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(54) **LIQUID UNLOADING METHOD AND SYSTEM**

(57) The present invention relates to a liquid unloading method for unloading liquid in a malfunctioning gas well having a top end and a bottom end and a gas production zone, the gas well having liquid accumulated in the bottom end and at least above the production zone. The method comprises the steps of providing a foaming agent on top of or in the liquid in the gas well; arranging a downhole tool at least partly submerged in the liquid; agitating fluid of the foaming agent and the liquid by the downhole tool; and forming foam of the liquid and the foaming agent at least partly above the gas production zone. Furthermore, the present invention relates to a downhole liquid unloading system for unloading liquid in a malfunctioning gas well.

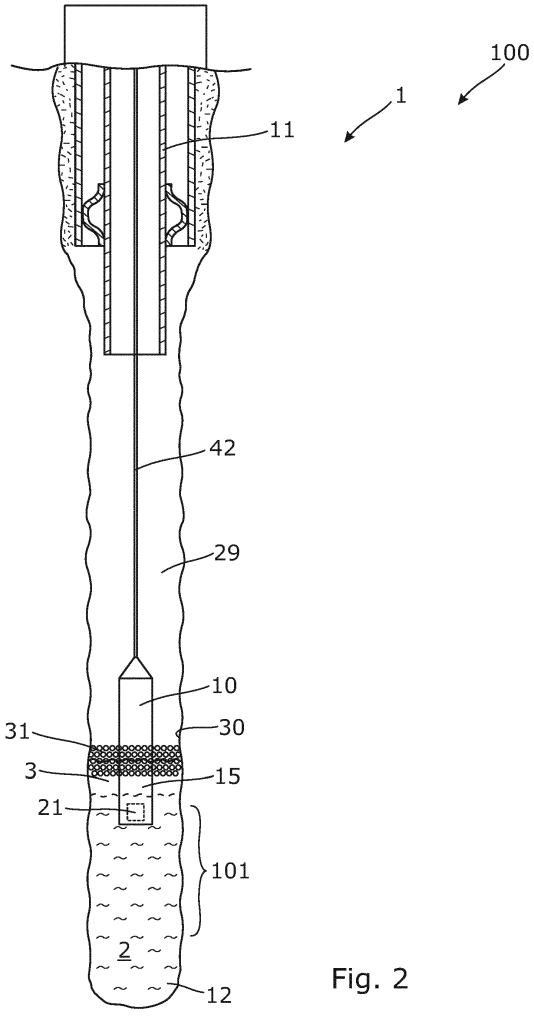

Fig. 2

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Description

Field of the invention

[0001] The present invention relates to a liquid unloading method for unloading liquid in a malfunctioning gas well having a top end and a bottom end and a gas production zone, the gas well having liquid accumulated in the bottom end and at least above the production zone. Furthermore, the present invention relates to a downhole liquid unloading system for unloading liquid in a malfunctioning gas well.

Background art

[0002] During production of gas, water vapour tends to condensate on the inner face of a production casing in a wellbore or on the inner face of the borehole. As the vapour condensates into liquid, liquid is accumulated in the bottom of the well, and eventually, the liquid accumulates and provides a water trap blocking the gas production zone. This causes the gas production to stop since the gas pressure in the production zone can no longer overcome the liquid column hydrostatic pressure. In order to remove the liquid from the bottom of the well, a foaming agent is provided on top of the liquid from the top of the well. However, the foaming process often never starts or it dies out after a short time.

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 liquid unloading system capable of unloading liquid accumulated in a gas 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 liquid unloading method for unloading liquid in a malfunctioning gas well having a top end and a bottom end and a gas production zone, the gas well having liquid accumulated in the bottom end and at least above the production zone, the method comprising the steps of:

- providing a foaming agent on top of or in the liquid in the gas well,
- arranging a downhole tool at least partly submerged in the liquid,
- agitating fluid of the foaming agent and the liquid by means of the downhole tool, and
- forming foam of the liquid and the foaming agent at least partly above the gas production zone.

[0005] The liquid unloading method may further comprise the step of producing gas from the gas production zone up through the foam.

[0006] In an embodiment, the step of providing the foaming agent may be performed by introducing the foaming agent from the top of the gas well.

[0007] Furthermore, the step of providing the foaming agent may be performed by submerging the downhole tool comprising the foaming agent into the liquid downhole and ejecting the foaming agent.

[0008] In addition, the step of arranging the downhole tool may be performed by means of a wireline, a driving unit, a drill pipe or coiled tubing.

[0009] In an embodiment, the liquid unloading method may further comprise the step of detecting liquid by means of a detection unit of the downhole tool.

[0010] The step of agitating the fluid may be performed by reciprocating, rotating and/or lateral movements of a tool part of the downhole tool or the downhole tool, and/or by pumping or circulating the fluid by means of a tool pump of the downhole tool.

[0011] In another embodiment, the liquid unloading method may further comprise the step of stopping agitating the fluid and detecting a flow of fluid.

[0012] Also, the liquid unloading method may further comprise the step of deciding to retract the downhole tool or continue agitating the fluid.

[0013] Additionally, the liquid unloading method may further comprise the step of providing a second portion of foaming agent into the well.

[0014] The present invention furthermore relates to a downhole liquid unloading system for unloading liquid in a malfunctioning gas well, comprising:

- the gas well having a top end and a bottom end, a gas production zone and liquid accumulated in the bottom end at least partly above the gas production zone,
- a foaming agent provided in or above the liquid, and
- a downhole tool configured to agitate a fluid of the liquid and foaming agent.

[0015] In an embodiment, the downhole liquid unloading system may further comprise a well pump arranged at the top for pumping the foaming agent into the gas well.

[0016] Furthermore, the downhole tool may comprise a chamber comprising the foaming agent to be partly or fully ejected into the gas well.

[0017] Moreover, the downhole tool may comprise a tool pump configured to eject the foaming agent into the gas well and/or circulating the fluid in the gas well.

[0018] Also, the downhole tool may comprise an inlet and an outlet.

[0019] The downhole liquid unloading system may further comprise a reciprocating means configured to agitate the fluid, the reciprocating means being arranged in the downhole tool or at the top.

[0020] Also, the downhole liquid unloading system may further comprise a rotating means configured to agitate the fluid, the rotating means being arranged in the downhole tool or at the top.

[0021] Moreover, the downhole liquid unloading system may further comprise a unit for generating lateral movements of the downhole tool.

[0022] In an embodiment, the downhole tool may have a tool axis and comprise a tool body and a tool part which is rotatable and axially slidable along the tool axis or pivoting around a pivot point in relation to the tool body.

[0023] In another embodiment, the tool part of the downhole tool may be or may comprise a brush, a whisk, an arm or an axial force generator.

[0024] In yet another embodiment, the downhole tool may further comprise an anchor section or a downhole driving unit for propelling the downhole tool forward in the gas well.

[0025] Furthermore, the downhole tool may comprise a wireline, a drill pipe or coiled tubing.

[0026] In addition, the downhole tool may comprise a detection unit configured to detect liquid and/or a flow of fluid.

[0027] Moreover, the downhole tool may comprise a logging unit configured to detect a position of the downhole tool or a content of the fluid.

[0028] Also, the gas well may comprise a well tubular metal structure.

[0029] The well tubular metal structure may comprise annular barriers, each annular barrier comprising a tubular metal part mounted as part of the well tubular metal structure and an expandable metal sleeve surrounding the tubular metal part and connected at its ends to the tubular metal part, defining an annular space.

Brief description of the drawings

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

Fig. 1 shows a cross-sectional view of a gas well,

Fig. 2 shows a partly cross-sectional view of a downhole liquid unloading system having a submerged tool,

Fig. 3 shows a partly cross-sectional view of another downhole liquid unloading system having rotation means and reciprocating means at the top,

Fig. 4 shows a partly cross-sectional view of another downhole liquid unloading system having a tool comprising reciprocating means,

Fig. 5 shows a partly cross-sectional view of yet another downhole liquid unloading system having a tool comprising a rotation unit, and

Fig. 6 shows a partly cross-sectional view of one downhole liquid unloading system having a tool comprising a unit configured to provide lateral movements of a tool part.

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

Detailed description of the invention

[0032] Fig. 1 shows a downhole liquid unloading system 100 comprising a malfunctioning gas well 1 having a top 11 and a bottom end 12 and a gas production zone 101. The gas well 1 comprises a liquid 2 accumulated at the bottom. During production of gas, water vapour tends to condensate on an inner face 27 of a well tubular structure 28 in a borehole 29 or on an inner face 30 of the borehole, as shown in Fig. 2. As the vapour condensates into liquid, liquid is accumulated in the bottom end 12, and eventually, the liquid accumulates above the gas production zone 101, which causes the gas production to deteriorate or stop because the gas pressure in the production zone can no longer overcome the liquid column hydrostatic pressure. In order to remove the liquid from the bottom of the well, a foaming agent 3 is provided on top of the liquid from the top of the well. However, the foaming process sometimes never starts or it dies out after a short time. When this happens, a downhole tool 10 is arranged at least partly submerged in the liquid, as shown in Fig. 2, for agitating a fluid of the foaming agent 3 and the liquid by means of the downhole tool 10. As a result, foam 31 is formed of the liquid and the foaming agent 3 at least partly above the gas production zone 101. As the downhole tool agitates, the foaming agent 3 and the liquid are turned into foam, which causes the liquid column hydrostatic pressure to decrease enough for the gas well 1 to start producing gas from the gas production zone up through the foam and bringing gas and foam to the top of the well. As the gas production is initiated, the gas brings up the liquid in the form of foam, and the well is in this way unloaded of the liquid blocking the production zone 101.

[0033] The foaming agent 3 may be pumped by a well pump 51 or poured into the well from the top of the well, as shown in Fig. 1, or the foaming agent may be provided by submerging the downhole tool comprising the foaming agent 3 and ejecting the foaming agent into the liquid downhole, as shown in Fig. 3. The foaming agent 3 is comprised in a chamber 16 in the downhole tool 10, and the foaming agent is partly or fully ejected into the gas well 1, as shown in Fig. 3.

[0034] The downhole tool 10 may be arranged in the well by means of a wireline 42 as shown in Fig. 2, a driving unit 43 as shown in Fig. 4, a drill pipe 44 or coiled tubing as shown in Fig. 3.

[0035] The agitation of the fluid is performed by reciprocating, rotating and/or lateral movements of a tool part

14 of the downhole tool 10, as shown in Fig. 3, or the downhole tool itself, and/or by pumping or circulating the fluid by means of a tool pump 15 of the downhole tool, as shown in Fig. 2. The downhole tool has an inlet 17 for taking in gas or fluid if fully submerged and an outlet 18 for ejecting the foaming agent 3, as shown in Fig. 3. The tool part 14 may be a whisk which is rotated and/or moved up and down in the fluid and in this way whisk gas into fluid comprising the liquid and the foaming agent 3.

[0036] In order to position the downhole tool to be at least partly submerged in the fluid, the downhole tool 10 comprises a detection unit 21, as shown in Fig. 2. The detection unit 21 is configured to detect liquid so that the downhole tool can be positioned partly, if not fully, submerged in the liquid.

[0037] When the downhole tool 10 has agitated the fluid at some time, the agitation is stopped and after a period of time the detection unit then detects if the fluid has started to flow and thus if the gas production is initiated. Thus, the detection unit may be configured to measure a flow velocity of the fluid. If the well has stated to produce gas again, the tool is retracted and if not the agitation is proceed. Before proceeding with the agitation, a second portion of foaming agent may be added to the fluid in the well.

[0038] The downhole liquid unloading system 100 further comprises a reciprocating means 19 configured to agitate the fluid. In Fig. 4, the reciprocating means is arranged in the downhole tool in the form of an axial force generator 14d. The tool part 14 of the downhole tool is a brush 14a reciprocated by the axial force generator 14d for forming foam. The downhole tool 10 further comprises an anchoring section 25 for anchoring the tool during reciprocation or rotation, and in addition, the downhole tool further comprises a downhole driving unit 42a for propelling the downhole tool forward in the gas well 1. In Fig. 3, the reciprocating means 19 is arranged at the top of the well and moves the drill pipe/coiled tubing up and down.

[0039] In Fig. 5, the downhole tool 10 comprises a rotating means 20 arranged in a tool body 23 and configured to agitate the fluid by rotating a tool part 14, such as an arm 14c. The rotating means 20 may also be arranged at the top of the well, as shown in Fig. 3.

[0040] In Fig. 6, the tool 10 comprises a unit 22 configured to provide lateral movements of a tool part 14, such as an arm 14c, of the downhole tool. The tool part 14 is thus pivoting around a pivot point 24 in relation to the tool body. The tool 10 comprises a logging unit 26 configured to detect a position of the downhole tool and/or a content of the fluid.

[0041] As can be seen in Fig. 3, the gas well comprises a well tubular metal structure 28 comprising annular barriers 40. Each annular barrier 40 comprises a tubular metal part 41 mounted as part of the well tubular metal structure 28 and an expandable metal sleeve 45 surrounding the tubular metal part and connected at its ends to the tubular metal part, defining an annular space 46. The annular barriers of the system isolate the production zone 101, and one annular barrier provides a main barrier between the well tubular metal structure 28 and the intermediate casing 47 in the top of the well. The annular barriers may be expanded by pressurised fluid from the well tubular metal structure entering through an opening in the tubular metal part into the space to expand the expandable sleeve. The annular barriers may also be expanded by the annular space comprising at least one thermally decomposable compound adapted to generate gas or super-critical fluid upon decomposition. The compound may decompose upon heating the compound.

[0042] An axial force generator is a tool providing an axial force, such as a stroking tool. 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 stroker 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.

[0043] 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.

[0044] By a casing or well tubular structure is meant any kind of pipe, tubing, tubular, liner, string etc. used downhole in relation to oil or natural gas production. The casing or well tubular structure is mainly made of metal.

[0045] In the event that the tool is not submergible all the way into the casing, a driving unit, such as 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®.

[0046] 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 liquid unloading method for unloading liquid in a malfunctioning gas well (1) having a top end (11) and a bottom end (12) and a gas production zone (101), the gas well having liquid (2) accumulated in the bottom end and at least above the production zone, the method comprising the steps of:

- providing a foaming agent (3) on top of or in the liquid in the gas well,
- arranging a downhole tool (10) at least partly submerged in the liquid,
- agitating a fluid of the foaming agent and the liquid by means of the downhole tool, and
- forming foam of the liquid and the foaming agent at least partly above the gas production zone.

2. A liquid unloading method according to claim 1, further comprising the step of producing gas from the gas production zone up through the foam.

3. A liquid unloading method according to any of claims 1-2, wherein the step of providing the foaming agent is performed by introducing the foaming agent from the top of the gas well.

4. A liquid unloading method according to any of claims 1-2, wherein the step of providing the foaming agent is performed by submerging the downhole tool comprising the foaming agent into the liquid downhole and ejecting the foaming agent.

5. A liquid unloading method according to any of claims 1-4, further comprising the step of detecting liquid by means of a detection unit (21) of the downhole tool.

6. A liquid unloading method according to any of claims 1-5, wherein the step of agitating the fluid is performed by reciprocating, rotating and/or lateral movements of a tool part (14) of the downhole tool or the downhole tool, and/or by pumping or circulating the fluid by means of a tool pump (15) of the downhole tool.

7. A liquid unloading method according to any of claims 1-6, further comprising the step of stopping agitating the fluid and detecting a flow of fluid.

8. A liquid unloading method according to any of claims 1-7, further comprising the step of providing a second portion of foaming agent into the well.

9. A downhole liquid unloading system (100) for unloading liquid (2) in a malfunctioning gas well (1), comprising:

- the gas well having a top end (11) and a bottom end (12), a gas production zone (101) and liquid (2) accumulated in the bottom end at least partly above the gas production zone,
- a foaming agent (3) provided in or above the liquid, and
- a downhole tool (10) configured to agitate a fluid (5) of the liquid and foaming agent.

10. A downhole liquid unloading system according to claim 9, further comprising a well pump (51) arranged at the top for pumping the foaming agent into the gas well.

11. A downhole liquid unloading system according to claim 9, wherein the downhole tool comprises a chamber (16) comprising the foaming agent to be partly or fully ejected into the gas well.

12. A downhole liquid unloading system according to claim 11, wherein the downhole tool comprises a tool pump (15) configured to eject the foaming agent into the gas well and/or circulating the fluid in the gas well.

13. A downhole liquid unloading system according to claim 9, further comprising a reciprocating means (19) configured to agitate the fluid, the reciprocating means being arranged in the downhole tool or at the top.

14. A downhole liquid unloading system according to any of claims 9-13, wherein the downhole tool has a tool axis (T) and comprises a tool body (23) and a tool part (14) which is rotatable and axially slidable along the tool axis or pivoting around a pivot point (24) in relation to the tool body.

15. A downhole liquid unloading system according to any of claims 9-14, wherein the downhole tool comprises a detection unit (21) configured to detect liquid and/or a flow of fluid.

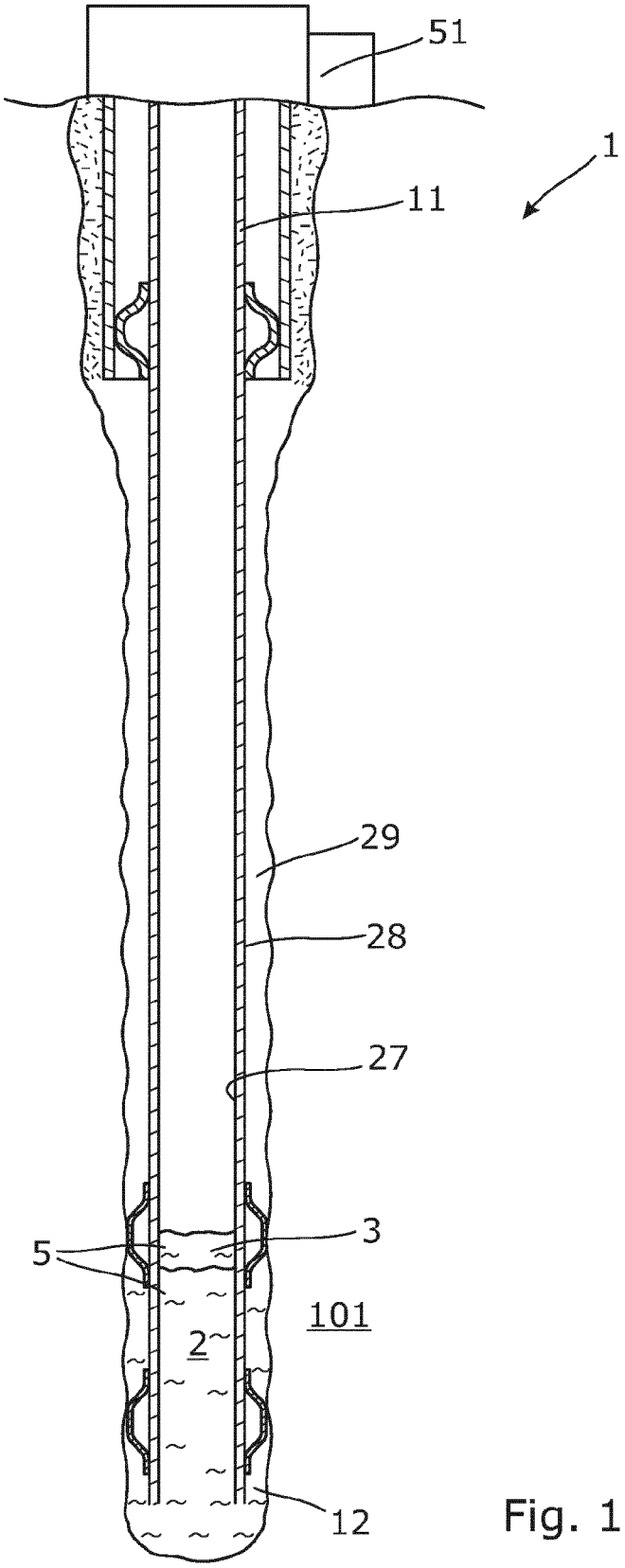

Fig. 1

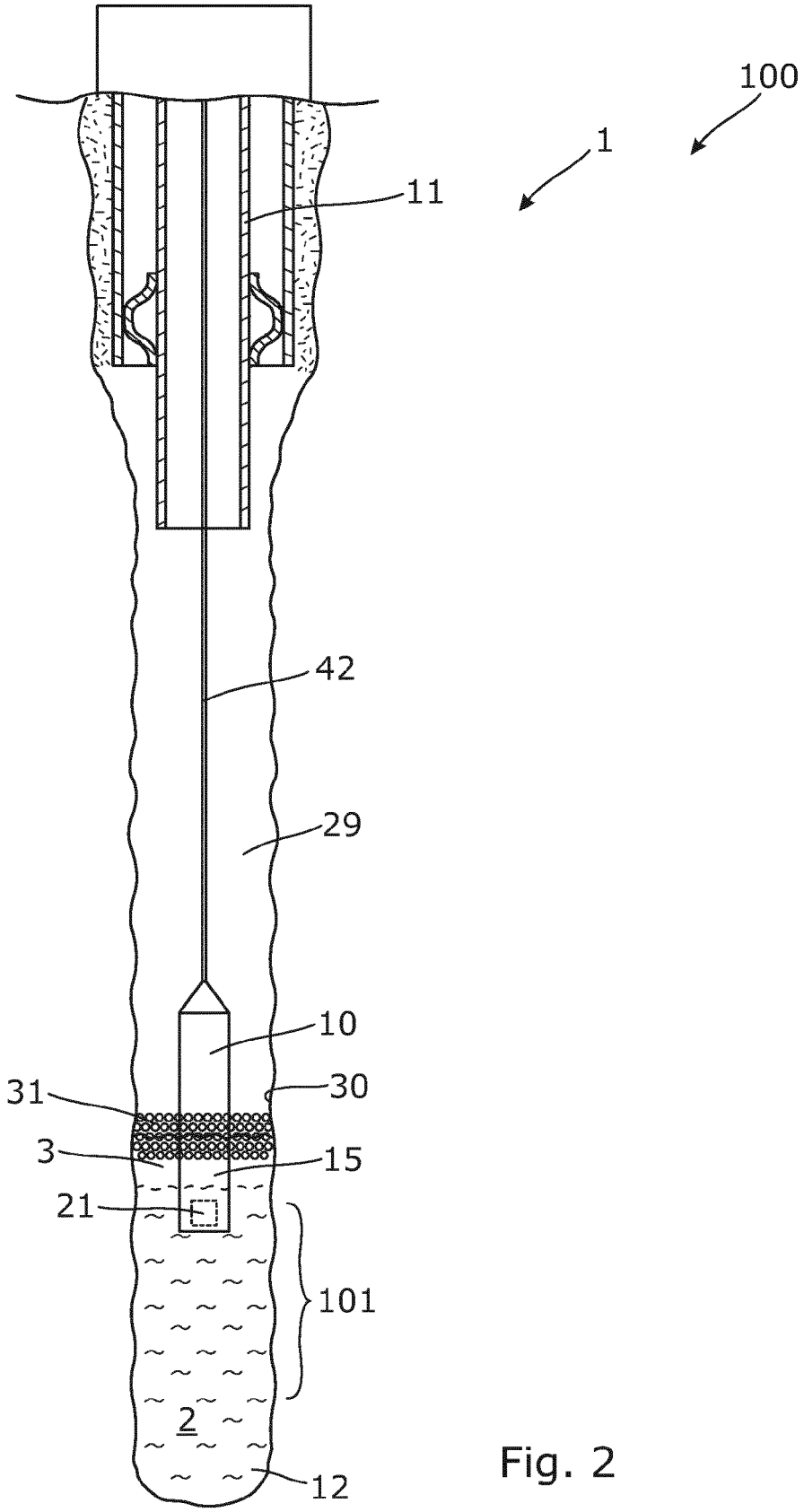

Fig. 2

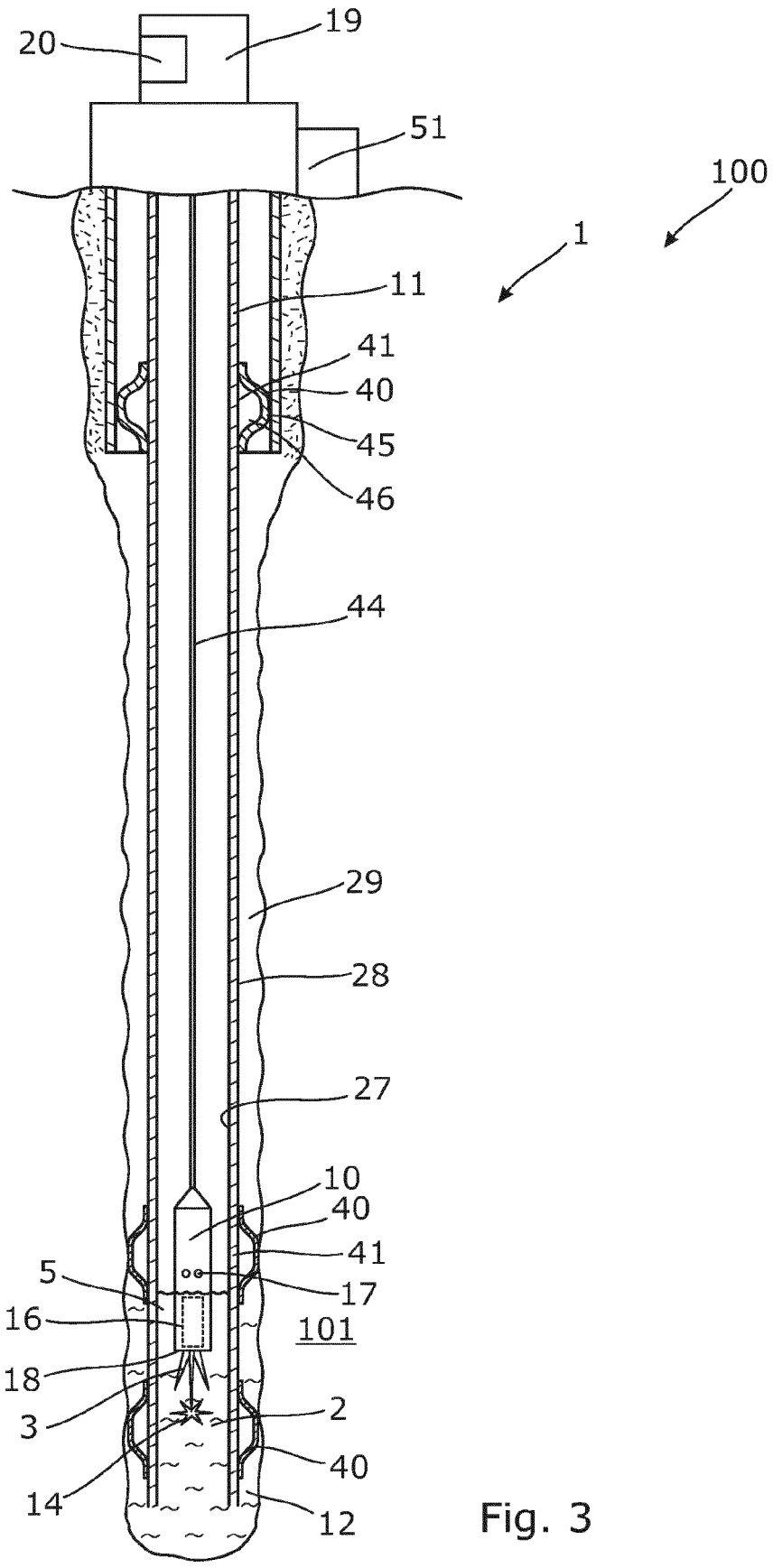
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Fig. 3

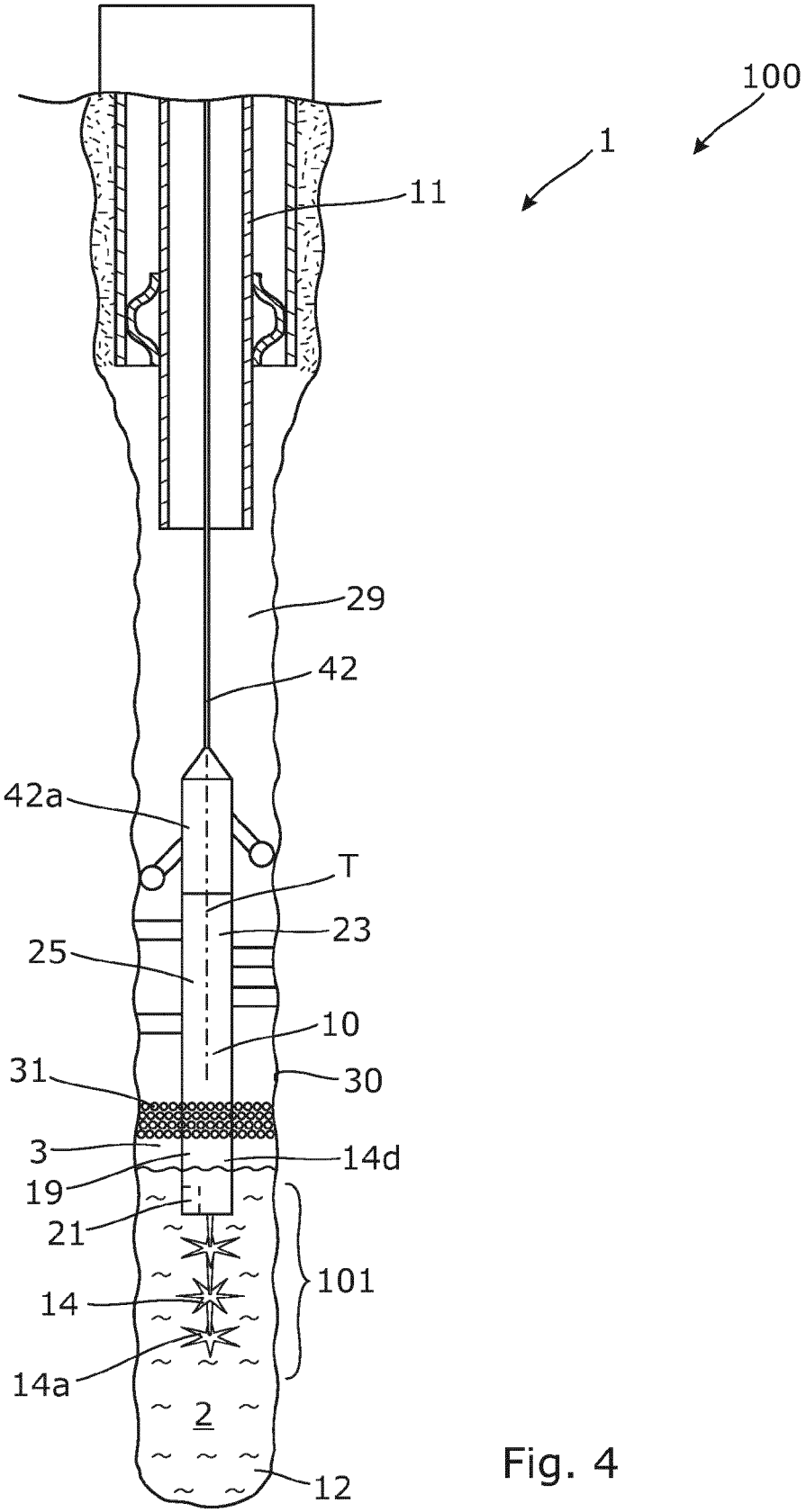

Fig. 4

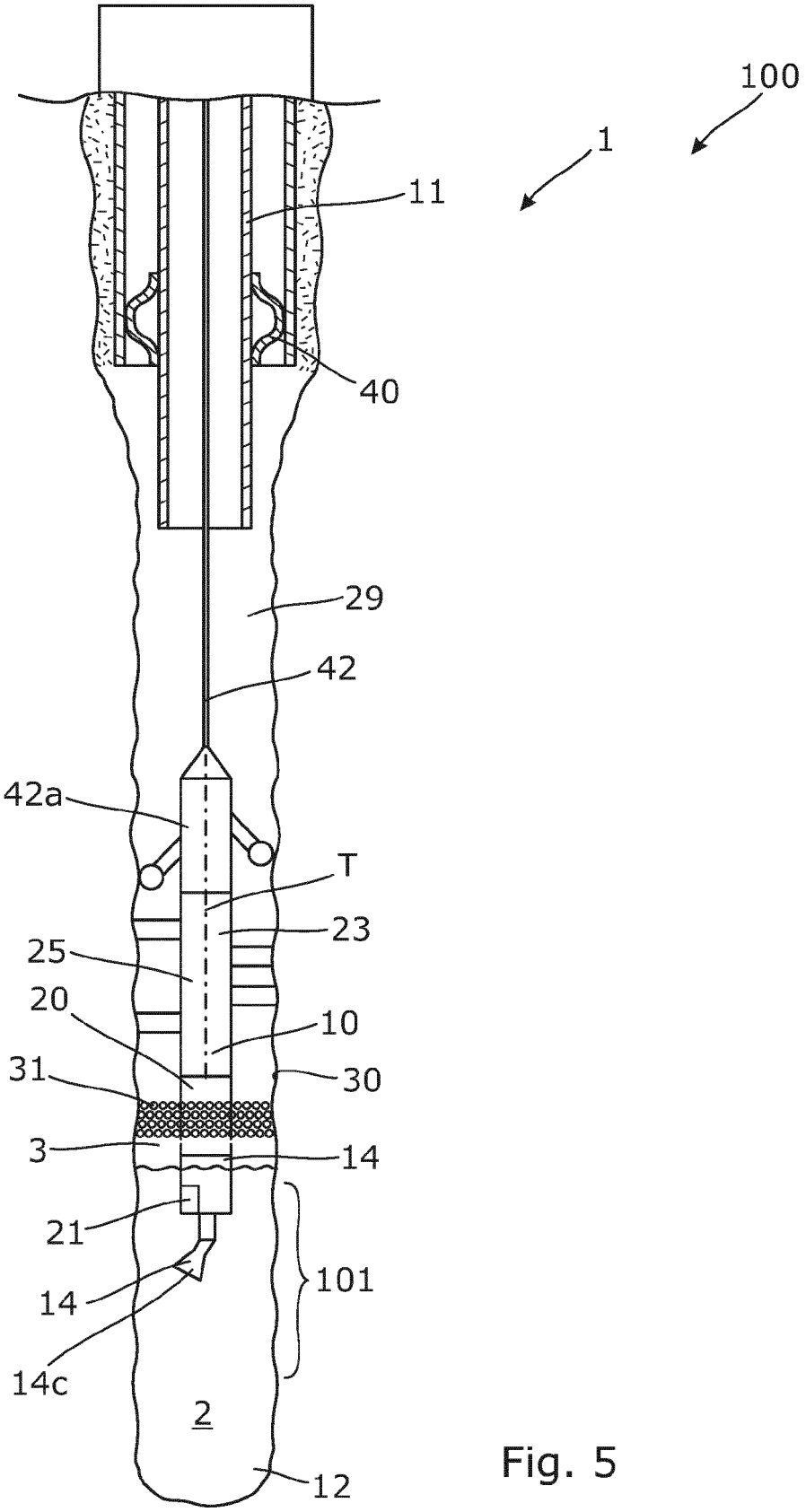

Fig. 5

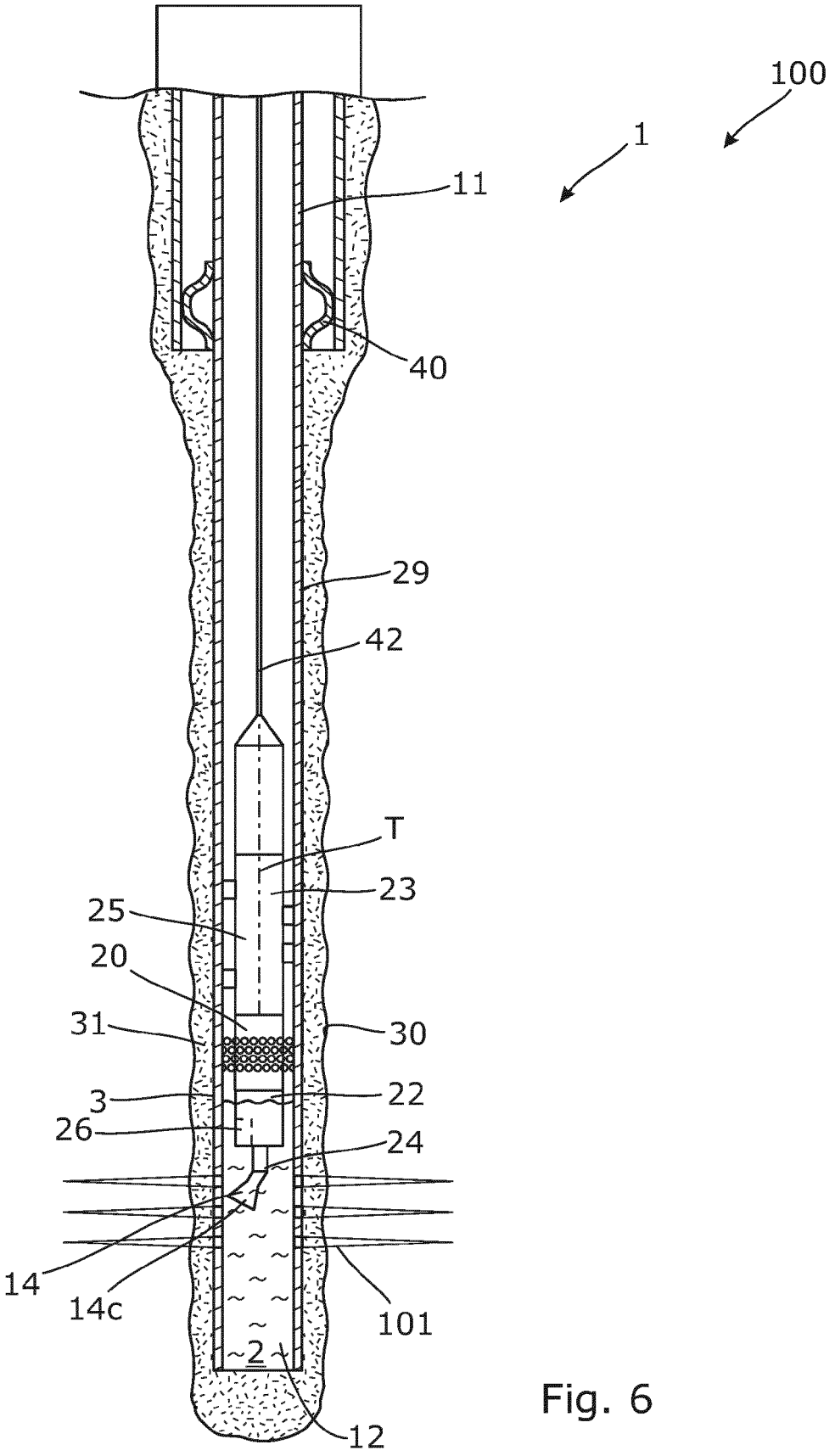

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 15 17 4090

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 2012/073820 A1 (RANKIN E EDWARD [US]) 29 March 2012 (2012-03-29) * paragraph [0002] * * paragraph [0006] * * paragraph [0029] - paragraph [0030] * * paragraph [0018] * * figures 1,3 *	1-12,14, 15	INV. E21B43/12
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A	* paragraph [0023] - paragraph [0025]; figures *	1-8, 11-15	
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TECHNICAL FIELDS SEARCHED (IPC)

E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	10 September 2015	Pieper, Fabian

CATEGORY OF CITED DOCUMENTS

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10-09-2015

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