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- **Vasques, Ricardo Reves**
2840 Holte (DK)
- **Stæhr, Lars**
2600 Glostrup (DK)
- **Jensen, Ivan Sciera**
2900 Hellerup (DK)

(71) Applicant: **Welltec A/S**
3450 Allerød (DK)

(74) Representative: **Hoffmann Dragsted A/S**
Rådhuspladsen 16
1550 Copenhagen V (DK)

(72) Inventors:
• **Hallundbæk, Jørgen**
3230 Græsted (DK)

(54) **Downhole setting tool**

(57) The present invention relates to a downhole setting tool for setting an annular base structure in an open-hole part of a well, comprising: a tool body having a tool axis, a shaft (7) having a first end and a second end, connected to the tool body at the second end, an expandable pipe (10) having a transport position in which the expandable pipe has an unexpanded diameter, and an

expanded position in which the expandable pipe has an expandable diameter, an annular sealing element (11), and a pipe expansion element (12) arranged at the first end of the shaft for expanding the pipe, wherein the expandable pipe and the annular sealing element are arranged in succession along the tool axis.

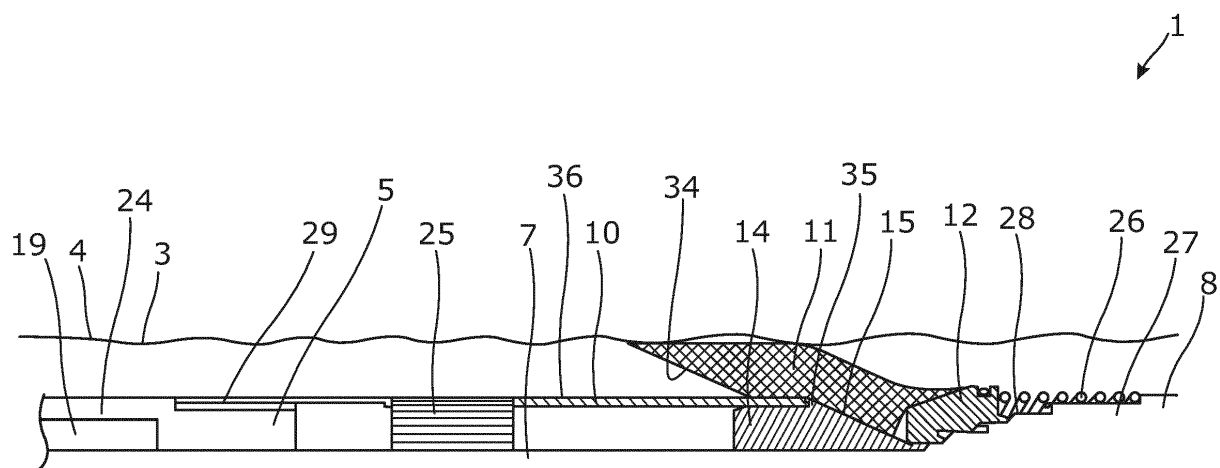


Fig. 3

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Description

Field of the invention

[0001] The present invention relates to a downhole setting tool for setting an annular base structure in an openhole part of a well. The present invention also relates to an annular base structure, a downhole sealing system and a method of expanding an annular base structure in an openhole.

Background art

[0002] A well may be partly cased and partly openhole so that the part of the well furthest away from the top of the well is an openhole well. Most often the production zone in which the hydrocarbon-containing fluid flows out of the reservoir is arranged in the openhole part of the well. In the event of a water breakthrough in the openhole part, the production zone needs to be sealed off. Due to the fact the openhole part has a larger diameter than the cased part, it may be difficult to set an annular sealing structure.

Summary of the invention

[0003] 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 tool capable of setting an annular sealing structure in an openhole well while being submersible through the cased part of the well.

[0004] 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 an openhole part of a well, comprising:

- a tool body having a tool axis,
- a shaft having a first end and a second end, connected to the tool body at the second end,
- an expandable pipe having a transport position in which the expandable pipe has an unexpanded diameter, and the expandable pipe having an expanded position in which the expandable pipe has an expandable diameter,
- an annular sealing element, and
- a pipe expansion element arranged at the first end of the shaft for expanding at least the pipe,

wherein the expandable pipe and the annular sealing element is arranged in succession along the tool axis.

[0005] In an embodiment, the annular sealing element may be arranged between the pipe expansion element and the expandable pipe.

[0006] Also, the downhole setting tool as described above may further comprise a second expansion element

having an inclined outer face on which the annular sealing element slides for providing the annular sealing element with an inner diameter which is larger than the unexpanded diameter of the expandable pipe.

[0007] The second expansion element may be hollow and may extend around the shaft.

[0008] Moreover, the downhole setting tool as described above may further comprise a pushing element, wherein the annular sealing element may have a first end and a second end, the pushing element being arranged at the second end of the annular sealing element, and the second expansion element being arranged at the first end of the annular sealing element.

[0009] Said pushing element may be the expandable pipe element.

[0010] In addition, the downhole setting tool as described above may further comprise a hydraulic cylinder for pulling the shaft into the tool body.

[0011] Moreover, the hydraulic cylinder may be a stroking tool, such as the Well Stroker®.

[0012] Further, the hydraulic cylinder may comprise a cylinder housing and a piston, and the shaft may comprise the piston or the cylinder housing.

[0013] In an embodiment, the tool may comprise two hydraulic cylinders, one for moving the second expansion element and one for moving the shaft.

[0014] The above-mentioned pushing means may comprise several arms, and the second expansion element may have fastening means for engagement with the arms of the pushing means.

[0015] Also, expandable rings may be arranged at the first end and the second end of the annular sealing element.

[0016] Additionally, the downhole setting tool as described above may further comprise an expandable tubular arranged around the shaft between the tool body and the expandable pipe.

[0017] The second expansion element may comprise radial cavities in which an engagement means extends for engagement with the pipe expansion element.

[0018] Furthermore, the second expansion element may comprise an elongated part for extending through the annular sealing element into the pipe expansion element, enabling engagement of the engagement means with the pipe expansion element.

[0019] In addition, the downhole setting tool may further comprise a tool housing from which the second expansion element is projectable.

[0020] Moreover, the pipe expansion element may comprise several cone segments movable in a radial direction.

[0021] In an embodiment, the expandable pipe may be made of metal.

[0022] Further, the annular sealing element may have an inclining surface facing the inclined outer face of the second expansion element.

[0023] Also, the annular sealing element may be made of elastomeric material, natural or synthetic rubber.

[0024] The present invention also relates to an annular base structure as described above, comprising:

- the annular sealing element of an elastomeric material, natural or synthetic rubber, and
- the expandable pipe of metal arranged inside the annular sealing element, pressing the annular sealing element radially outwards when in an expanded position.

[0025] Furthermore, the present invention relates to a downhole sealing system for sealing off a production zone in an openhole well, comprising:

- a first and a second annular base structure set by the downhole setting tool as described above,
- a tubular having a first and a second tubular end and arranged between the two annular base structures, so that the first tubular end overlaps the first annular base structure, and the second tubular end overlaps the second annular base structure, and
- two packers arranged between the annular base structure and the tubular.

[0026] Finally, the present invention relates to a method of expanding an annular base structure in an openhole, comprising the steps of:

- inserting a downhole tool as described above into the openhole,
- moving the second expansion element for expanding and sliding the annular sealing element on the outside of the expandable pipe,
- expanding the expandable pipe and the annular sealing element by means of the pipe expansion element, and
- retracting the tool from the expandable pipe.

Brief description of the drawings

[0027] The invention and its many advantages will be described in more detail below with reference to the accompanying schematic drawings, which for the purpose of illustration show some non-limiting embodiments and in which

Fig. 1 shows a production zone being sealed off by two base structures and a tubular arranged therebetween,

Fig. 2 shows a cross-sectional view of a downhole setting tool according to the invention in its initial position,

Fig. 3 shows a cross-sectional view of the downhole setting tool of Fig. 2 in which the annular sealing element has been partly pushed on the outside of the expandable pipe,

Fig. 4 shows a cross-sectional view of the downhole setting tool of Fig. 2 in which the pipe expansion element expands the expandable pipe and the annular sealing element,

Fig. 5 shows a cross-sectional view of the downhole setting tool of Fig. 2 in which the pipe expansion element has fully expanded the expandable pipe and the annular sealing element,

Fig. 6 shows a cross-sectional view of another embodiment of the downhole setting tool in its initial position,

Fig. 7 shows a cross-sectional view of the downhole setting tool of Fig. 6 in which the second expansion element engages the shaft ready to push the annular sealing element,

Fig. 8 shows a cross-sectional view of the downhole setting tool of Fig. 6 in which the annular sealing element has been pushed on the outside of the expandable pipe,

Fig. 9 shows a cross-sectional view of the downhole setting tool of Fig. 6 in which the annular sealing element has been compressed, and

Fig. 10 shows a cross-sectional view of the downhole setting tool of Fig. 6 in which the pipe expansion element expands the expandable pipe and the annular sealing element.

[0028] 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

[0029] Fig. 1 shows a downhole sealing system 100 for sealing off a production zone 30 producing water 61 in an openhole part 3 of a well 4. The downhole sealing system 100 comprises a first and a second annular base structure 2 and a tubular arranged between the two annular base structures, so that a first tubular end of the tubular overlaps the first annular base structure and a second tubular end of the tubular overlaps the second annular base structure. The system further comprises two packers arranged between the annular base structure and the tubular. The annular base structures press against a wall 3a of the openhole and thus provide - together with the packers - an annular barrier on the outside of the tubular, said annular barrier sealing off the production zone. The annular base structure 2 comprises an annular sealing element 11 surrounding an expandable pipe 10 pressing the annular sealing element towards the wall 3a of the openhole part 3 of the well 4.

[0030] The annular base structure is set by a downhole setting tool as shown in Figs. 2-10. The downhole setting tool 1 comprises a tool body 5 having a tool axis 6 and a shaft 7 connected to the tool body at a second end 9 of the shaft. A first end 8 of the shaft projects from a tool housing 29 through the expandable pipe 10 in its transport position in which the expandable pipe has an unexpanded diameter d_u . In Fig. 1, the expandable pipe has an expanded position in which the expandable pipe has an expandable diameter d_e . The shaft extends further through the annular sealing element 11 and into a pipe expansion element 12 arranged at the first end of the shaft for expanding the pipe and the annular sealing element. Thus, the expandable pipe and the annular sealing element are arranged in succession along the tool axis, hence minimising the outer diameter of the setting tool 1. The setting tool is hereby capable of passing down through the cased part of the well (not shown) to the openhole part of the well.

[0031] As shown in Fig. 2, the downhole setting tool further comprises a second expansion element 14 having an inclined outer face 15 on which the annular sealing element slides, as shown in Fig. 3, for providing the annular sealing element 11 with an inner diameter which is larger than the unexpanded diameter of the expandable pipe 10. The annular sealing element 11 has an inclining surface 34 facing the outer face 15 of the expansion element 14, and upon retraction of the shaft into the tool body 5, the first end 8 of the shaft having a wider part 27 presses towards the annular sealing element 11 and pushes the annular sealing element 11 to slide on the inclining surface 34 of the second expansion element 14. The second expansion element is hollow, extends around the shaft and is positioned partly under the expandable pipe and is fastened to the expandable pipe by a breakable part 35, such as a shear pin. In this way, the annular sealing element 11 is pushed onto an outside 36 of the expandable pipe as shown in Fig. 3. The expandable pipe element 12 is thus a pushing element 18.

[0032] In order to retract the shaft, the downhole setting tool further comprises a hydraulic cylinder 19, as shown in Fig. 2. The hydraulic cylinder comprises a cylinder housing 24 and a piston 23 forming a part of the second end of the shaft. The piston divides the cylinder housing 24 into a first housing part 37 and a second housing part 38, and when pressurised fluid is injected into the first housing part, the piston on the shaft moves and the shaft is retracted into the tool body.

[0033] When the annular sealing element 11 has been pushed all the way onto the expandable pipe 10, the shaft is further retracted into the tool body 5, as shown in Fig. 4. The pipe expansion element 12 comprises several cone segments 20 which are movable in a radial direction, and at this stage the cones have moved radially outwards and thus climbed a stepwise, radially increasing surface 28 on the wider part 27. In this way, the outer diameter of the first end of the shaft is increased, and as the shaft is further retracted, the expandable pipe and

the annular sealing element are expanded. The breakable part of the second expansion element 14 is broken, and the second expansion element 14 is allowed to move into the expandable pipe 10 as the wider part of the first end of the shaft moves towards the tool body 5.

[0034] As the pipe expansion element 12 is moved even further towards the tool body, the expandable pipe is fully expanded, as shown in Fig. 5, and the second expansion element 14 is also pushed into the tool housing 29. In order to be able to fully expand the expandable pipe, the downhole setting tool further comprises an expandable tubular in the form of a slotted liner 25 arranged around the shaft between the tool body and the expandable pipe. As the pipe expansion element 12 moves further towards the tool body, the slotted liner 25 is expanded by the pipe expansion element 12, so that the pipe expansion element 12 is capable of passing under the slotted liner 25. In this way, the tool is capable of fully expanding the expandable pipe and the annular sealing element to press against the wall of the openhole part, as shown in Fig. 1, even though the openhole has a greater diameter than the cased part of the well, since the annular sealing element is pushed on the outside of the expandable pipe and the pipe keeps the annular sealing element pressed towards the wall of the openhole.

[0035] In Fig. 7, the second expansion element comprises an elongated part 50 arranged inside the tool housing. The second expansion element 14 is slidably arranged around the shaft 7 inside the expandable pipe 10. The shaft 7 extends from its second end in the hydraulic cylinder inside the tool housing and through the second expansion element 14 and the expandable pipe. The shaft extends further in through the annular sealing element 11 and in through a separate pushing means 18 in order to, at its first end, to penetrate a first and a second pipe expansion element 12. In this embodiment, the expansion element 12 thus comprises two expansion sections. The first and second pipe expansion elements 12 comprise several cone segments which are movable in a radial direction. When the cone segments move radially outwards in the first expansion element, a gap is created between two adjacent cone segments, and by arranging the second expansion element behind and angularly displaced in relation to the first expansion element, the gaps from the first expansion element are covered by the cone segments of the second expansion element.

[0036] As shown in Fig. 10, the second expansion element 14 is projectable from the tool housing for extending through the annular sealing element into the pipe expansion element, enabling engagement of engagement means 44 with cavities 41 in the pipe expansion element 12. When the engagement means 44 are arranged opposite the cavities 41, the engagement means 44 are forced outwards by springs (not shown) and to enter the cavities 41.

[0037] The annular sealing element has a first end 16 and a second end 17, and the pushing element 18 is arranged at the second end of the annular sealing ele-

ment, and the second expansion element is arranged at the first end of the annular sealing element. Expandable rings 21 are arranged at the first and the second end of the annular sealing element, so that the pushing element 18 presses on one of the expandable rings 21 arranged therebetween.

[0038] In Fig. 7, the second expansion element 14 has moved through the annular sealing element 11, expanding the expandable rings 21 and an inner diameter d_i of the annular sealing element 11. The second expansion element 14 comprises radial cavities in which engagement means 45 are pressed outwards by means of a spring 46 engaging cavities 42 in the pushing element 18. The pushing element 18 comprises several arms 52 which are forced radially outwards due to the inclined outer face 15 of the second expansion element 14 as the second expansion element 14 projects through the annular sealing element 11. The arms 52 of the pushing element 18 are held together by a flexible ring penetrating an opening in the arms. The flexible ring is made of a spring material and will therefore attempt to force the arms radially inwards.

[0039] When the second expansion element 14 has engaged the arms of the pushing element 18, the second expansion element 14 is retracted, pushing the annular sealing element 11 and the expandable rings 21 onto the expandable pipe on the outside of the expandable pipe, as shown in Fig. 8. When the expandable ring 21 reaches a stop 47 arranged on the outside of the expandable pipe, the retraction of the second expansion element 14 is continued for compressing the annular sealing element 11, as shown in Fig. 9. In this way, the expandable pipe is pressed into the arms 52, releasing the fastening means 45, and the arms slide down the inclined outer face 15 of the second expansion element 14 as the shaft and the second expansion element 14 are retracted even further, as shown in Fig. 10.

[0040] In Fig. 10, the first and second pipe expansion elements 12 have been pulled partly through the expandable pipe 10, and thus the pipe and the annular sealing element 11 have been expanded. The expansion process of the expandable pipe is continued until the pipe has been fully expanded and the expandable pipe and the annular sealing element 11 have been set so that the annular sealing element 11 presses against the wall 3a of the openhole 3.

[0041] The downhole setting tool 1 of Figs. 6-10 comprises a first hydraulic cylinder and a second hydraulic cylinder. The first hydraulic cylinder moves the second expansion element between its projected and retracted position and the second hydraulic cylinder moves the shaft.

[0042] In order to keep the annular sealing element 11 in its expanded position pressing against the wall of the openhole, the expandable pipe is made of metal. The annular sealing element is made of a flexible material such as elastomeric material, natural or synthetic rubber in order that it can conform to the dented shape of the

openhole wall.

[0043] The setting tool is thus capable of providing the openhole with annular base structures comprising the annular sealing element of an elastomeric material, natural or synthetic rubber, and the expandable pipe of metal arranged inside the annular sealing element pressing the annular sealing element radially outwards when in an expanded position. Due to the arrangement of the expandable pipe and the annular sealing element in succession along the tool axis, the tool can be designed to have an outer diameter which is small enough for the tool to pass the cased part of the well. Furthermore, by arranging the annular sealing element outside the expandable pipe and subsequently expand the pipe, the outer diameter of the base structure is increased so that the sealing element is capable of reaching the openhole wall and press against it.

[0044] The hydraulic cylinder may be a stroking tool, such as the Well Stroker®. The stroking tool is a tool providing an axial force. The stroking tool comprises an electrical motor for driving a pump. The pump pumps fluid into a piston housing to move a piston acting therein. The piston is arranged on the stoker shaft which is the aforementioned shaft. The pump may pump fluid into the piston housing on one side and simultaneously suck fluid out on the other side of the piston.

[0045] 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 openhole, 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.

[0046] By a casing is meant any kind of pipe, tubing, tubular, liner, string etc. used downhole in relation to oil or natural gas production.

[0047] 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®.

[0048] Although the invention has been described in the above in connection with preferred embodiments of the invention, it will be evident for a person skilled in the art that several modifications are conceivable without departing from the invention as defined by the following claims.

Claims

1. A downhole setting tool (1) for setting an annular

base structure (2) in an openhole part (3) of a well (4), comprising:

- a tool body (5) having a tool axis (6),
 - a shaft (7) having a first end (8) and a second end (9), connected to the tool body at the second end,
 - an expandable pipe (10) having a transport position in which the expandable pipe has an unexpanded diameter (d_u), and the expandable pipe having an expanded position in which the expandable pipe has an expandable diameter (d_e),
 - an annular sealing element (11), and
 - a pipe expansion element (12) arranged at the first end of the shaft for expanding at least the pipe, wherein the expandable pipe and the annular sealing element is arranged in succession along the tool axis.
2. A downhole setting tool according to claim 1, wherein the annular sealing element is arranged between the pipe expansion element and the expandable pipe.
 3. A downhole setting tool according to claims 1 and 2, further comprising a second expansion element (14) having an inclined outer face (15) on which the annular sealing element slides for providing the annular sealing element with an inner diameter (d_i) which is larger than the unexpanded diameter of the expandable pipe.
 4. A downhole setting tool according to claim 3, wherein the second expansion element is hollow and extends around the shaft.
 5. A downhole setting tool according to any of the preceding claims, further comprising a pushing element (18), wherein the annular sealing element has a first end (16) and a second end (17), the pushing element being arranged at the second end of the annular sealing element, and the second expansion element being arranged at the first end of the annular sealing element.
 6. A downhole setting tool according to claim 5, wherein the pushing element is the expandable pipe element.
 7. A downhole setting tool, further comprising a hydraulic cylinder (19) for pulling the shaft into the tool body.
 8. A downhole setting tool according to claim 7, wherein the hydraulic cylinder comprises a cylinder housing (24) and a piston (23), and the shaft comprises the piston or the cylinder housing.
 9. A downhole setting tool according to any of the pre-

ceding claims, wherein expandable rings (21) are arranged at the first end and the second end of the annular sealing element.

- 5 10. A downhole setting tool according to any of the preceding claims, further comprising an expandable tubular arranged around the shaft between the tool body and the expandable pipe.
- 10 11. A downhole setting tool according to any of the preceding claims, wherein the pipe expansion element comprises several cone segments (20) movable in a radial direction.
- 15 12. A downhole setting tool according to any of the preceding claims, wherein the annular sealing element has an inclining surface facing the inclined outer face of the second expansion element.
- 20 13. An annular base structure according to any of the preceding claims, comprising:
 - the annular sealing element of an elastomeric material, natural or synthetic rubber, and
 - the expandable pipe of metal arranged inside the annular sealing element, pressing the annular sealing element radially outwards when in an expanded position.
- 25 14. A downhole sealing system for sealing off a production zone in an openhole well, comprising:
 - a first and a second annular base structure (2) set by the downhole setting tool according to any of claims 1-12,
 - a tubular having a first and a second tubular end and arranged between the two annular base structures, so that the first tubular end overlaps the first annular base structure, and the second tubular end overlaps the second annular base structure, and
 - two packers arranged between the annular base structure and the tubular.
- 30 15. A method of expanding an annular base structure in an openhole, comprising the steps of:
 - inserting a downhole tool according to any of claims 1-12 into the openhole,
 - moving the second expansion element for expanding and sliding the annular sealing element on an outside of the expandable pipe,
 - expanding the expandable pipe and the annular sealing element by means of the pipe expansion element, and
 - retracting the tool from the expandable pipe.
- 35 40 45 50 55

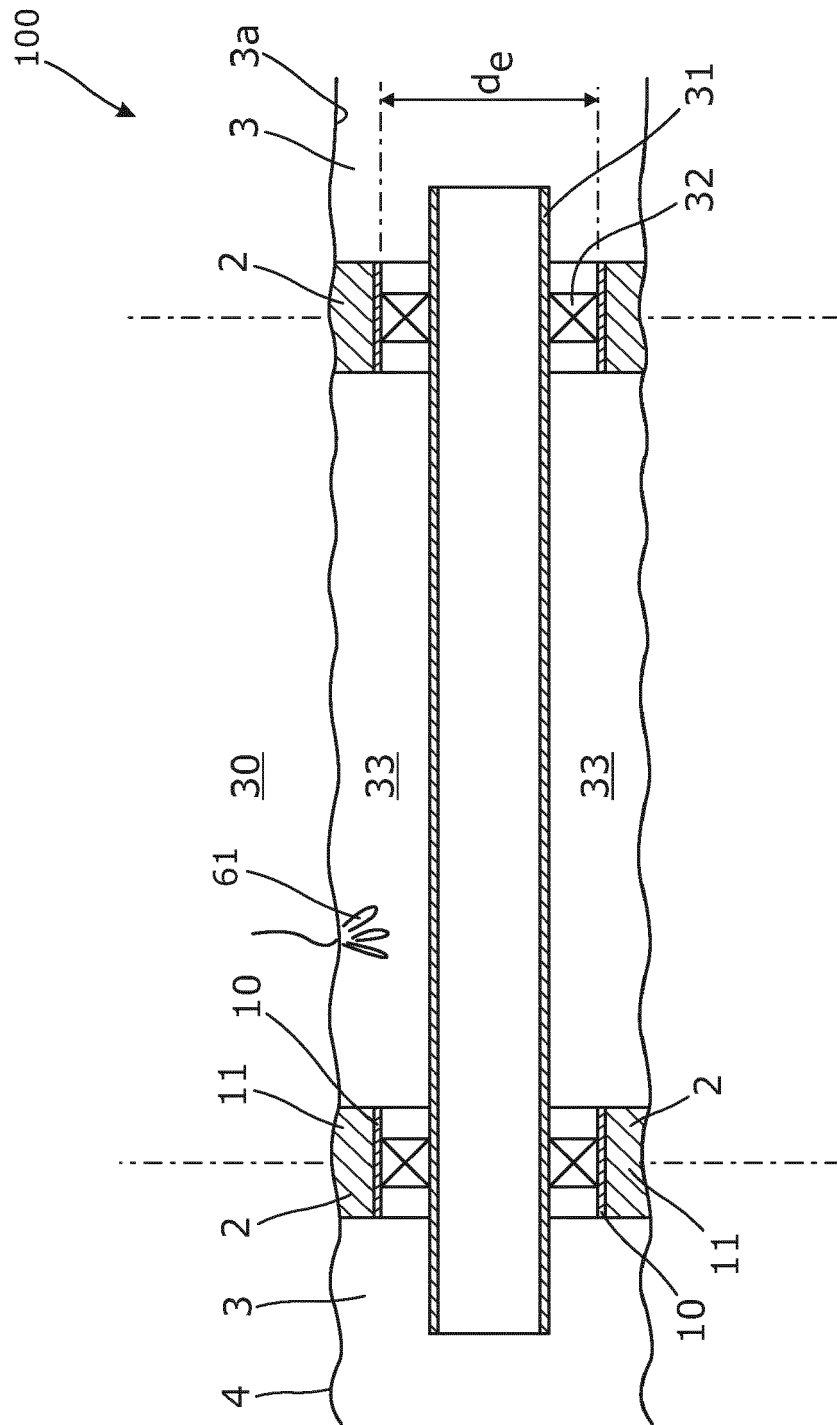


Fig. 1

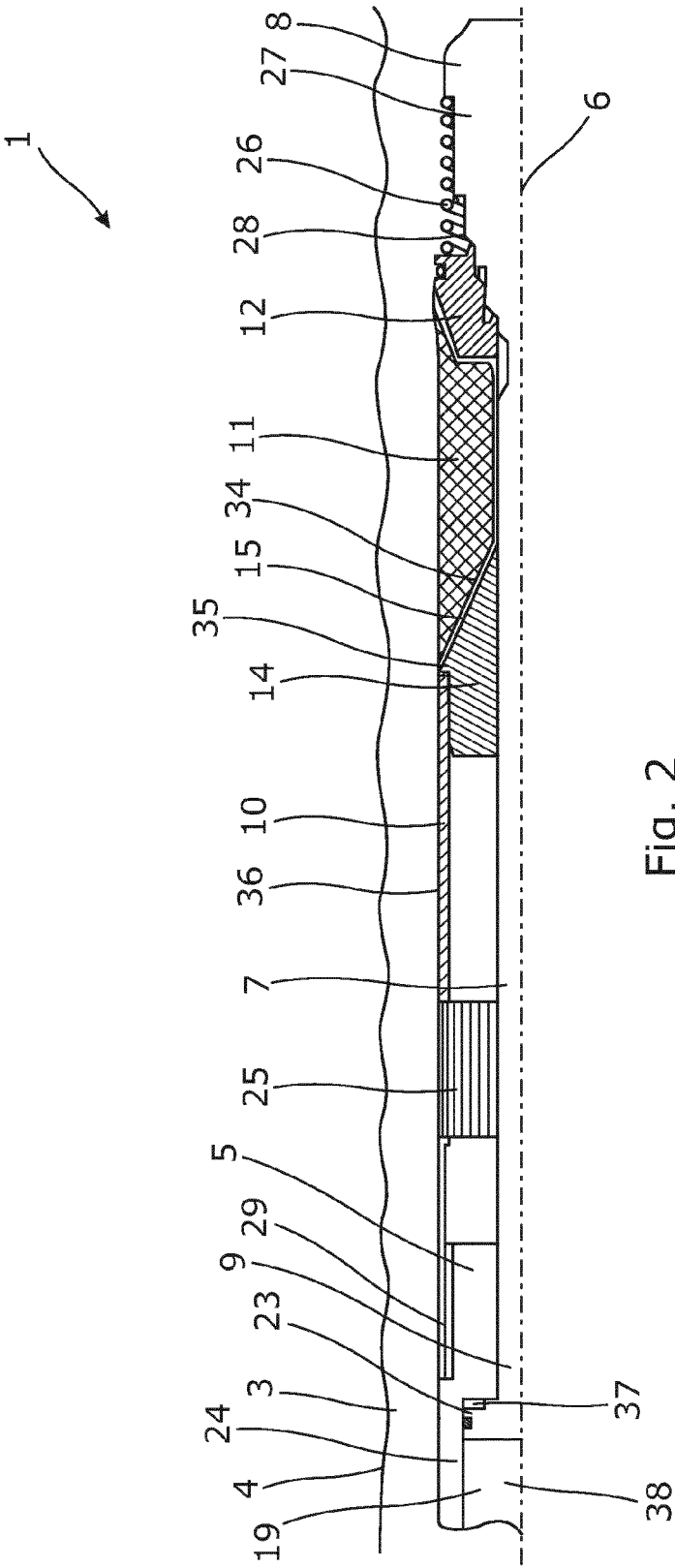


Fig. 2

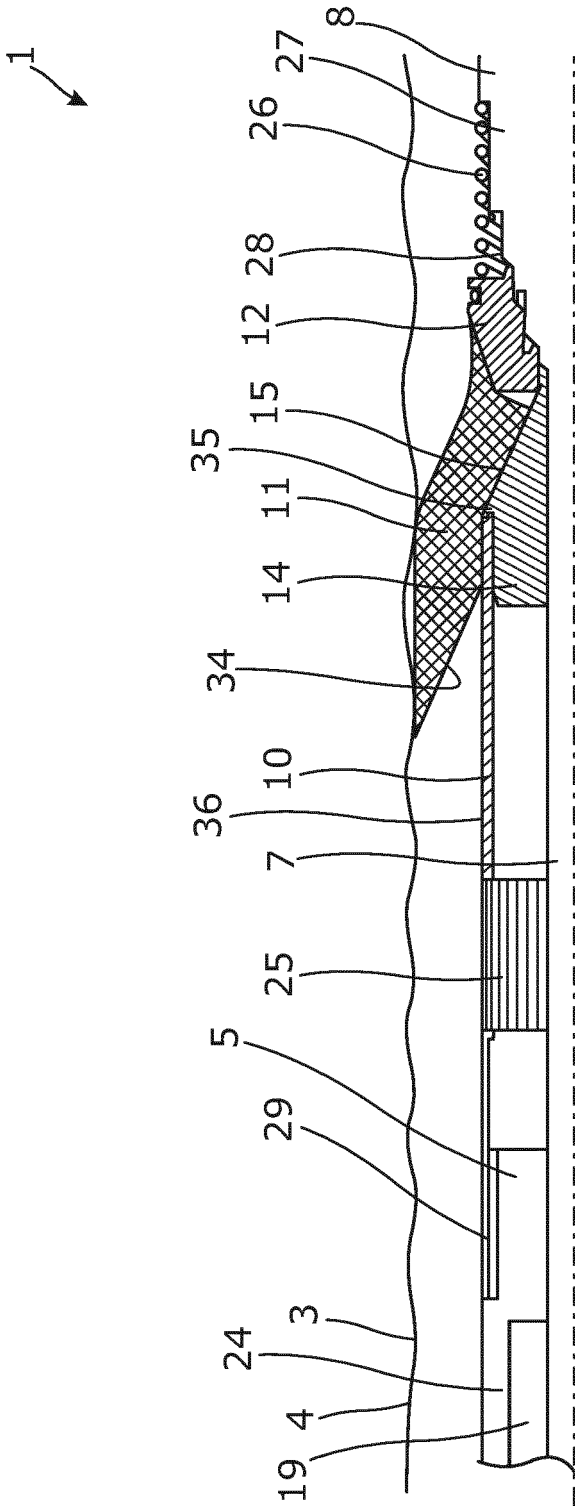


Fig. 3

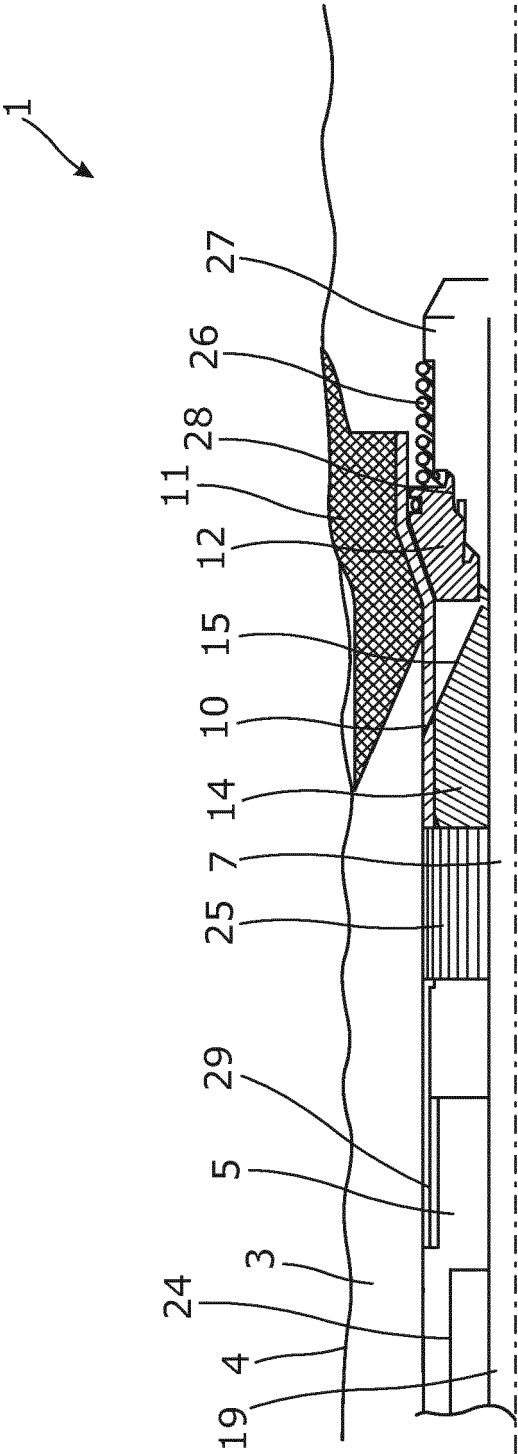


Fig. 4

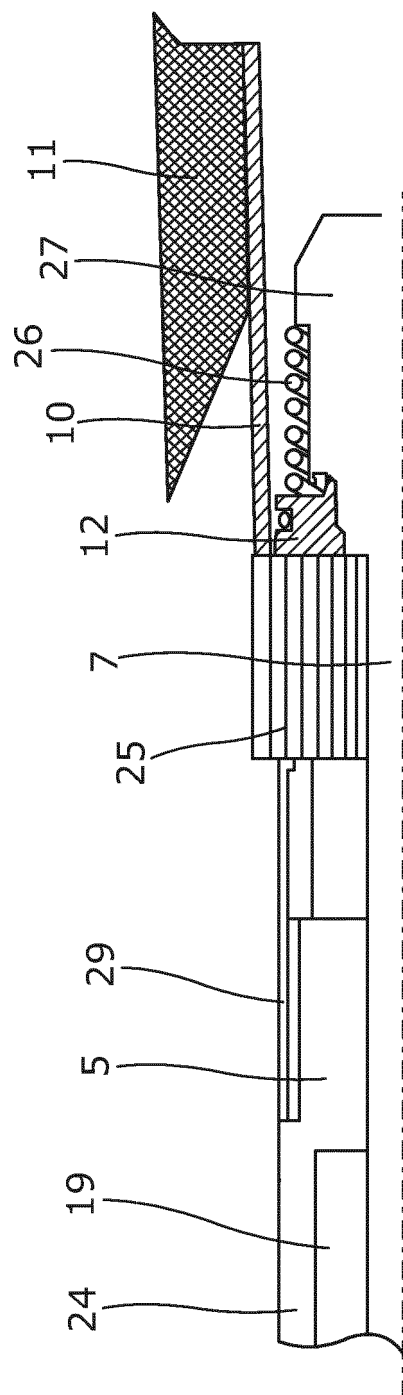


Fig. 5

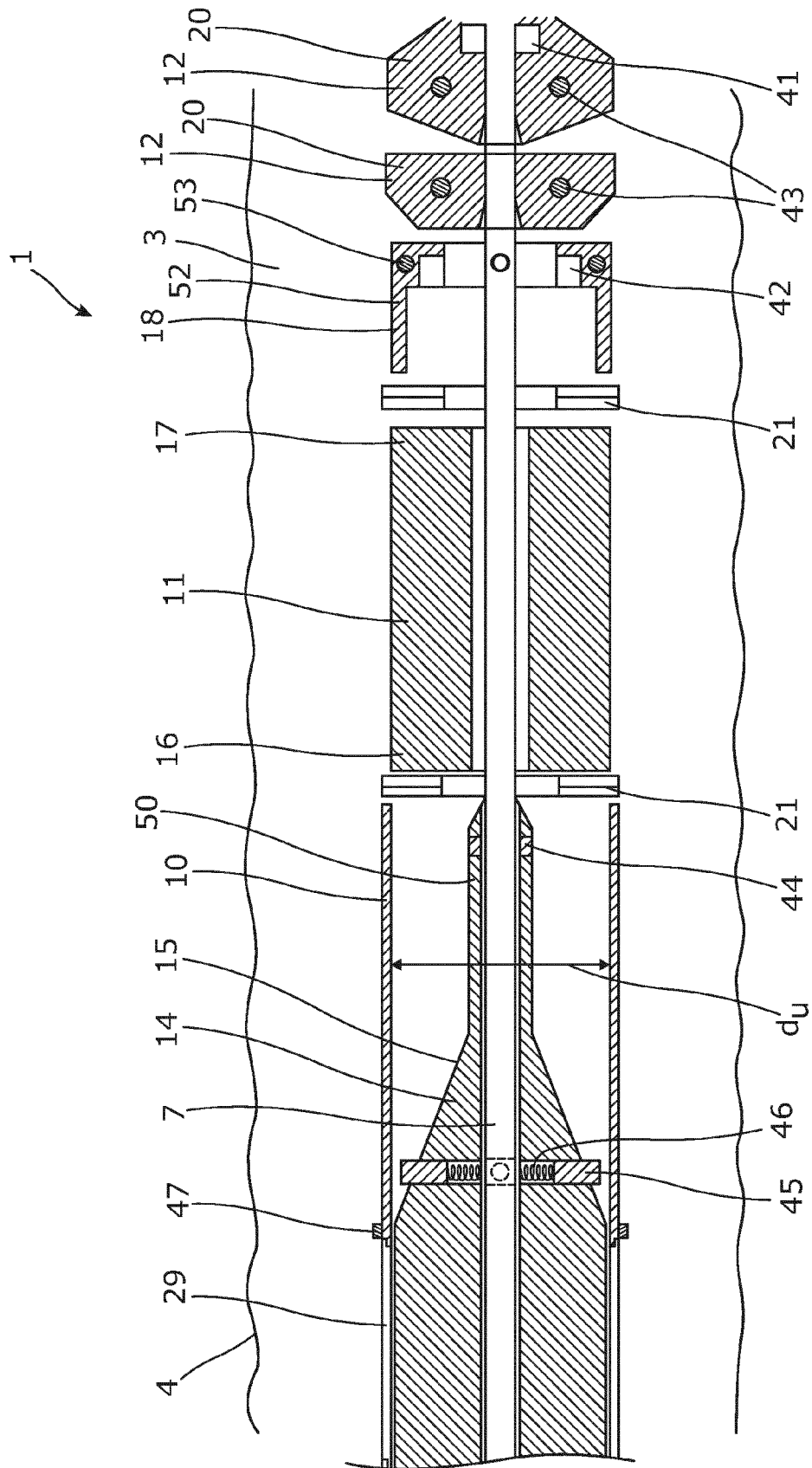


Fig. 6

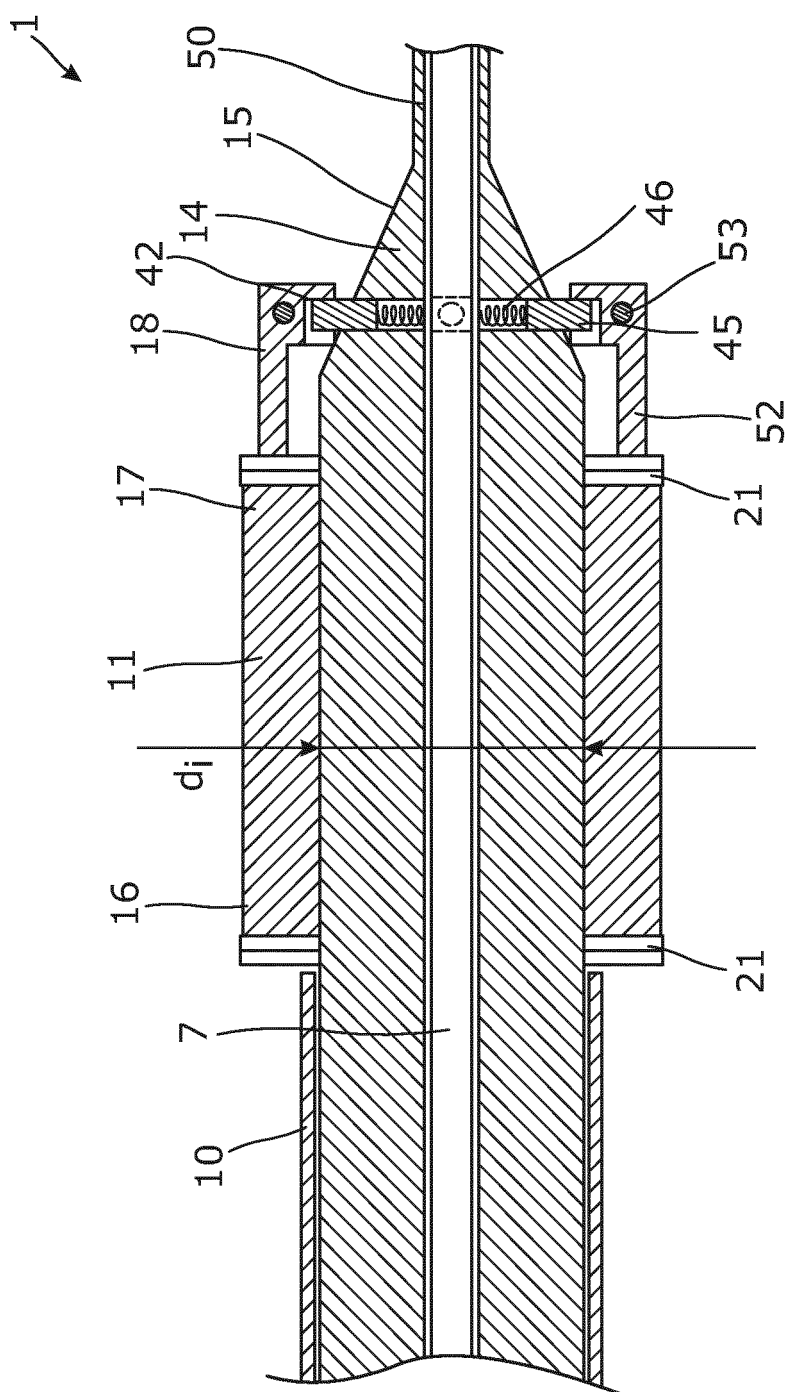


Fig. 7

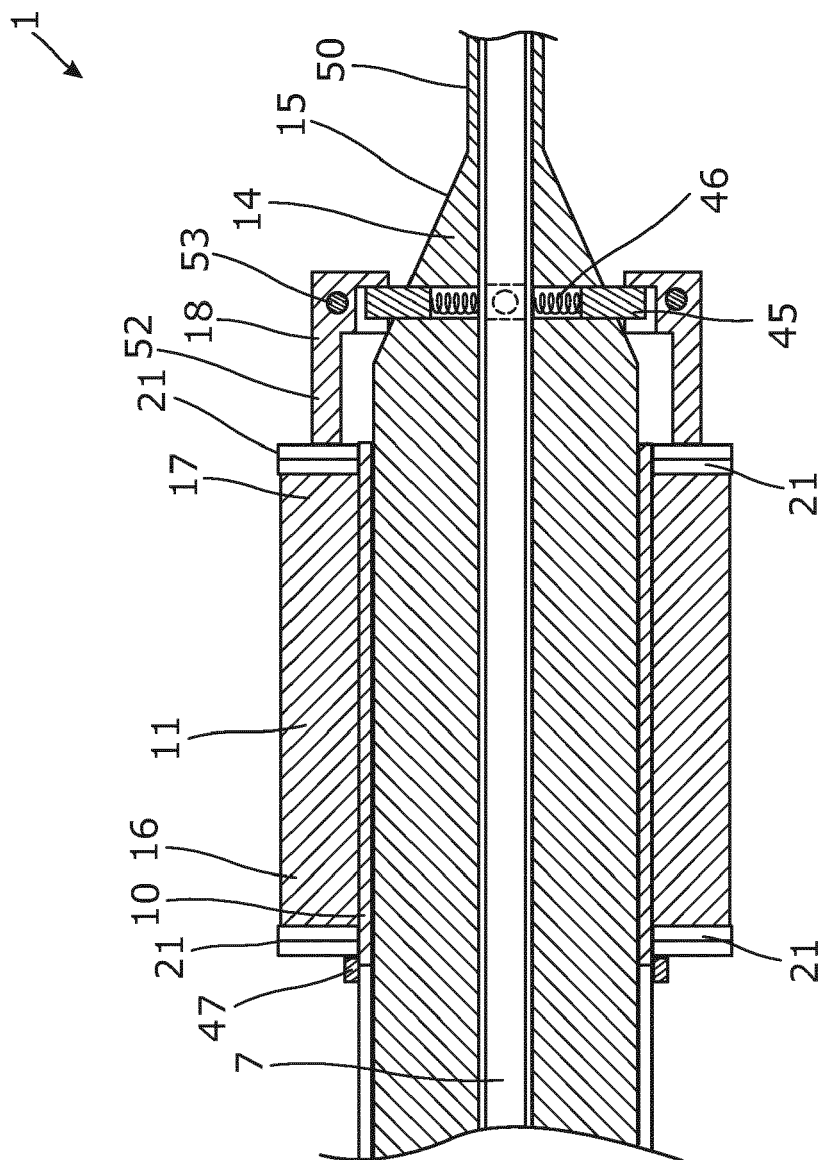


Fig. 8

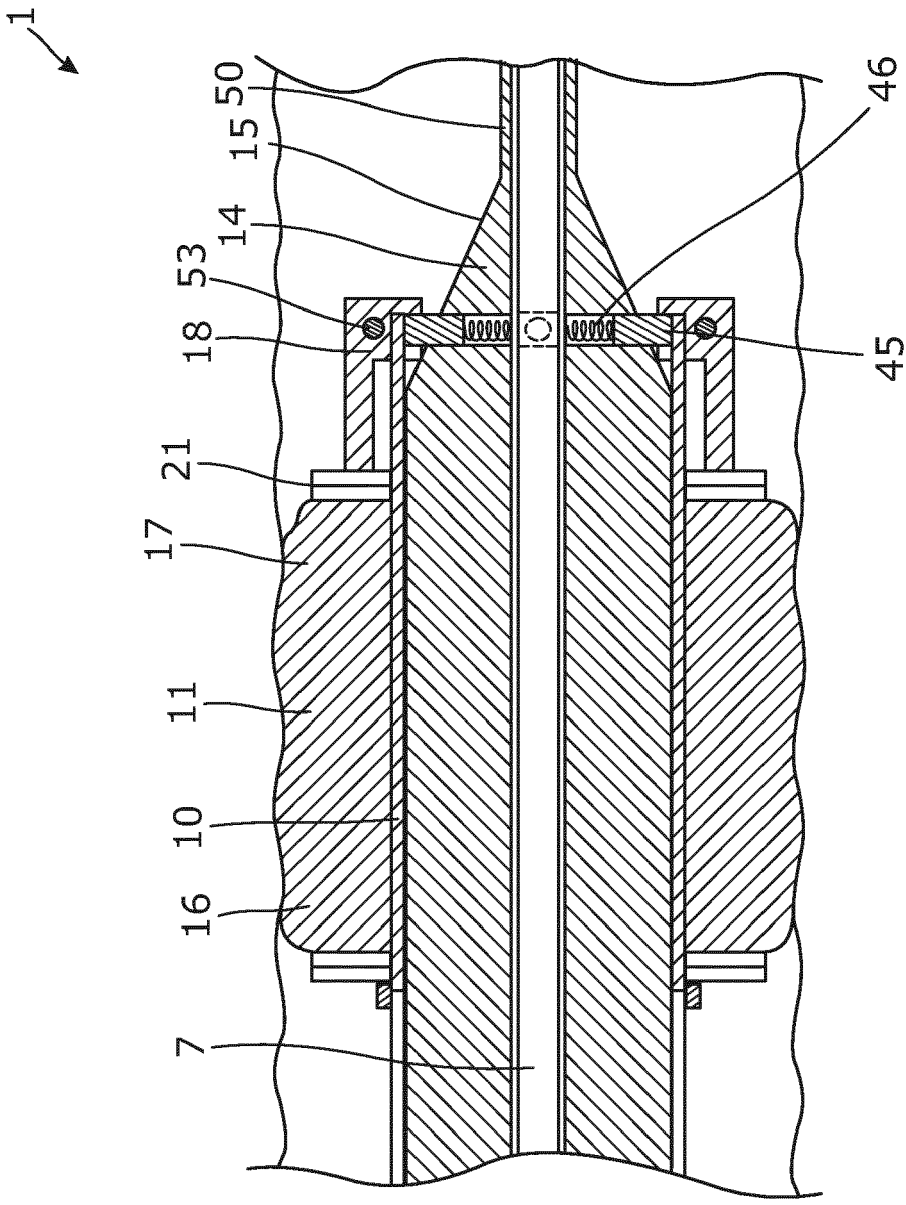


Fig. 9

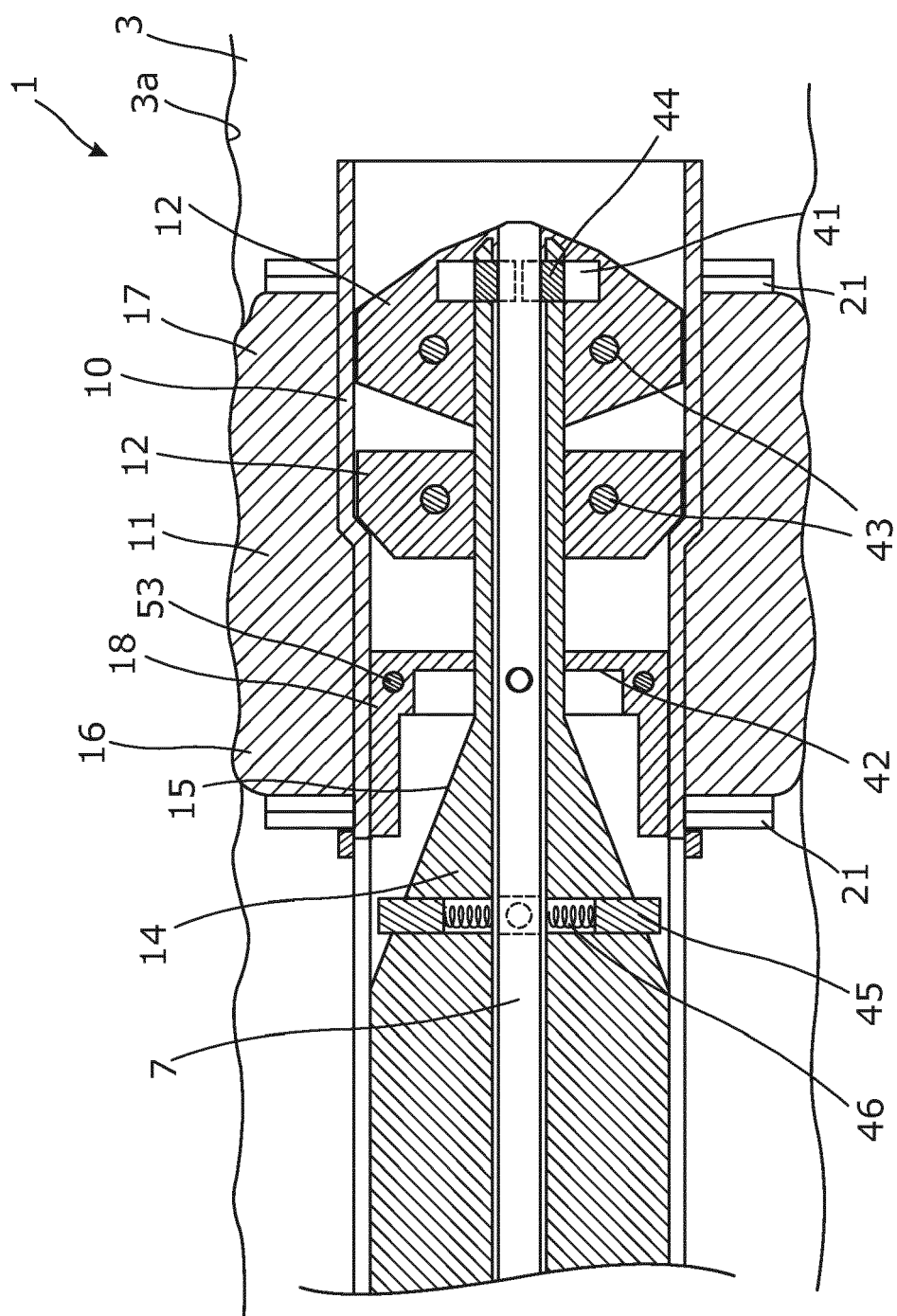


Fig. 10



EUROPEAN SEARCH REPORT

Application Number
EP 12 19 6155

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 2004/123988 A1 (COOK ET AL.) 1 July 2004 (2004-07-01)	1,7,8, 13,14	INV. E21B43/10
Y	* paragraphs [0055] - [0058], [0070], [0082], [0088], [0090], [0129] * -----	11	
Y	US 2005/045342 A1 (LUKE ET AL.) 3 March 2005 (2005-03-03) * paragraph [0072] * -----	11	
			TECHNICAL FIELDS SEARCHED (IPC)
			E21B
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 27 May 2013	Examiner Rampelmann, Klaus
CATEGORY OF CITED DOCUMENTS 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 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 & : member of the same patent family, corresponding document			

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EPO FORM 1503 03/82 (P04001)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 12 19 6155

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The members are as contained in the European Patent Office EDP file on
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27-05-2013

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82