(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 518 257 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
**31.10.2012 Bulletin 2012/44**

(51) Int Cl.:
***E21B 17/02*** *(2006.01)* ***E21B 17/18*** *(2006.01)*

(21) Application number: **11164298.9**

(22) Date of filing: **29.04.2011**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
**BA ME**

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

(72) Inventor: **Hallundbaek, Jørgen**
**3230 Græsted (DK)**

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

(54) **A tool string**

(57) The present invention relates to a tool string for being suspended in a well, the tool string extending in a longitudinal direction and comprising a first string part and a second string part, each having a centre axis and comprising; an electrical connection in a first end, and a fluid channel extending at least partly through the string part, a connecting element rotatably connected to one string part and adapted to be threadably connected to a threaded portion of the other string part, to join the electrical connections of the first and second string parts. Furthermore, the present invention relates to a method for assembling two string parts of a tool string by rotating a connecting element.

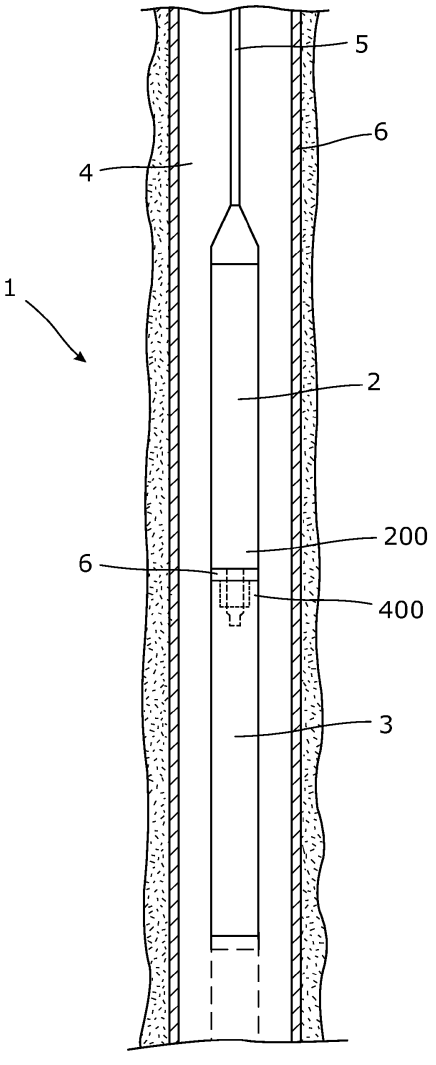


Fig. 1

EP 2 518 257 A1

## Description

### Field of the invention

**[0001]** The present invention relates to a tool string for being suspended in a well, the tool string extending in a longitudinal direction and comprising a first string part and a second string part, each having a centre axis and comprising; an electrical connection in a first end, and a fluid channel extending at least partly through the string part, a connecting element rotatably connected to one string part and adapted to be threadably connected to a threaded portion of the other string part, to join the electrical connections of the first and second string parts. Furthermore, the present invention relates to a method for assembling two string parts of a tool string by rotating the connecting element to join electrical connections of the first and second string parts and to force a pipe connection of one string part into a hole in fluid communication with a fluid channel of the other string part.

### Background art

**[0002]** The extraction rate from hydrocarbon-producing wells and the surrounding formations are becoming increasingly important due to decreasing oil reserves. Therefore, increasingly advanced tools are being developed and deployed in the search for and extraction of oil and gas. Tools deployed downhole in a well are often assembled or joined in a tool string comprising multiple tools, such as driving tools for driving the tool string forward in inclining sections of the well and/or operational tools for performing various operations downhole.

**[0003]** Various principles for joining pipe sections for use in a drill string of a casing is known from the prior art. Such pipe couplings may provide a fluid-tight coupling between pipe sections and may also comprise an electrical coupling for transferring electrical power. However, known couplings do not provide the necessary connections for connecting advanced tools and tool parts. Present downhole tools, such as a downhole tractor, require a supply of both electrical power and hydraulic fluid in order to operate. A need has therefore arisen for a coupling between different tool sting parts wherein both fluid and electrical power can be transferred. Some downhole tool may require several separate fluid channels running between different parts of the tool string. The coupling has to be robust and capable of withstanding considerable tensile forces and twisting during deployment downhole. At the same time, the coupling has to be relatively easy and fast to assemble.

### Summary of the invention

**[0004]** 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 tool string wherein electrical power and fluid(s) can be transferred from one part of the tool string to another. Further, it is an object to provide a connection between two string parts, wherein fluid channels in each of the string parts are brought into fluid communication and wiring in each of the string parts are connected.

**[0005]** 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 tool string for being suspended in a well, the tool string extending in a longitudinal direction and comprising: a first string part and a second string part, each having a centre axis and comprising; an electrical connection in a first end, and a fluid channel extending at least partly through the string part. The tool string further comprising a connecting element rotatably connected to one string part and adapted to be threadably connected to a threaded portion of the other string part, to join the electrical connections of the first and second string parts; wherein one of the string parts comprises a pipe connection extending in the longitudinal direction from the first end and into the fluid channel of the other string part, when the string parts are mutually connected by the connecting element, the pipe connection being arranged eccentrically in relation to the centre axis for preventing mutual rotation of the string parts.

**[0006]** Hereby, a connection for transferring both electrical power and fluid between two string parts of a tool string may be provided. The connection has the necessary rigidity to provide and maintain a fluid-tight seal between the fluid channels of the first and second string parts. Furthermore, the electrical wires are not twisted or bent.

**[0007]** In one embodiment, one of the string parts may comprise at least two pipe connections.

**[0008]** In another embodiment, one of the string parts may comprise a guide pin and the other string part may comprise a hole for receiving the guide pin, when the string parts are mutually connected by the connecting element.

**[0009]** Further, the connecting element may comprise two connectable collar elements adapted to be mutually connected around a section of one of the string parts.

**[0010]** Moreover, the connecting element may comprise an outer threaded portion.

**[0011]** Also, the connecting element may be arranged around a protrusion of one of the string parts having a reduced diameter compared to a maximum diameter of the string part.

**[0012]** Additionally, the connecting element may be arranged in a recess of one of the string parts, whereby the connecting element is prevented from substantially moving in the longitudinal direction.

**[0013]** Furthermore, the connecting element may be prevented from substantially moving in the longitudinal direction towards the first end, by a protruding part of the string part having an increased outer diameter.

**[0014]** Said connecting element may have an outer diameter being equal to or less than an outer diameter of the tool string.

**[0015]** Also, the connecting element may have an outer diameter being equal to or less than a minimum outer diameter of the tool string.

**[0016]** In one embodiment, the pipe connection may comprise a circumferential sealing element adapted to provide a fluid-tight seal between the pipe connection and the corresponding fluid channel into which it extends.

**[0017]** In addition, one of the string parts may comprise a circumferential sealing element adapted to provide a fluid-tight seal between the first and second string parts.

**[0018]** In one embodiment, one of the string parts may be a driving unit for propelling the tool string in the well.

**[0019]** The present invention furthermore relates to a method for assembling two string parts of a tool string, the method comprising the steps of:

- moving a first end of a first string part towards a first end of a second string pa rt,
- arranging a guide pin of one of the string parts in a hole in another string part,
- connecting a threaded portion of a connecting element rotatably connected to one of the string parts, with a threaded portion of the other string part.
- rotating the connecting element to join electrical connections of the first and second string parts and to force a pipe connection of one string part into a hole in fluid communication with a fluid channel of the other string part.

Brief description of the drawings

**[0020]** 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 tool string being suspended in a well,

Fig. 2 shows the ends of two string parts in an assembled state being connected by a connecting element,

Figs. 3a and 3b show a layout of the end faces of two string parts adapted to be assembled,

Fig. 4 shows a connecting element comprising two connectable collar elements,

Fig. 5 shows a tool string comprising a downhole tractor having wheel sections.

**[0021]** 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

**[0022]** Fig. 1 shows a tool string 1 being suspended in a well 4 from a wire line 5. The tool string 1 may also be suspended using coiled tubing or by being part of a drill string. The shown well comprises a casing 6, but the tool string 1 may also be used in an uncased well.

**[0023]** The tool string 1 extends in a longitudinal direction and comprises at least a first tool string part 2 and a second tool string part 3. A first end 200 of the first string part 2 and a first end 400 of the second string part 3 are connected via a connecting element 6 arranged between the two string parts 2, 3 in the longitudinal direction. The dotted lines in Fig. 1 illustrate how part of the first end 200 of the first string part extends through the connecting element 6 and into the first end 400 of the second string part.

**[0024]** Referring to Fig. 2, a connection shown in Fig. 1 between the first string part 2 and the second string part 3 will be described in further detail below. For the purpose of clarity, the connecting element 6 and part of the second string part 3 has been cut through and are shown in a cross-sectional view.

**[0025]** The string parts 2, 3 and the connecting element 6 each have a circular cross-section. In the first end 200, the first string part 2 comprises a protrusion 27 having a reduced diameter 37b. The protrusion 27 extends between a face 39 of the first string part and a protrusion end face 201. Towards the end face 201, the protrusion 27 comprises a circumferential projecting flange 29. Together with the face 39, the projecting flange 29 defines a recess 28 encircling the protrusion 27. At the end face 201, a plurality of pipe connections 22, 23, 24 and a guide pin 26 extend. Further, a plug 21 is provided in the end face 201 and a circumferential seal 33 is arranged around the protrusion 27 adjacent the end face 201. Each of the pipe connections extends in the longitudinal direction 10 from the end face 201 towards a tapered free end. At a distance from the tapered end, a circumferential seal 30, 31 are arranged around each of the pipe connections. The guide pin 26 also extends in the longitudinal direction from the end face 201 towards a tapered free end. Around the protrusion 27 having a recess of reduced diameter, the connecting element 6 is provided in the recess 28. The connecting element 6 is comprised by two connectable collar elements 601, 602 as shown in Fig. 4. During assembly, the two collar elements 601, 602 are arranged in the recess 28 around the projection 27 and connected by bolts 62. The connecting element 6 is thereby rotatably connected to the first string part 2 and restricted from moving in the longitudinal direction by the face 39 and the projecting flange 29. The connecting element 6 comprises an outer threaded portion 61 adapted to be connected to a threaded portion 48 of the second string part 3, as shown in Fig. 2. It is obvious to the person skilled in the art that the connecting element may be designed

in a number of other ways without departing from the essence of the invention.

**[0026]** In the first end 400, the second string part 3 comprises a bore 47 adapted to receive the protrusion 27 of the first string part 2 and the connecting element 6. The bore is encircled by a threaded portion 48 of the second string part 3 adapted to be connected to the threaded portion 61 of the connecting element 6. At one end, the bore 47 is delimited by a face 401 comprising a plurality of holes 42, 43, 44 adapted to receive the pipe connections 22, 23, 24, as shown in Figs. 3a and 3b. The face 401 further comprises a hole 46 adapted to receive the guide pin 26, and a socket 41 adapted to be connected to the plug 21, as shown in Fig. 3a and Fig. 3b.

**[0027]** An approximated layout of the protruding pipe connections 22, 23, 24, guide pin 26 and plug 21 is shown in Fig. 3a, and a layout of the matching holes 42, 43, 44 and socket 41 is shown in Fig. 3b. The pipe connections 22, 23, 24 are fluidly connected to respective fluid channels 220, 240 in the first string part and the holes 42, 43, 44 are in fluid communication with respective fluid channels 420, 440 in the second string part 3. By arranging the pipe connections 22, 23, 24 in the respective holes 42, 43, 44, the fluid channels 220, 240 of the first string part is brought into fluid communication with the fluid channels of the second string part. In a similar manner, the plug 21 and the socket 41 provide an electrical connection between the first and second string parts.

**[0028]** As shown in Figs. 3a and 3b, the pipe connections 22, 23, 24 of the first string part 2 and the respective holes 42, 43, 44 in the second string part 4 are arranged eccentrically in relation to a centre axis 10. By at least one pipe connection 22, 23, 24 being arranged eccentrically at a distance from the centre axis, the first and second string parts 2, 3 are prevented from mutual rotation. The one or more pipe connections thus have the additional functionality of fixating the string parts in relation to one another, both during assembly of the string parts and use of the tool string downhole.

**[0029]** The guide pin 26 extends further away from the end face 201 than the pipe connections. During assembly of the first and second string parts, the guide pin 26 is thus inserted into the hole 46 to control the assembly process and prevent damage caused by the string parts being rotated or angled in relation to one another. The plug and socket and the pipe connections may be bent or destroyed if the string parts are not arranged in parallel. When the guide pin 26 is at least partially arranged in the hole 46, the two string parts are kept substantially parallel relative to each other. By having a guide pin, the first and second string parts are prevented from tilting slightly in the connection therebetween. Such slight tilting in the connection itself may result in the pipe connections leaking, either because the pipe connection being an integral part of the one end of the string parts has been bent and thus slightly separated, forming a fracture, or the pipe connection as a separate part has tilted in the holes.

**[0030]** The pipe connections may be integral parts of one of the string parts or they may separate pipes. One pipe connection may be arranged in one string part and another pipe connection in the other, in order that when joining the string parts, the pipe connections function as guides during the assembly process.

**[0031]** The connecting element 6 is arranged in the recess of the first string part and in Fig. 2, the first string part 2 also comprises the pipe connection and the pin. However, the connecting element 6 may be arranged in the recess of the first string part, and the pipe connection and the pin may be arranged in the second string part 3.

**[0032]** Fig. 5 shows a downhole tractor 81 being part of a tool string 1, wherein two string elements 2, 3 are assembled using the connecting element 6 described above. The downhole tractor is suspended from and powered through a wire line 5 connected with the downhole tractor through a top connector 71. The downhole tractor 81 comprises an electronics section 72, an electrical motor 73, a hydraulic pump 74 and two wheel sections 80 driven by hydraulics. The wheel sections are in fluid communication with the hydraulic pump 74 and may also be denoted as driving units 80 for propelling the downhole tractor and the tool string in the well. The downhole tractor may be connected to one or more operational downhole tools 75, also being part of the tool string 1. Such operational tools could be a stroker tool providing an axial force in one or more strokes, a key tool opening or closing valves in the well, positioning tools such as a casing collar locator (CCL), a milling tool, a drilling tool, etc.

**[0033]** The connection between two string parts 2, 3, e.g. two wheel sections 80 of a downhole tractor, may be used for transferring fluid(s) and/or electrical power. Electrical power may be transferred from the wire line 5 to the first string part and via the plug 21 and socket 41 to the subsequent string part. The pipe connection 22 may be used for connecting fluid channels providing a pressurised fluid from the hydraulic pump 74 to the wheel sections, for projecting, pivotally mounted wheel arms 76. The pipe connection 24 may be used for connecting fluid channels providing a pressurised fluid from the hydraulic pump 74 to the wheel sections, for rotating wheels 77 mounted at the wheel arms 76 in a clockwise direction. The pipe connection 23 may be used for connecting fluid channels providing a pressurised fluid from the hydraulic pump 74 to the wheel sections, for rotating wheels 77 mounted at the wheel arms 76 in a counterclockwise direction. The pipe connection 25 may be used for connecting fluid channels providing a return channel for fluid supplied to the wheel sections.

**[0034]** 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.

**[0035]** By a casing is meant any kind of pipe, tubing, tubular, liner, string etc. used downhole in relation to oil or natural gas production.

**[0036]** In the event that the tools are not submergible all the way into the casing, a downhole tractor can be used to push the tools all the way into position in the well. A downhole tractor is any kind of driving tool capable of pushing or pulling tools in a well downhole, such as a Well Tractor®.

**[0037]** 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 tool string (1) for being suspended in a well (4), the tool string extending in a longitudinal direction and comprising:

- a first string part (2) and a second string part (3), each having a centre axis (10) and comprising;
  - an electrical connection (21, 41) in a first end (200, 400), and
  - a fluid channel (220, 240, 420, 440) extending at least partly through the string part,
- a connecting element (6) rotatably connected to one string part and adapted to be threadably connected to a threaded portion (48) of the other string part, to join the electrical connections of the first and second string parts; wherein one of the string parts comprises a pipe connection (22, 23, 24) extending in the longitudinal direction from the first end and into the fluid channel of the other string part, when the string parts are mutually connected by the connecting element, the pipe connection being arranged eccentrically in relation to the centre axis for preventing mutual rotation of the string parts.

**2.** A tool string according to claim 1, wherein one of the string parts comprises at least two pipe connections (22, 23, 24).

**3.** A tool string according to claim 1 or 2, wherein one of the string parts comprises a guide pin (26) and the other string part comprises a hole (46) for receiving the guide pin, when the string parts are mutually connected by the connecting element.

**4.** A tool string according to any of the preceding claims, wherein the connecting element comprises two connectable collar elements (601, 602) adapted to be mutually connected around a section (27) of one of the string pa rts.

**5.** A tool string according to any of the preceding claims, wherein the connecting element comprises an outer threaded portion (61).

**6.** A tool string according to any of the preceding claims, wherein the connecting element is arranged around a protrusion (27) of one of the string parts having a reduced diameter (37b) compared to a maximum diameter of the string part.

**7.** A tool string according to any of the preceding claims, wherein the connecting element is arranged in a recess (28) of one of the string parts, whereby the connecting element is prevented from substantially moving in the longitudinal direction.

**8.** A tool string according to any of the preceding claims, wherein the connecting element is prevented from substantially moving in the longitudinal direction towards the first end, by a protruding part (29) of the string part having an increased outer diameter.

**9.** A tool string according to any of the preceding claims, wherein the connecting element has an outer diameter (66) being equal to or less than an outer diameter (37a) of the tool string.

**10.** A tool string according to any of the preceding claims, wherein the pipe connection comprises a circumferential sealing element (30, 31) adapted to provide a fluid-tight seal between the pipe connection and the corresponding fluid channel (420, 440) into which it extends.

**11.** A tool string according to any of the preceding claims, wherein one of the string parts comprises a circumferential sealing element (33) adapted to provide a fluid-tight seal between the first and second string parts.

**12.** A tool string according to any of the preceding claims, wherein one of the string parts is a driving unit (80) for propelling the tool string in the well.

**13.** Method for assembling two string parts (2, 4) of a tool string (1), the method comprising the steps of:

- moving a first end (200) of a first string part (2) towards a first end (400) of a second string part (4),
- arranging a guide pin (26) of one of the string parts in a hole (46) in another string part,
- connecting a threaded portion (61) of a con-

necting element (6) rotatably connected to one of the string parts, with a threaded portion (48) of the other string part.

- rotating the connecting element to join electrical connections of the first and second string parts and to force a pipe connection (22, 23, 24) of one string part into a hole (42, 43, 44) in fluid communication with a fluid channel (420, 440) of the other string part.

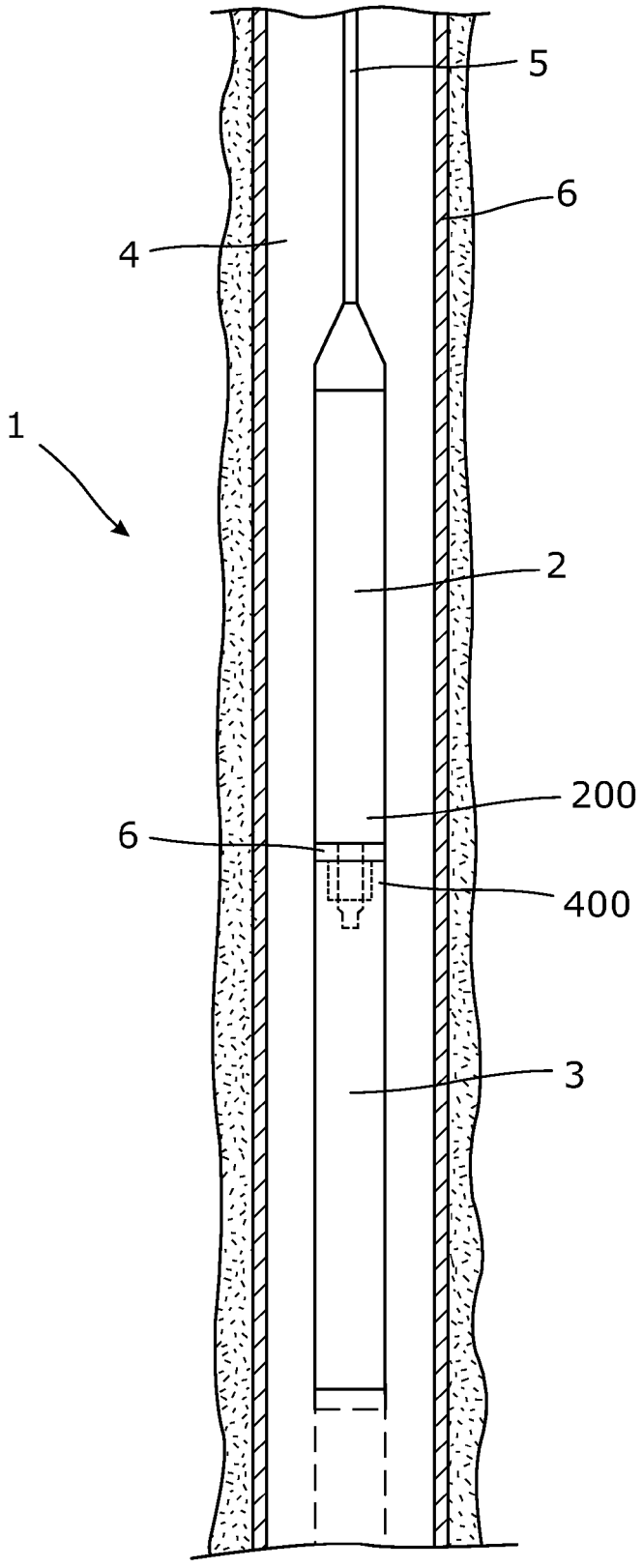


Fig. 1

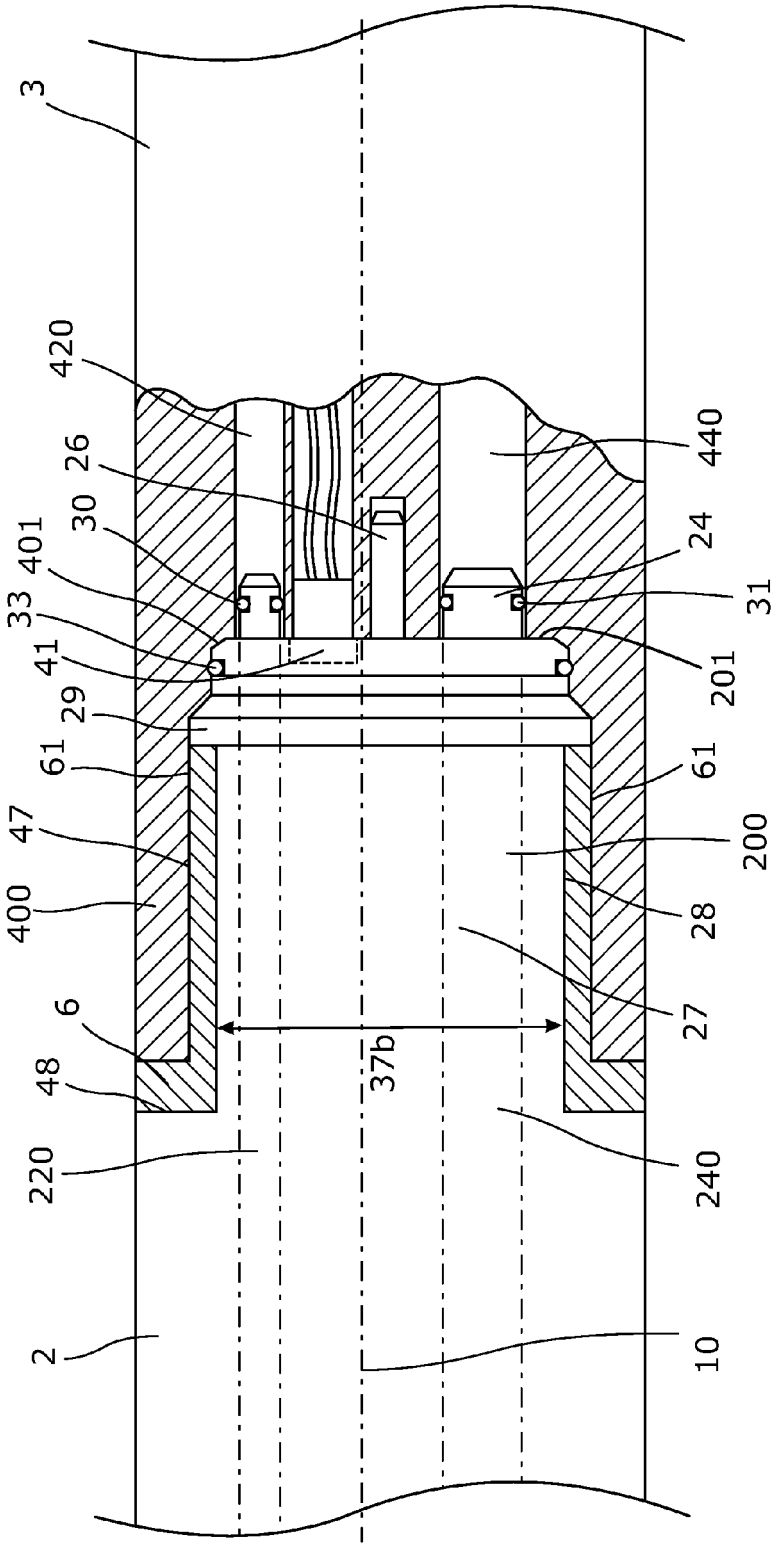
3
420
26
30
401
33
41
29
61
47
400
6
48
220
2
440
24
31
201
61
200
28
27
37b
240
10

Fig. 2

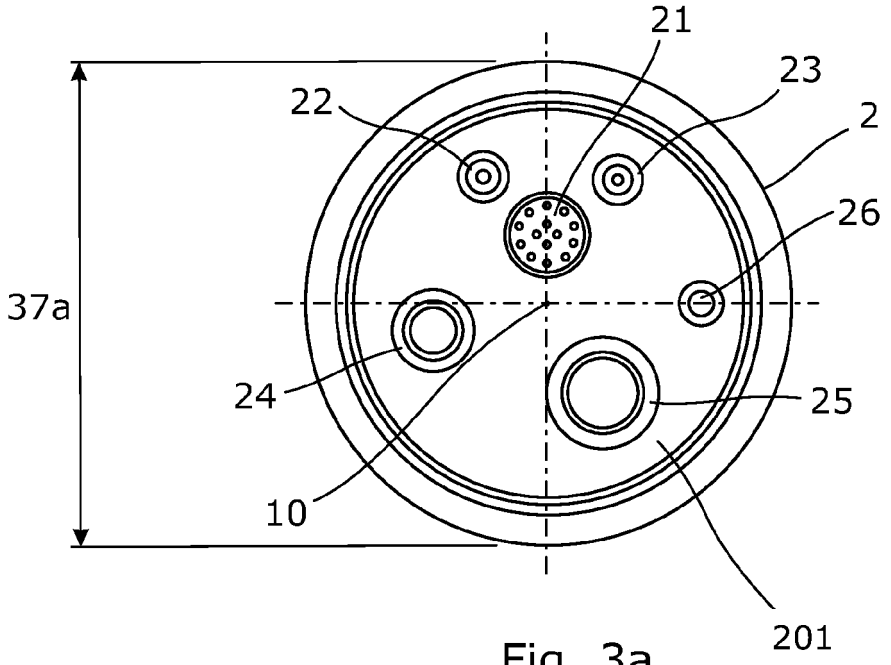


Fig. 3a

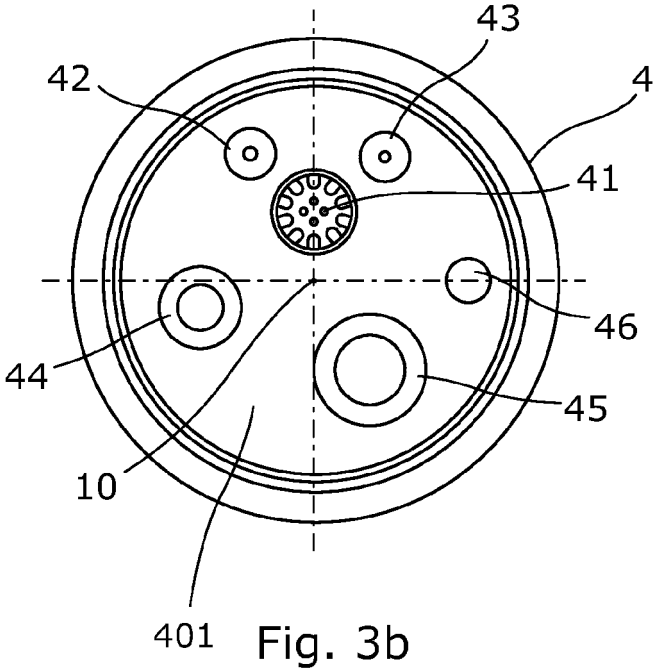


Fig. 3b

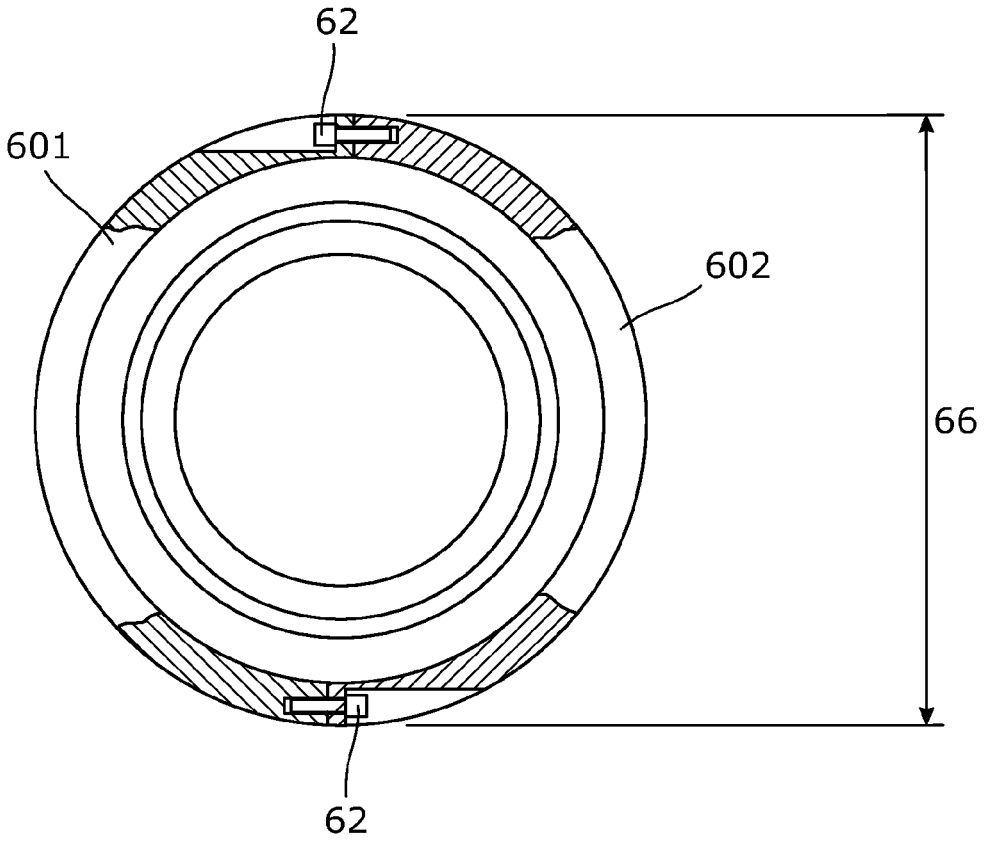


Fig. 4

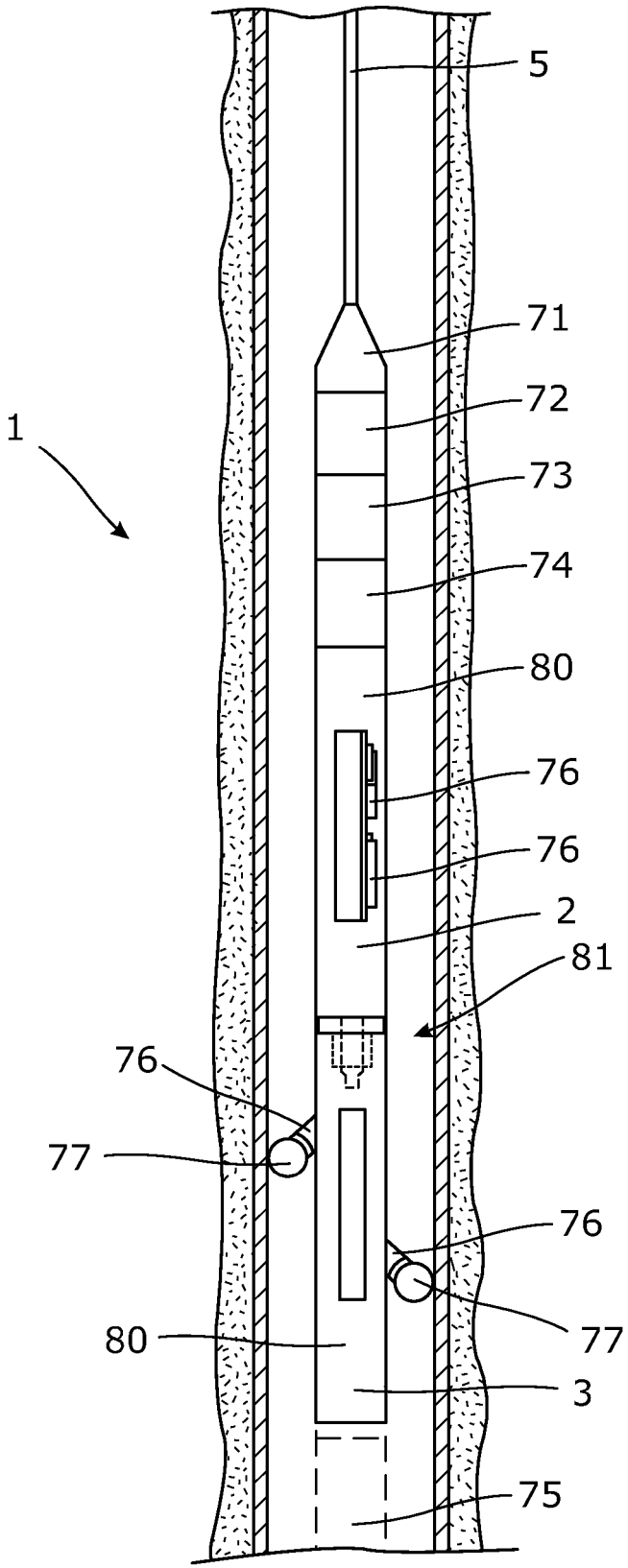


Fig. 5

Europäisches Patentamt
European Patent Office
Office européen des brevets

# EUROPEAN SEARCH REPORT

Application Number
EP 11 16 4298

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| A | US 2009/229817 A1 (PARTOUCHE ASHERS [US]) 17 September 2009 (2009-09-17) * page 4, paragraph 52 - page 5, paragraph 60; figures 3,4 * | 1-13 | INV. E21B17/02 E21B17/18 |
| A | US 2009/195250 A1 (WELSHANS DAVID [US] ET AL) 6 August 2009 (2009-08-06) * page 5, paragraph 54 - paragraph 61; figure 8 * | 1-13 | |
| A | WO 2010/122342 A1 (ARTIFICIAL LIFT COMPANY LTD [GB]; HEAD PHILIP [GB]) 28 October 2010 (2010-10-28) * the whole document * | 1-13 | |
| A | US 2007/275585 A1 (GRIFFITHS NEIL [NL]) 29 November 2007 (2007-11-29) * the whole document * | 1-13 | |
| | | | 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 | 24 August 2011 | Morrish, Susan |

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

1 EPO FORM 1503 03.82 (P04C01)

## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 16 4298

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

24-08-2011

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| US 2009229817 A1 | 17-09-2009 | CA 2549113 A1 | 15-12-2006 |
| | | CA 2689858 A1 | 15-12-2006 |
| | | CN 1880723 A | 20-12-2006 |
| | | CN 101240694 A | 13-08-2008 |
| | | DE 102006027545 A1 | 11-01-2007 |
| | | FR 2887286 A1 | 22-12-2006 |
| | | FR 2914005 A1 | 26-09-2008 |
| | | GB 2427214 A | 20-12-2006 |
| | | GB 2444372 A | 04-06-2008 |
| | | US 2006283606 A1 | 21-12-2006 |
| US 2009195250 A1 | 06-08-2009 | AU 2007257804 A1 | 21-12-2007 |
| | | CA 2651054 A1 | 21-12-2007 |
| | | CN 101466915 A | 24-06-2009 |
| | | EP 2027365 A2 | 25-02-2009 |
| | | WO 2007146801 A2 | 21-12-2007 |
| WO 2010122342 A1 | 28-10-2010 | NONE | |
| US 2007275585 A1 | 29-11-2007 | AU 2004282358 A1 | 28-04-2005 |
| | | BR PI0414977 A | 07-11-2006 |
| | | CA 2540972 A1 | 28-04-2005 |
| | | CN 1863982 A | 15-11-2006 |
| | | WO 2005038190 A1 | 28-04-2005 |
| | | GB 2422168 A | 19-07-2006 |

EPO FORM P0459

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