Fig. 8

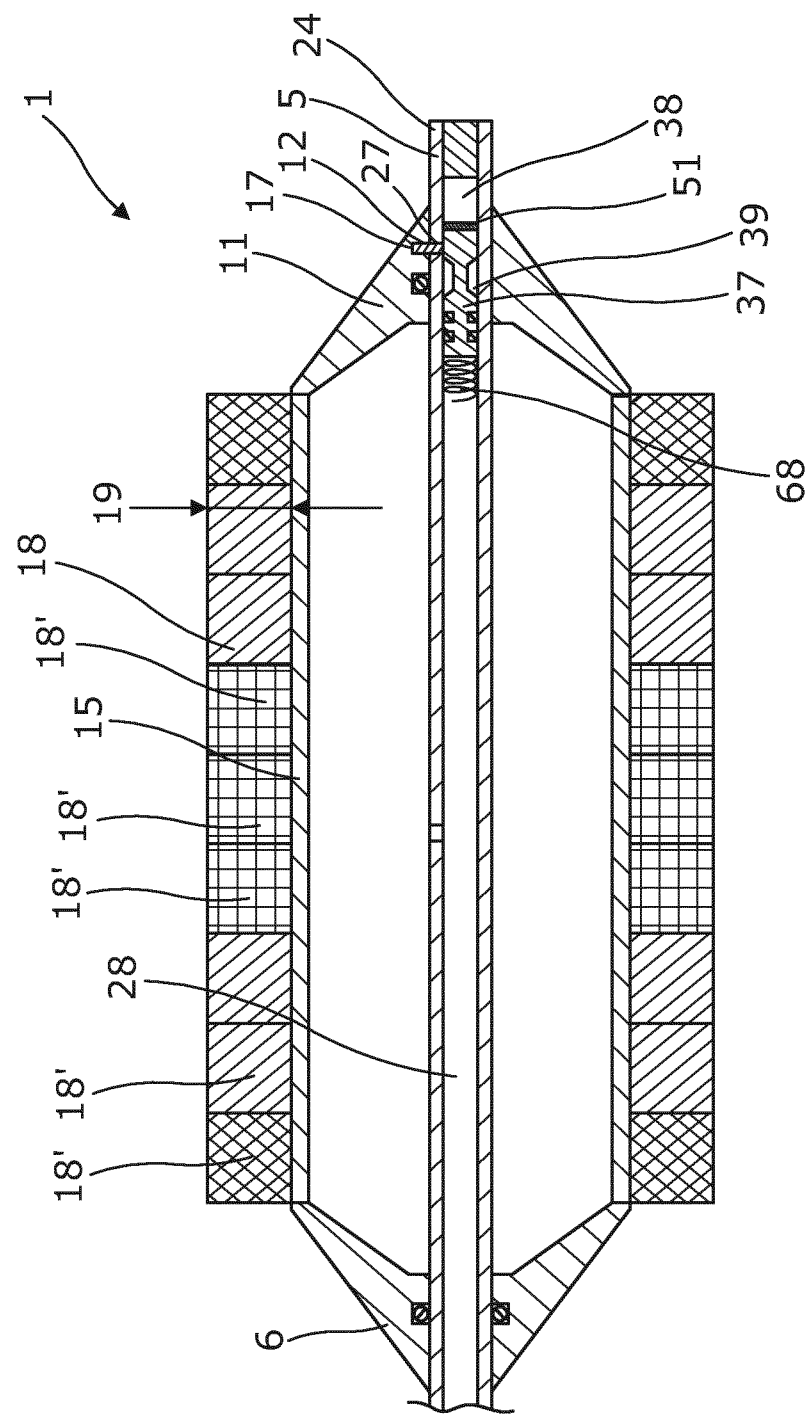


Fig. 9

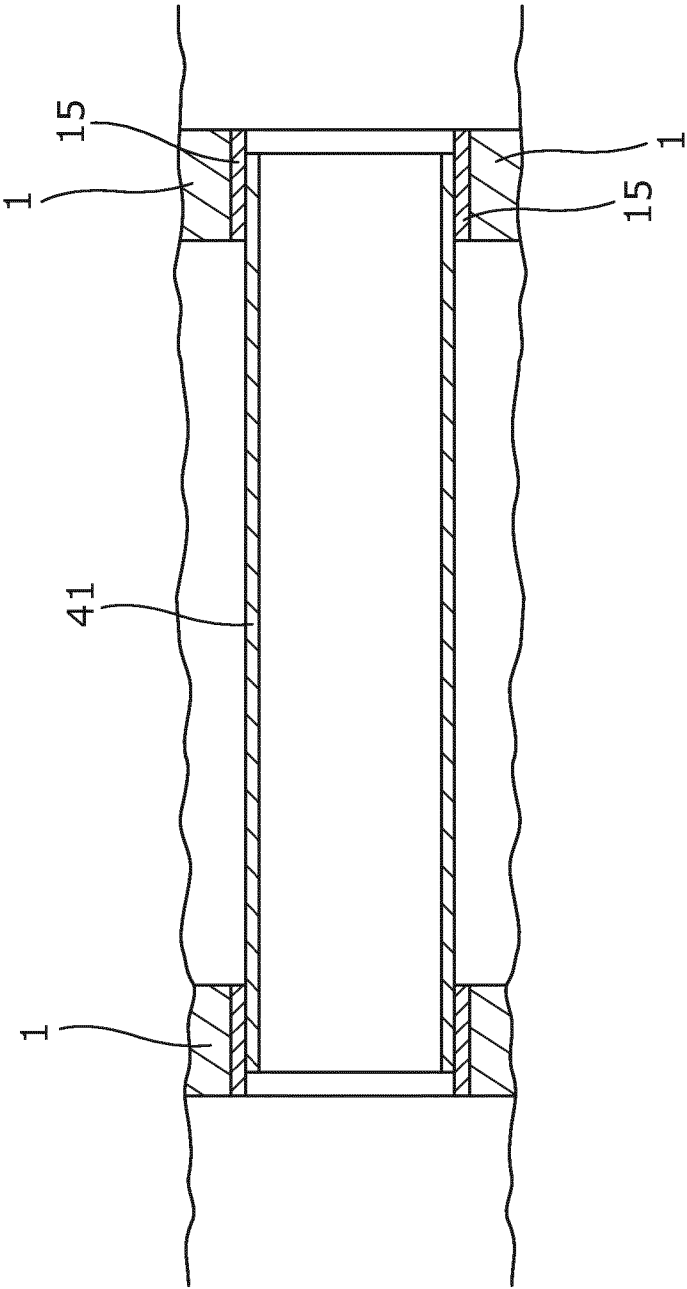


Fig. 10

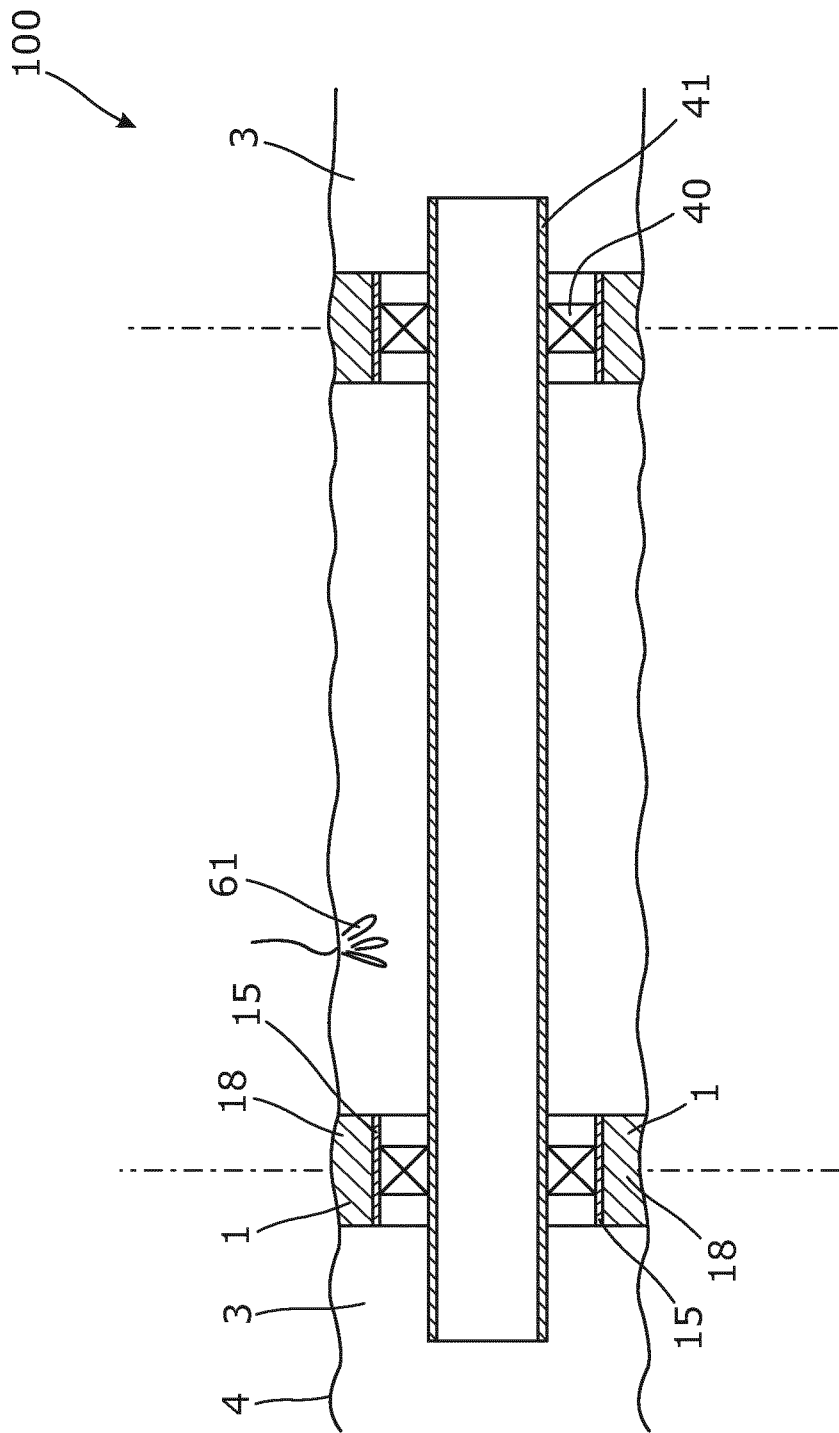


Fig. 11

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2014/063482

A. CLASSIFICATION OF SUBJECT MATTER

INV. E21B33/127 E21B33/128 E21B23/06
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.
Y	WO 2012/045355 A1 (WELLTEC AS [DK]; HALLUNDBAEK JOERGEN [DK]; HAZEL PAUL [GB]; ANDERSEN T) 12 April 2012 (2012-04-12) page 9, line 12 - line 26; figure 3 page 14, line 17 - line 25 -----	1-21
Y	US 2005/161232 A1 (PATEL DINESH R [US] ET AL) 28 July 2005 (2005-07-28) paragraph [0019] - paragraph [0020]; figures 1,2 -----	1-21
A	WO 03/048508 A1 (SHELL INT RESEARCH [NL]; AKINLADE MONSURU OLATUNJI [NL]; LIGIHELM DIRK) 12 June 2003 (2003-06-12) page 7, line 1 - line 13; figure 3 -----	1-21
A	US 2012/325499 A1 (MOFFITT MICHAEL ERIC [US]) 27 December 2012 (2012-12-27) paragraph [0021]; figure 2 -----	1-21



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search

3 September 2014

Date of mailing of the international search report

12/09/2014

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2014/063482

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