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DESCRIPTION

Description

[0001] The present invention relates to a workover tool string for cutting into a production tubing of a well completion having a top, the well completion comprising a casing into which the production tubing is arranged and a production packer arranged between the casing and the production tubing, defining an annulus above the production packer. The invention also relates to a downhole system and to a repairing method.

[0002] US 2018/0087352 A1 and EP 3 085 882 A1 disclose known workover apparatuses and methods.

[0003] As the reservoir in a hydrocarbon-producing well depletes, attempts to optimise the well completion is performed in order to recover more of the remaining hydrocarbon-containing fluid from the reservoir.

[0004] One way is to insert gas lift valves in the upper part of the well completion by replacing the production tubing with a new production tubing having gas lift valves in the top of the tubing. Another way is to insert a velocity string into the production tubing. Both ways are performed by heavy, expensive equipment, such as a drill rig, and after the oil prices have dropped, there is a need for a less expensive way to optimise the wells.

[0005] It is an object of the present invention to wholly or partly overcome the above disadvantages and drawbacks of the prior art. More specifically, it is an object to provide an improved downhole system for increasing the hydrocarbon production which is less expensive than the known system while not jeopardising the safety of the well.

[0006] The above objects, together with numerous other objects, advantages and features, which will become evident from the below description, are accomplished by a solution in accordance with the present invention as defined in claim 1, i.e. by a workover tool string for cutting into a production tubing of a well completion having a top, the well completion comprising a casing into which the production tubing is arranged and a production packer arranged between the casing and the production tubing, defining an annulus above the production packer, the workover tool string comprising:

- a longitudinal axis,
- a first tool string end and a second tool string end, the first tool string end being arranged closer to the top when submerged into the well completion,
- a tubing cutting unit comprising a body, a first unit part, a second unit part and a cutting edge configured to be rotated around the longitudinal axis while being projected in

relation to the body for cutting into a wall of the production tubing from within in order to separate a first part of the production tubing closest to the top from a second part of the production tubing,

wherein the workover tool string further comprises a tubing penetration unit comprising a projectable penetration element configured to create at least one hole in the wall of the first part for creating fluid communication between the annulus and an inside of the production tubing in order to obtain well control by circulating fluid therebetween, the penetration unit being arranged closer to the first tool string end than the tubing cutting unit, and wherein

the workover tool further comprises a deployment tool for setting a plug inside in the second part of the production tubing, the deployment tool being arranged connected to the tubing cutting unit in order that the tubing cutting unit is arranged between the tubing penetration unit and the deployment tool, and the workover tool string comprising a swirl connection between the second unit part of the tubing cutting unit and the deployment tool.

[0007] By having a tubing penetration unit comprising a projectable penetration element and a tubing cutting unit in one workover tool string, the production tubing can be cut and an equalising hole made in one run. And by having the hole, fluid, such as heavy fluid, can be circulated through the hole between the annulus and the inside of the production tubing, and the well is in control during the replacement process, and the main part of the replacement operation can be performed by an intervention/workover tool string, and a substantial amount of drill rig time is saved, which reduces the cost significantly without jeopardising the safety of the well. In this way, the first part of the production tubing can be replaced with a replacement production tubing having gas lift valves, and a gas lift can be initiated to recover more oil from the reservoir.

[0008] The workover tool string may be a chargeless workover tool string, i.e. a workover tool string without charges.

[0009] Furthermore, by having a chargeless workover tool string, a safer way of replacing a first part of the production tubing is provided. In the oil industry, safety is of increasing importance, both due to safety for the personal but also for avoiding oil spill.

[0010] The workover tool string as described above further comprises a deployment tool for setting a plug inside in the second part of the production tubing, the deployment tool being arranged connected to the tubing cutting unit in order that the tubing cutting unit is arranged between the tubing penetration unit and the deployment tool.

[0011] When abandoning a well, the well is to be plugged and as much as possible of the completion pulled out of the well for creating a safe plug and abandonment (P&A). By having a deployment tool as part of and in front of the workover tool string, all the operations of setting the plug, drilling a hole for circulating fluid for maintaining well control, and cutting the

production casing for pulling the first part out of the well can be made in one run. Thus, the main part of the P&A operation can be performed by an intervention/workover tool string, and a substantial amount of drill rig time is saved, which reduces the cost significantly without jeopardising the safety of the well.

[0012] Furthermore, the deployment tool may be configured for setting and releasing a plug downhole.

[0013] Also, the deployment tool may function as an anchoring tool by means of the plug.

[0014] The workover tool string as described above may further comprise the plug forming the second tool string end when running the tool into the production tubing.

[0015] Moreover, the tubing cutting unit may comprise a cutting arm having a first arm end pivotably connected with the body and a second arm end having the cutting edge.

[0016] In addition, the tubing cutting unit comprises a first unit part and a second unit part arranged closest to a top of the well, the second unit part may have the cutting arm, and the second unit part may be rotatably connected with the first unit part.

[0017] Also, the workover tool string comprises a swirl connection between the second unit part of the tubing cutting unit and the deployment tool.

[0018] The projectable penetration element may comprise a drilling bit or a punching part.

[0019] Furthermore, the tubing penetration unit may rotate the projectable penetration element for providing the at least one hole.

[0020] Additionally, the projectable penetration element may comprise a drilling bit, and the tubing penetration unit may rotate the drilling bit.

[0021] The tubing penetration unit may be arranged above the tubing cutting unit so that the tubing penetration unit is closer to the top of the well.

[0022] Furthermore, the tubing penetration unit may be arranged above the tubing cutting unit at a predetermined distance.

[0023] In addition, the tubing penetration unit may comprise a motor and gears for rotating the projectable penetration element.

[0024] Furthermore, the projectable penetration element may have a projected position and a retracted position.

[0025] Moreover, the tubing penetration unit may comprise a hydraulic cylinder with a piston to

project the projectable penetration element and a spring for retracting the projectable penetration element, the spring being compressed by the piston when projecting the projectable penetration element. The projectable penetration element may form part of the piston.

[0026] The workover tool string as described above may further comprise a wireline so that the workover tool string is a wireline workover tool string.

[0027] The workover tool string as described above is not part of the permanent structure in the well, i.e. not part of the completion, and thus the workover tool string as described above is an intervention workover tool string.

[0028] Moreover, the workover tool string as described above may further comprise a logging unit for detecting a position of the tool string.

[0029] The present invention also relates to a downhole system comprising:

- a borehole,
- a casing arranged in the borehole,
- a production tubing arranged at least partly within the casing,
- a production packer arranged between the casing and the production tubing, defining an annulus above the production packer, and
- a workover tool as described above configured to be arranged inside the production tubing.

[0030] Also, the cutting edge of the tubing cutting unit may be arranged opposite or above the production packer.

[0031] Additionally, the tool string may comprise a driving unit/downhole tractor.

[0032] The workover tool string further comprises a deployment tool for setting a plug inside in the second part of the production tubing, the deployment tool being arranged connected to the tubing cutting unit so that the tubing cutting unit is arranged between the tubing penetration unit and the deployment tool.

[0033] Furthermore, the workover tool string may further comprise the plug.

[0034] The downhole system as described above may further comprise a pumping unit configured to circulate heavy fluid down the annulus through the at least one hole into the production tubing.

[0035] Furthermore, the downhole system as described above may further comprise equipment configured to pull the first part of the production tubing out of the borehole and/or

configured to insert a replacement production tubing for replacing the first part.

[0036] Also, the equipment may be configured to pull the production packer out.

[0037] Moreover, the replacement production tubing may comprise a production tubing packer.

[0038] In addition, the production tubing packer may comprise an expandable sleeve.

[0039] Also, the downhole system may be used for plug and abandonment so that after having retrieved the first part of the production tubing, cement is provided on top of the plug.

[0040] The present invention also relates to a repairing method for repairing a well completion having a top, the well completion comprising a casing into which a production tubing is arranged and a production packer arranged between the casing and the production tubing, defining an annulus above the production packer, the workover tool string comprising the cutting edge configured to be rotated around the longitudinal axis while being projected in relation to the body for cutting into a wall of the production tubing from within in order to separate a first part of the production tubing closest to the top from a second part of the production tubing, the repairing method comprising:

- arranging a workover tool string as described above in the production tubing, the workover tool string comprising the cutting edge configured to be rotated around the longitudinal axis while being projected in relation to the body for cutting into a wall of the production tubing from within in order to separate a first part of the production tubing closest to the top from a second part of the production tubing,
- providing at least one hole above the production packer in the first part by means of the tubing penetration unit,
- circulating heavy fluid through the at least one hole,
- cutting in the wall of the production tubing above a plug arranged inside the second part of the production tubing, dividing the first part and the second part of the production tubing,
- pulling the tool string out of the production tubing, and
- pulling the first part of the production tubing out of the casing.

[0041] Furthermore, the plug may be set inside in the second part of the production tubing by a deployment unit, the deployment tool being arranged connected to the tubing cutting unit so that the tubing cutting unit is arranged between the tubing penetration unit and the deployment tool.

[0042] The present invention also relates to an abandonment method for abandoning a well completion having a top, the well completion comprising a casing into which a production tubing is arranged and a production packer arranged between the casing and the production tubing, defining an annulus above the production packer, the workover tool string comprising

the cutting edge configured to be rotated around the longitudinal axis while being projected in relation to the body for cutting into a wall of the production tubing from within in order to separate a first part of the production tubing closest to the top from a second part of the production tubing, the abandonment method comprising:

- arranging a workover tool string as described above in the production tubing, the workover tool string comprising the cutting edge configured to be rotated around the longitudinal axis while being projected in relation to the body for cutting into a wall of the production tubing from within in order to separate a first part of the production tubing closest to the top from a second part of the production tubing,
- providing at least one hole above the production packer in the first part by means of the penetration unit,
- circulating heavy fluid through the at least one hole,
- cutting in the wall of the production tubing above a plug arranged inside the second part of the production tubing, dividing the first part and the second part of the production tubing,
- pulling the tool string out of the production tubing,
- pulling the first part of the production tubing out of the casing, and
- providing cement above the plug.

[0043] Finally, pulling the first part of the production tubing out of the casing and providing cement above the plug may be performed simultaneously.

[0044] 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 partly cross-sectional view of a workover tool string in a well completion,

Fig. 2 shows a partly cross-sectional view of the well completion of Fig. 1, where the production tubing has been separated into a first part and a second part, and the tool string has been withdrawn,

Fig. 3 shows a partly cross-sectional view of the well completion of Fig. 2, wherein a replacement production tubing for replacing the first part has been inserted,

Fig. 4 shows a partly cross-sectional view of another well completion in which the workover tool string has a deployment tool and a plug,

Fig. 5 shows a view of another workover tool string having a deployment tool and a plug, and

Fig. 6 shows a view of another workover tool string having a driving unit, such as a downhole tractor, and a logging unit.

[0045] 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.

[0046] Fig. 1 shows a workover tool string 1 which is configured to cut into a production tubing 2 of a well completion 100. The well completion 100 comprises a casing 4 into which the production tubing is arranged so that the production tubing extends partly below the casing. A production packer 5 is arranged between the casing and the production tubing defining an annulus 6 above the production packer and thus extending towards a top 3 of the well completion. The workover tool string is configured to cut into the production tubing 2 for dividing the production tubing 2 into a first part 15 closest to the top and a second part 16 in order that the first part can be pulled out of the well, and a replacement production tubing can be inserted for replacing the first part. The workover tool string comprises a first tool string end 8 and a second tool string end 9. The first tool string end is arranged closer to the top when suspended from the top by a wireline into the well completion. The workover tool string 1 further comprises a tubing cutting unit 10 comprising a body 11 and a cutting edge 12 configured to be rotated around a longitudinal axis 7 of the tool string while being projected in relation to the body for cutting into a wall 14 of the production tubing from within in order to separate the first part 15 from the second part 16 of the production tubing. The workover tool string 1 further comprises a tubing penetration unit 20 comprising a projectable penetration element 21 configured to create at least one hole 22 in the wall of the first part for creating fluid communication between the annulus and an inside 23 of the production tubing in order to obtain well control by circulating fluid therebetween. The penetration unit 20 is arranged closer to the first tool string end 8 than to the tubing cutting unit 10, and the penetration unit 20 is arranged adjacent the tubing cutting unit so that the holes are made in the first part 15 and not in the second part 16 which stays in the well so that heavy fluid can be circulated to replace the fluid just above the production packer to obtain well control before cutting into the production tubing.

[0047] By being able to circulate fluid, such as heavy fluid, between the annulus and the inside of the production tubing, the main part of the replacement operation can be performed by an intervention tool string, and a lot of drill rig time is saved, which reduces the cost significantly without jeopardising the safety of the well. In this way, the first part of the production tubing can be replaced with a replacement production tubing having gas lift valves 85 (shown in Fig. 3), and a gas lift can be initiated to recover more oil from the reservoir.

[0048] The plug 18 shown in Fig. 4 may be set by the workover tool string in that the string may comprise a deployment tool 17 for setting the plug 18 inside in the second part of the production tubing. The deployment tool 17 is arranged connected to the tubing cutting unit so that the tubing cutting unit is arranged between the tubing penetration unit and the deployment tool. The plug thus forms the second tool string end when running the tool into the production tubing. The plug 18 of Fig. 1 may also be provided in the second part of the production tubing in a previous operation.

[0049] In Fig. 1, the projectable penetration element 21 of the tubing penetration unit 20 is making a hole 22 in the wall of the production tubing, and subsequently fluid can be circulated to maintain well control before the cutting edge 12 of the tubing cutting unit 10 cuts into the production tubing. In Fig. 2, the tubing cutting unit has cut into the production tubing, separating the first part from the second part, and subsequently the tool string has been withdrawn in order that the first part can be pulled out of the well, and a replacement production tubing 60 having a production tubing packer 61 can be inserted, as shown in Fig. 3. As can be seen in Fig. 3, the production tubing packer 61 has an expandable metal sleeve 62 surrounding a tubular metal part 63 mounted as part of the replacement production tubing 60. The expandable metal sleeve 62 is permanently deformed by letting fluid into an annular space between the expandable metal sleeve and the tubular metal part 63 through an opening in the tubular metal part. The annular barrier may have a valve system in fluid communication with the opening and the annular space, e.g. for in a first position to allow fluid from the opening into the annular space, and in a second position closing off the opening or the fluid communication between the opening and the annular space. The valve system may in the second position allow fluid communication between the annular space and the annulus to pressure-equalise therebetween.

[0050] Even though not shown, the replacement production tubing may have a smaller inner diameter than that of the first part of the production tubing. By having a smaller inner diameter, the replacement production tubing reduces the flow area and increases the flow velocity to enable liquids to be carried from the wellbore/reservoir.

[0051] In Fig. 4, the workover tool string further comprises a deployment tool 17, which is configured for setting and releasing the plug 18 downhole. The releasing of the plug may be performed before the workover tool string moves upwards for providing the hole and subsequently cuts the production tubing into a first part and a second part. In this way, the plug can be arranged far down the production tubing away from the production packer even just above e.g. a liner hanger 81. The releasing of the plug may also be performed in a second operation, also called a second run, if the workover tool string is connected to the top of the well by means of a wireline 40 since the pulling of the first part of the production tubing hinders a wireline workover tool string from remaining in the well and performing the release of the plug after pulling the first part. If the workover tool string is wireless, the workover tool string may remain in the well while replacing the first part of the production tubing with the replacement production tubing, and subsequently the workover tool string may release the plug before the workover tool string is retrieved from the well, and thereby also performs the release of the plug in the same first run.

[0052] The deployment tool may function as an anchoring tool by means of the plug so that the deployment tool does not release from the plug while the tubing penetration unit makes at least one hole and while the tubing cutting unit cuts into the production tubing.

[0053] The tubing cutting unit of Fig. 5 comprises a cutting arm 24 having a first arm end 25 pivotably connected with the body 11 and a second arm end 26 comprising the cutting edge

which, when the cutting arm is projected radially, contacts the wall. The tubing cutting unit comprises a first unit part 31 and a second unit part 32. The second unit part 32 comprises the cutting arm 24 and is rotatably connected with the first unit part so that the second unit part rotates the cutting arm and the cutting edge in relation to the rest of the body 11. Thus, the tubing cutting unit comprises a motor for rotating the first unit part in relation to the second unit part, and the tubing cutting unit comprises a hydraulic cylinder for moving the cutting arm 24 between a retracted and a projected position around the pivot point in the body.

[0054] In Fig. 5, the workover tool string 1 may comprise a swirl connection 33 between the second unit part 32 of the tubing cutting unit 10 and the deployment tool 17 so that the second unit part can rotate while the deployment tool has set the plug and is still connected thereto.

[0055] In Fig. 5, the projectable penetration element comprises a drilling bit 34 which makes the holes by rotating the bit and drilling through the wall of the production tubing. In addition, the tubing penetration unit 20 comprises a motor 38 and gears 41 for rotating the projectable penetration element 21. Furthermore, the projectable penetration element has a projected position and a retracted position. The tubing penetration unit comprises a hydraulic cylinder 37 with a piston 39 to project the projectable penetration element and a spring 42 for retracting the projectable penetration element. The spring is compressed by the piston when the piston moves and projects the projectable penetration element. The projectable penetration element forms a first part of the piston so that a first part of the piston projects from the hydraulic cylinder and a second part of the piston remains in the hydraulic cylinder. Thus, the hole is made without explosives, and the workover tool string is thus an explosive-free workover tool string or a chargeless workover tool string.

[0056] In Fig. 6, the projectable penetration element comprises a punching part 35 which makes the holes by being forced through the wall of the production tubing. The punching part has a projected position and a retracted position, and a hydraulic cylinder is moving the punching part between the retracted and projected position. Thus the production tubing is separated without explosives, and the workover tool string is thus an explosive-free workover tool string or a chargeless workover tool string.

[0057] By having the cutting unit and the penetration unit in one workover tool string and the penetration unit arranged at a predetermined distance d (shown in Fig. 1) above the cutting unit, the hole is made safely above the cut/separation line, i.e. the cut/line where the first part is separated from the second part of the production tubing. The tool string can be rigged-up so that the hole is made at the predetermined distance from the separation line.

[0058] The workover tool string further comprises a logging unit 36 for detecting a position of the tool string, as shown in Fig. 5. In this way, the workover tool string can detect the position of the production packer, etc., more precisely before performing the operations in order that the workover tool string does not cut into the production packer unintentionally.

[0059] In some well completions, it is possible to also cut into the production packer and

retrieve the production packer while pulling out the first part of the production tubing. Then the cutting edge of the tubing cutting unit is arranged opposite or above the production packer.

[0060] The logging unit 36 may be a tool using magnets and/or magnetometers in order to detect the separate elements in the well completion to detect a specific position.

[0061] The downhole system 200 shown in Fig. 1 comprises a borehole 28, a casing 4 arranged in the borehole, a production tubing 2 arranged at least partly within the casing and a production packer 5 arranged between the casing and the production tubing, defining an annulus 6 above the production packer as described above. The downhole system further comprises the workover tool string 1 configured to be arranged inside the production tubing for dividing the production tubing into a first part 15 and a second part 16 in order to retrieve the first part and replace it. Before cutting into the production tubing 2, the tubing penetration unit 20 provides at least one hole 22. The downhole system 200 further comprises a pumping unit 52 configured to circulate heavy fluid down the annulus 6 through the at least one hole 22 into the production tubing 2 before the first part is retrieved. The pump is arranged in the top at the surface or the seabed.

[0062] The downhole system further comprises an equipment 53 configured to pull at least the first part of the production tubing out of the borehole 28 and/or to insert a replacement production tubing for replacing the first part. The equipment 53 is also configured to pull the production packer out if needed, and if the production packer is suitable for being released by cutting into the packer.

[0063] The downhole system may also be used for plug and abandonment so that after having retrieved the first part of the production tubing, cement is provided on top of the plug.

[0064] As shown in Fig. 3, the well completion may comprise a liner 82 hung off in a liner hanger 81. The liner comprises an annular barrier 70 which has an expandable metal sleeve 71 surrounding a tubular metal part 73 mounted as part of the liner 82. The expandable metal sleeve 71 is permanently deformed by letting fluid into an annular space 72 between the expandable metal sleeve 71 and the tubular metal part 73, e.g. through an opening 75 in the tubular metal part 73. The expandable metal sleeve 71 is connected at its ends 74 with the tubular metal part 73.

[0065] The well completion is thus repaired by arranging the workover tool string in the production tubing, providing at least one hole above the production packer in the first part by means of the tubing penetration unit, circulating heavy fluid through the at least one hole, cutting in the wall of the production tubing above the plug arranged inside the second part of the production tubing, pulling the tool string out of the production tubing, and pulling the first part of the production tubing out of the casing.

[0066] Thus, by arranging the workover tool string in the production tubing, the downhole system provides at least one hole above the production packer in the first part by means of the

penetration unit, circulating heavy fluid through the at least one hole, cutting in the wall of the production tubing above a plug arranged inside the second part of the production tubing, dividing the first part and the second part of the production tubing, pulling the tool string out of the production tubing, pulling the first part of the production tubing out of the casing, and providing cement above the plug. The pulling of the first part of the production tubing out of the casing and providing cement above the plug may be performed simultaneously.

[0067] 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.

[0068] By a casing, production tubing, replacement production tubing, liner or well tubular metal structure is meant any kind of pipe, tubing, tubular, liner, string etc. used downhole in relation to oil or natural gas production.

[0069] In the event that the workover tool string is not submersible all the way into the production tubing/casing, a driving unit 51, such as 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 54 having wheels 55, 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[®].

[0070] Although the invention has been described above in connection with preferred embodiments of the invention, it will be evident to a person skilled in the art that several modifications are conceivable without departing from the invention as defined by the following claims.

REFERENCES CITED IN THE DESCRIPTION

Cited references

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Patent documents cited in the description

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Patentkrav

1. Bearbejdningsværktøjsstreng (1) til skæring ind i et produktionsrør (2) af en brøndkomplettering (100), der har en top (3), hvilken brøndkomplettering
- 5 omfatter et foringsrør (4), i hvilket produktionsrøret er anbragt, og en produktionspakning (5), der er anbragt mellem foringsrøret og produktionsrøret, definerende et ringvolumen (6) over produktionspakningen, idet bearbejdningsværktøjsstrengen omfatter:
- en langsgående akse (7),
 - 10 - en første værktøjsstrengsende (8) og en anden værktøjsstrengsende (9), idet den første værktøjsstrengsende er anbragt tættere på toppen, når den er nedsænket i brøndkompletteringen,
 - en rørsøkæreenhed (10), der omfatter et legeme (11), en første enhedsdel (31), en anden enhedsdel (32) og en skærekant (12), som er indrettet til at blive roteret
 - 15 omkring den langsgående akse, mens den fremskydes i forhold til legemet til skæring ind i en væg (14) af produktionsrøret indefra med henblik på at adskille en første del (15) af produktionsrøret tættest på toppen fra en anden del (16) af produktionsrøret,
 - hvor bearbejdningsværktøjsstrengen endvidere omfatter en rørpenetrations-
 - 20 enhed (20), der omfatter et fremskydeligt penetrationselement (21), som er indrettet til at skabe mindst ét hul (22) i den første dels væg for at skabe fluidforbindelse mellem ringvolumenet og en inderside (23) af produktionsrøret med henblik på at opnå brøndkontrol ved at cirkulere fluid derimellem, idet penetrationsenheden er anbragt tættere på den første værktøjsstrengsende end
 - 25 rørsøkæreenheden,
 - hvor bearbejdningsværktøjsstrengen endvidere omfatter et implementeringsværktøj (17) til indføring af en prop (18) inde i den anden del af produktionsrøret, hvilket implementeringsværktøj er anbragt forbundet med rørsøkæreenheden, således at rørsøkæreenheden er anbragt mellem rørpenetrationsenheden og
 - 30 implementeringsværktøjet, og bearbejdningsværktøjsstrengen omfatter en hvirvelforbindelse (33) mellem den anden enhedsdel (32) af rørsøkæreenheden (10) og implementeringsværktøjet (17).
2. Bearbejdningsværktøjsstreng ifølge krav 1, der endvidere omfatter den prop,
- 35 som udgør den anden værktøjsstrengsende, når værktøjet indføres i produktionsrøret.

3. Bearbejdningsværktøjsstreng ifølge et hvilket som helst af de foregående krav, hvor rørskæreenheden omfatter en skærearm (24), der har en første armende (25), som er drejeligt forbundet med legemet, og en anden armende (26), der har skærekanten.

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4. Bearbejdningsværktøjsstreng ifølge et hvilket som helst af de foregående krav, hvor den anden enhedsdel har skærearmen, og den anden enhedsdel er roterbart forbundet med den første enhedsdel.

10 5. Bearbejdningsværktøjsstreng ifølge et hvilket som helst af de foregående krav, hvor det fremskydelige penetrationselement omfatter en borebit (34) eller en stansedel (35).

15 6. Bearbejdningsværktøjsstreng ifølge et hvilket som helst af de foregående krav, hvor rørpenetrationsenheden roterer det fremskydelige penetrationselement til tilvejebringelse af det mindst ene hul.

20 7. Bearbejdningsværktøjsstreng ifølge et hvilket som helst af de foregående krav, der endvidere omfatter en ledningsforbindelse (40), således at bearbejdningsværktøjsstrengen er en ledningsforbundet bearbejdningsværktøjsstreng.

25 8. Bearbejdningsværktøjsstreng ifølge et hvilket som helst af de foregående krav, der endvidere omfatter en logningsenhed (36) til detektering af en position af værktøjsstrengen.

9. Brøndsystem (200), der omfatter:

- et borehul (28),

- et foringsrør (4), der er anbragt i borehullet,

30 - et produktionsrør (2), der er anbragt i det mindste delvist inde i foringsrøret,

- en produktionspakning (5), der er anbragt mellem foringsrøret og produktionsrøret, definerende et ringvolumen (6) over produktionspakningen, og

- en bearbejdningsværktøjsstreng (1) ifølge et hvilket som helst af krav 1-8, der er indrettet til at blive anbragt inde i produktionsrøret.

35

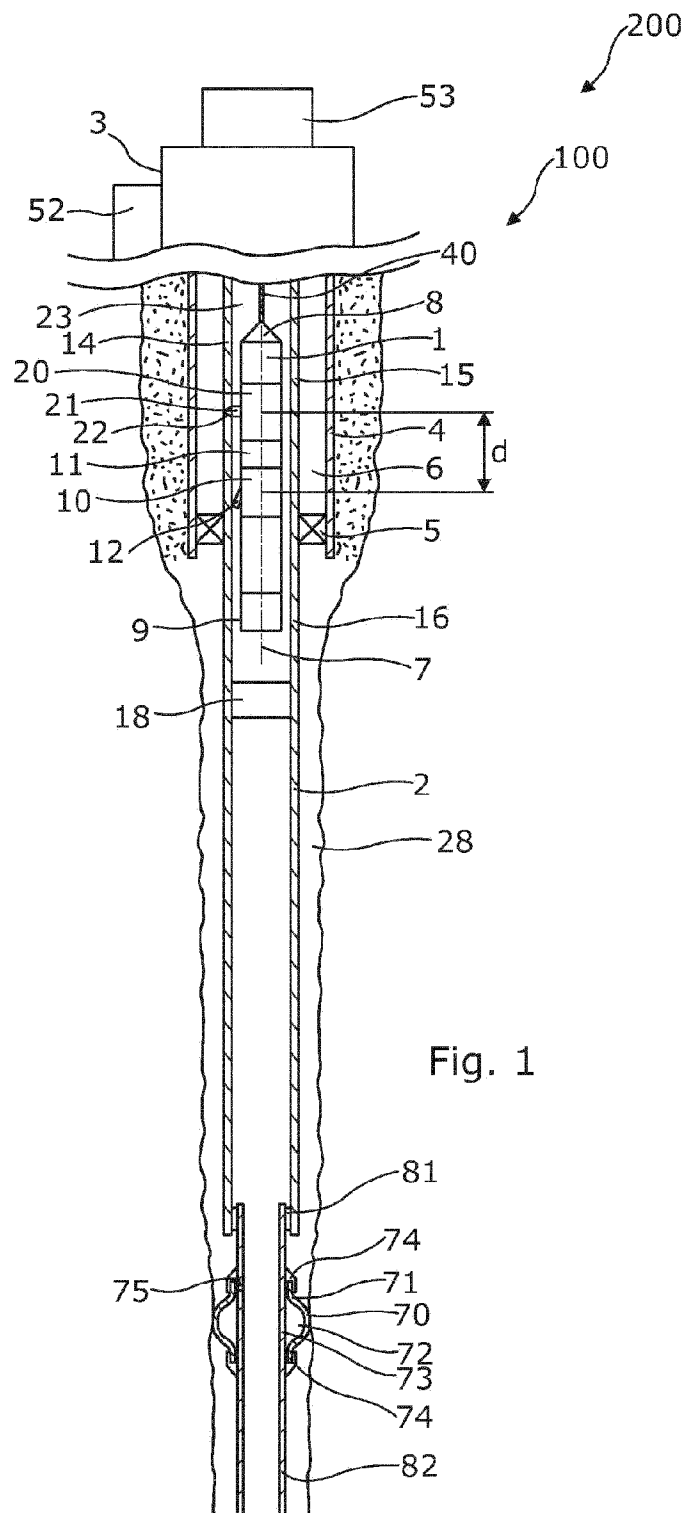
10. Brøndsysteem ifølge krav 9, der endvidere omfatter en pumpeenhed (52), som er indrettet til at cirkulere tungt fluid nede i ringvolumenet gennem det mindst ene hul ind i produktionsrøret.
- 5 11. Brøndsysteem ifølge et hvilket som helst af krav 9-10, der endvidere omfatter udstyr (53), som er indrettet til at trække den første del af produktionsrøret ud af borehullet og/eller indrettet til at indføre et erstatningsproduktionsrør som erstatning for den første del.
- 10 12. Brøndsysteem ifølge et hvilket som helst af krav 9-11, hvor erstatningsproduktionsrøret (60) omfatter en produktionsrørpakning (61).
13. Brøndsysteem ifølge krav 12, hvor produktionsrørpakningen omfatter et ekspanderbart rørstykke (62).
- 15 14. Reparationsfremgangsmåde til reparation af en brøndkomplettering (100), der har en top (3), hvilken brøndkomplettering omfatter et foringsrør (4), i hvilket der er anbragt et produktionsrør (2), og en produktionspakning (5), der er anbragt mellem foringsrøret og produktionsrøret, idet der defineres et ringvolumen (6) over produktionspakningen, idet bearbejdningsværktøjsstrengen omfatter skærekanten (12), der er indrettet til at blive roteret omkring den langsgående akse, mens den fremskydes i forhold til legemet til skæring ind i en væg (14) af produktionsrøret indefra med henblik på at adskille en første del (15) af produktionsrøret tættest på toppen fra en anden del (16) af produktionsrøret,
- 20 25 hvilken reparationsfremgangsmåde omfatter:
- anbringelse af en bearbejdningsværktøjsstreng (1) ifølge et hvilket som helst af krav 1-8 i produktionsrøret, hvilken bearbejdningsværktøjsstreng omfatter skærekanten (12), der er indrettet til at blive roteret omkring den langsgående akse, mens den fremskydes i forhold til legemet til skæring ind i en væg (14) af produktionsrøret indefra med henblik på at adskille en første del (15) af produktionsrøret tættest på toppen fra en anden del (16) af produktionsrøret,
 - tilvejebringelse af mindst ét hul over produktionspakningen i den første del ved hjælp af rørpenetrationsenheden,
 - cirkulering af tungt fluid gennem det mindst ene hul,
 - 35 - skæring i produktionsrørets væg over en prop, der er anbragt inde i den anden del af produktionsrøret, og hvilket opdeler produktionsrøret i den første del og den anden del,

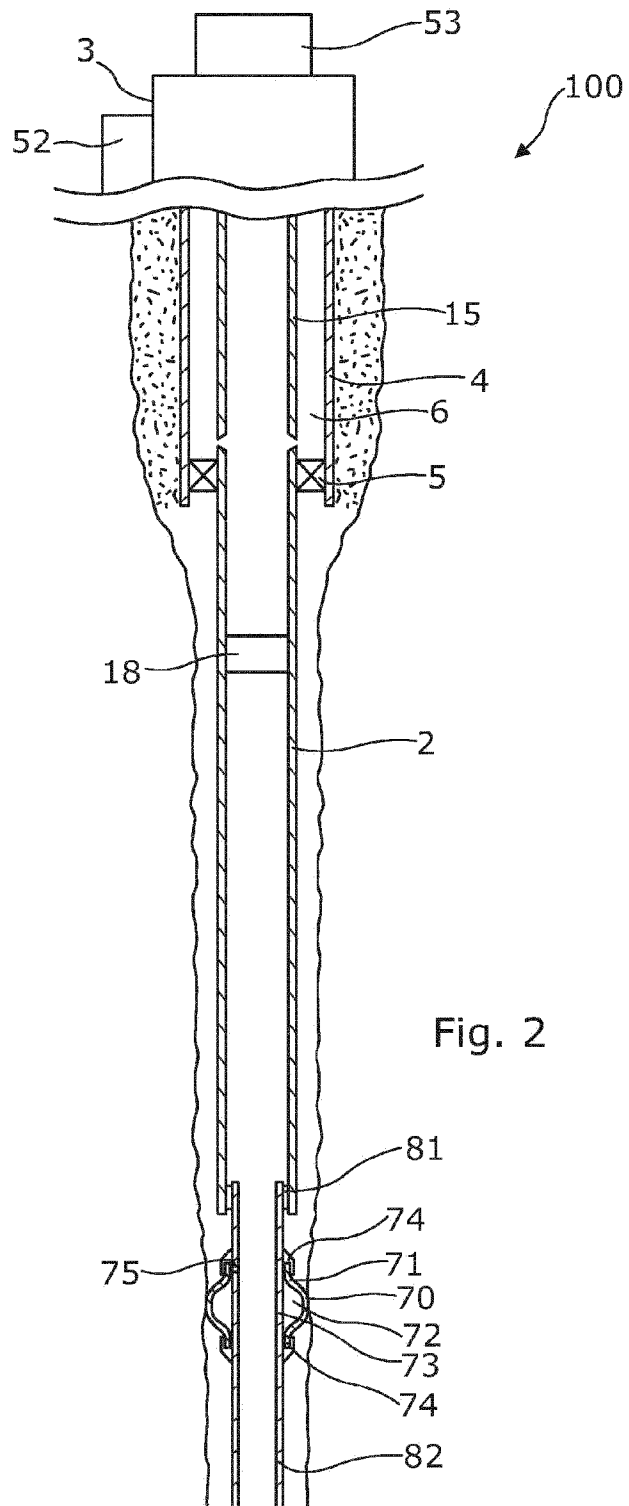
- trækning af værktøjsstrengen ud af produktionsrøret, og
- trækning af den første del af produktionsrøret ud af foringsrøret.

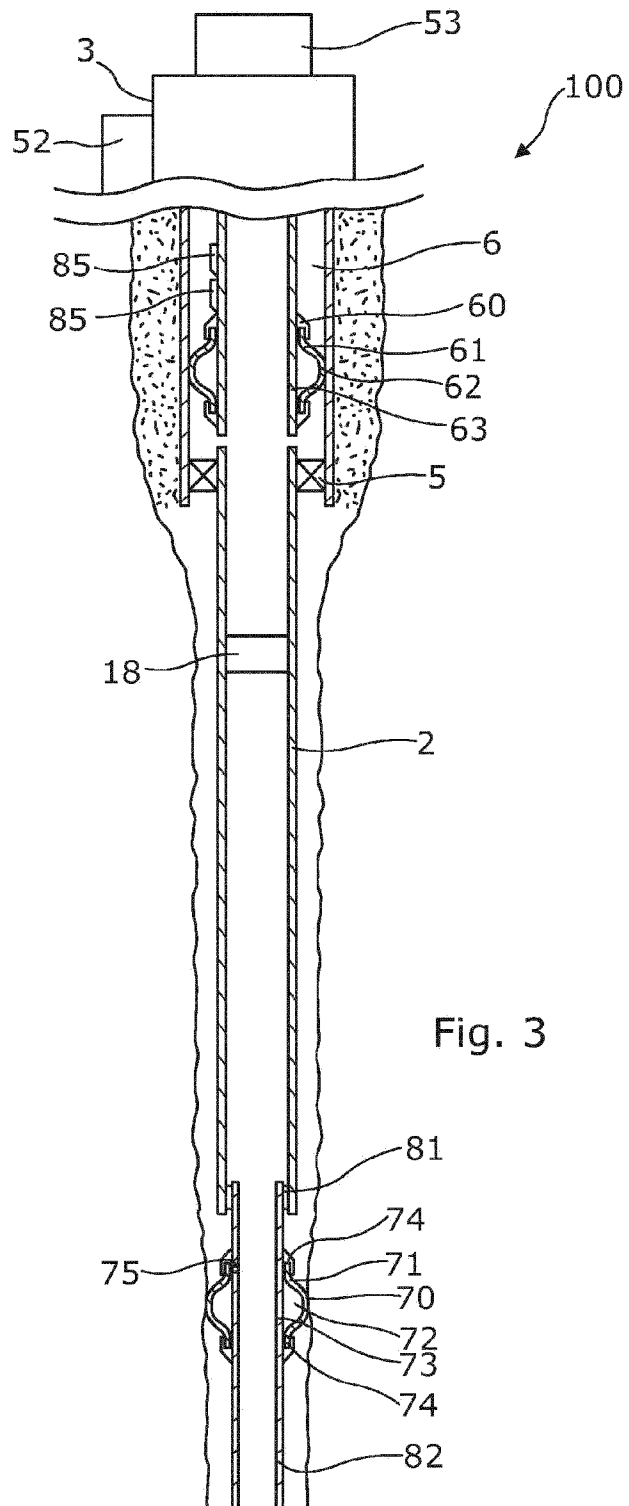
15. Sløjfningsfremgangsmåde til sløjfning af en brøndkomplettering, der har en
- 5 top, hvilken brøndkomplettering omfatter et foringsrør, i hvilket der er anbragt et produktionsrør, og en produktionspakning, der er anbragt mellem foringsrøret og produktionsrøret, idet der defineres et ringvolumen over produktionspakningen, en bearbejdningsværktøjsstreng ifølge et hvilket som helst af krav 1-8, hvilken sløjfningsfremgangsmåde omfatter:
- 10 - anbringelse af bearbejdningsværktøjsstrengen ifølge et hvilket som helst af krav 1-8 i produktionsrøret, hvilken bearbejdningsværktøjsstreng omfatter skærekanten, der er indrettet til at blive roteret omkring den langsgående akse, mens den fremskydes i forhold til legemet til skæring ind i en væg af produktionsrøret indefra med henblik på at adskille en første del af
- 15 produktionsrøret tættest på toppen fra en anden del af produktionsrøret,
- tilvejebringelse af mindst ét hul over produktionspakningen i den første del ved hjælp af penetrationsenheden,
 - cirkulering af tungt fluid gennem det mindst ene hul,
 - skæring i produktionsrørets væg over en prop, der er anbragt inde i den anden
- 20 del af produktionsrøret, og hvilket opdeler produktionsrøret i den første del og den anden del,
- trækning af værktøjsstrengen ud af produktionsrøret,
 - trækning af den første del af produktionsrøret ud af foringsrøret, og
 - tilvejebringelse af cement over proppen.

DRAWINGS

Drawing







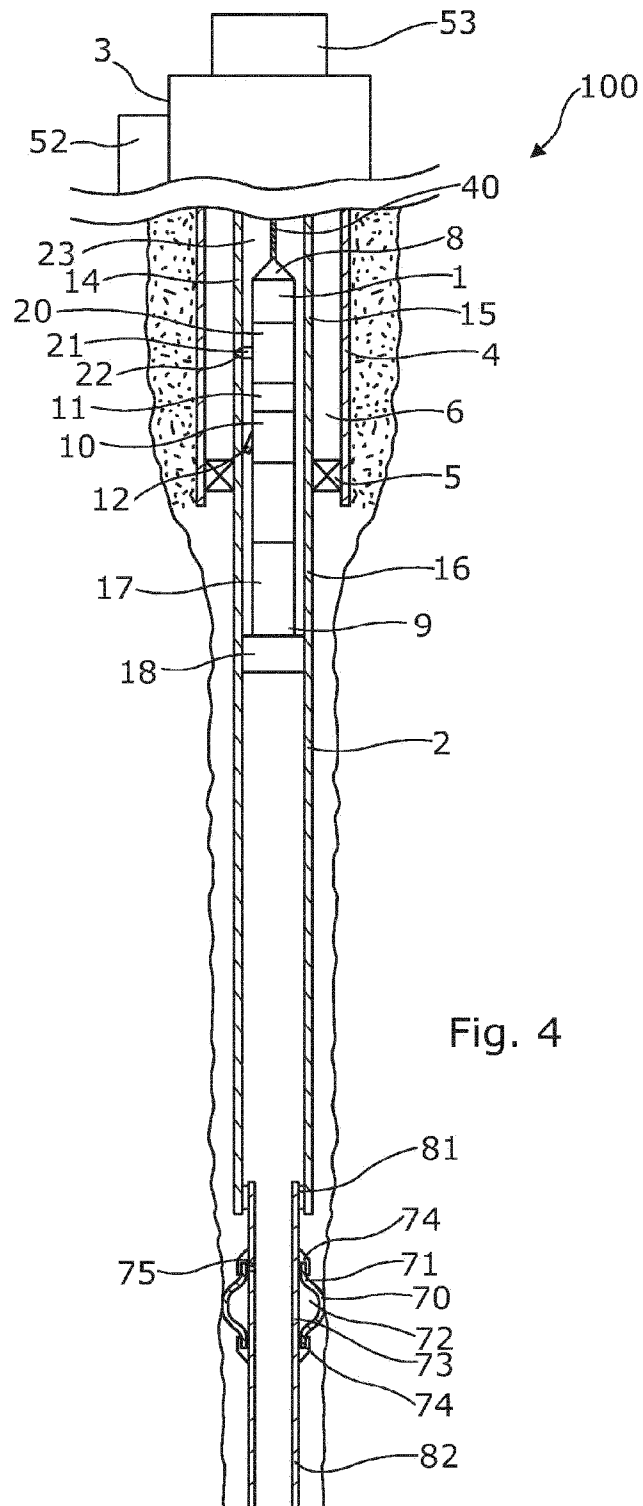


Fig. 4

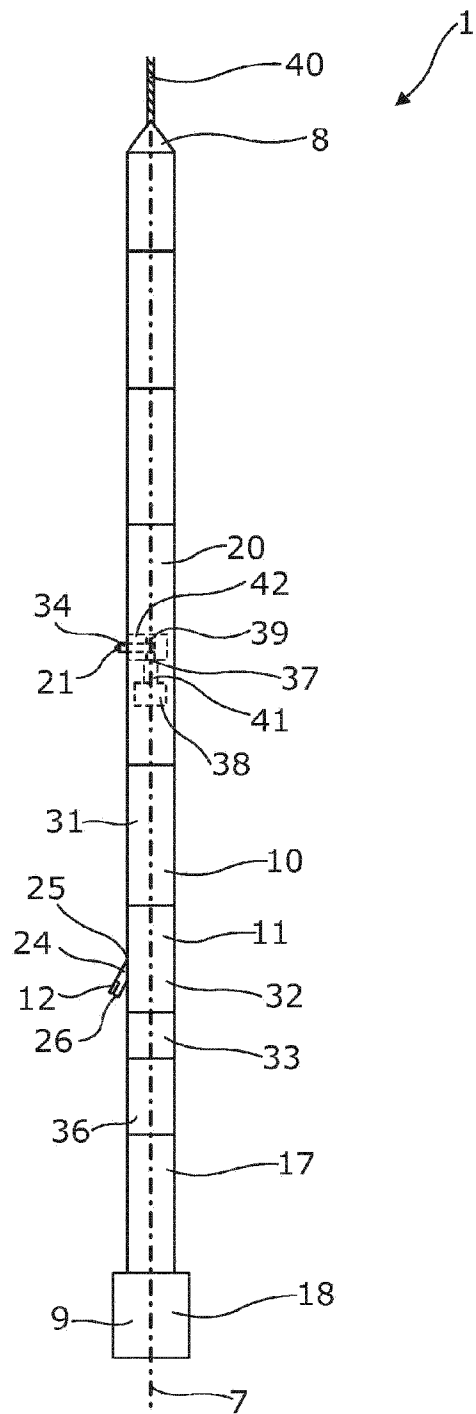


Fig. 5

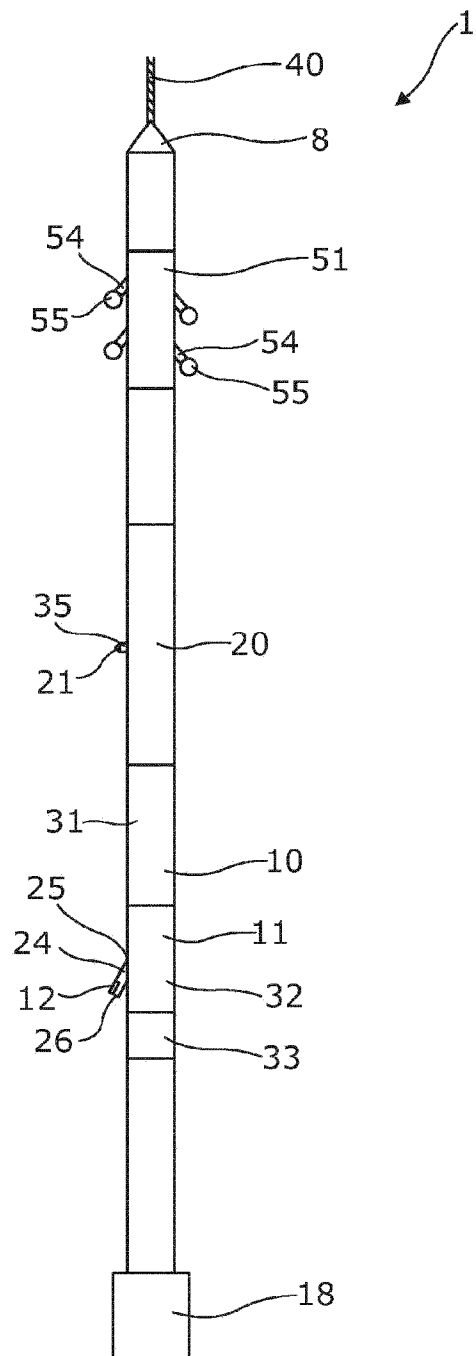


Fig. 6