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(54) Title: DOWNHOLE TOOL

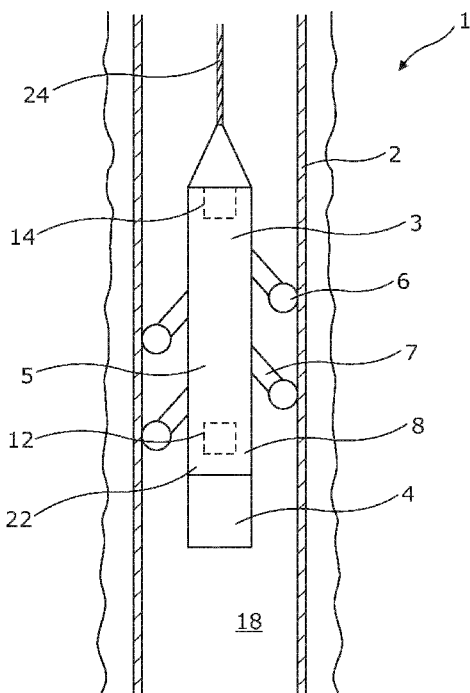


Fig. 1

(57) Abstract: The present invention relates to downhole system comprising a well containing acidic fluid, and a self-propelling downhole driving tool for performing an operation in an acid-containing well. The driving tool comprises a tool housing made of a first metal, wheels, each wheel being arranged on a wheel arm and being projectable from the tool housing, and a sacrificial anode made of a second metal and arranged in connection with the tool housing, the second metal having a more negative electrochemical potential than the first metal. Furthermore, the invention relates to a downhole operation method for operating the downhole driving tool of the downhole system.



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DOWNHOLE TOOL

Field of the invention

The present invention relates to a downhole system comprising a well containing
5 acidic fluid, and a self-propelling downhole driving tool for performing an
operation in an acid-containing well. Furthermore, the present invention relates
to a downhole operation method for operating the downhole driving tool
according to the invention.

10 Background art

Operations in a well are performed by means of different kinds of tools, and in
some cases, the well contains acid or acid is introduced with the tools in the well,
which complicates the operation since the acid environment is too harsh for the
15 downhole tools used for performing the operations. Thus, operations in wells
containing acid have to be performed after the well is flushed and the acid
concentration has been brought down or tools have been entered into the acidic
environment for performing the operation. This flushing process is time-
consuming and in some wells impossible because circulation of fluid is not
20 possible, and in some wells impossible because acid is introduced as part of the
service operation.

Another way is to use coiled tubing. However, transportation of coiled tubing
equipment normally takes approximately two weeks, which results in the well
25 being prevented from producing in the meantime.

Summary of the invention

It is an object of the present invention to wholly or partly overcome the above
30 disadvantages and drawbacks of the prior art. More specifically, it is an object to
provide an improved downhole system capable of performing operations in closed
acid-containing wells

The above objects, together with numerous other objects, advantages, and
35 features, which will become evident from the below description, are accomplished

by a solution in accordance with the present invention by a downhole system comprising:

- a well containing acidic fluid, and
- a self-propelling downhole driving tool for performing an operation in an acid-

5 containing well, the driving tool comprising:

- a tool housing made of a first metal,
- wheels, each wheel being arranged on a wheel arm and being projectable from the tool housing, and

10 - a sacrificial anode made of a second metal and arranged in connection with the tool housing, the second metal having a more negative electrochemical potential than the first metal.

When entering an acid-containing well with a downhole driving tool, the acid erodes the metal tool housing to such an extent that the downhole tool cannot be
15 reused for another operation and is often simply discarded. Downhole tools are made as reusable tools since the operations often require a significant amount of force, and the downhole tools thus have a robust design and are made of robust materials, such as stainless steel, and they are therefore quite expensive to manufacture. However, operations requiring this kind of force and thus robust
20 tools may still need to be performed in wells containing aggressive acids, and by arranging a sacrificial anode in connection with the tool housing, such operations in acid environments may be performed without having to compromise the tool itself.

25 In one embodiment, the driving tool may be connected with a tubing string adapted to supply the acidic fluid from a top of the well.

Thus, the tubing string may be coiled tubing.

30 In another embodiment, the tool may be a wireline tool.

Also, the well may be a cased well or an openhole well.

Further, the tubing string may have openings for letting the acidic fluid into the
35 well.

Also, the openings may be arranged in a first end of the tubing string adjacent to the driving tool.

5 In an embodiment, the sacrificial anode may be arranged in a first end and/or a second end of the tool housing.

Said anode may be threadedly connected with one of the ends of the housing.

10 Furthermore, the self-propelling downhole driving tool may comprise several sacrificial anodes arranged along the tool housing at predetermined intervals.

The downhole driving tool may comprise several tool parts, and the anode may be arranged between two tool parts.

15 Furthermore, the sacrificial anode may be an elongated element and may be arranged on an outer face of the tool housing.

Moreover, the sacrificial anode may have an electrical potential higher than -0.9 V.
20

In addition, the second metal may be stainless steel.

Also, the anode may be shaped as a rod.

25 In an embodiment, the sacrificial anode may be arranged in a groove in the tool housing.

Moreover, the anode may be shaped as a mesh surrounding at least part of the tool housing.
30

The first metal may be stainless steel.

The second metal may comprise chrome, bismuth, aluminium, molybdenum, cobalt, copper, or a combination thereof.
35

Furthermore, the second metal may comprise additives or other constituents.

In an embodiment, the first metal may have an electrical potential between -0.32 and -0.40 V.

Also, the second metal may have an electrical potential between -0.82 and -0.60 V.

Further, the second metal may have an electrical potential which is at least -0.3 V lower than that of the first metal, preferably at least -0.40 V lower than that of the first metal, more preferably at least -0.5 V lower than that of the first metal.

10

Additionally, the anode may be replaceably arranged in connection with the tool housing.

Several anodes may be connected with each other.

15

The downhole driving tool as described above may further comprise a compartment, such as a magazine or cassette, of a plurality of anodes.

Said compartment may comprise anodes of various metals.

20

Additionally, the downhole tool as described above may further comprise an erosion detection sensor for detection of erosion of the first metal of the tool housing.

Moreover, the downhole driving tool as described above may comprise a communication unit for receiving information from the sensor for detection of erosion of the first metal and communicating the information to surface.

The sensor and the communication unit enable retraction of the downhole driving tool before the downhole driving tool is eroded to an extent where it cannot be reused. The sensor detects the thickness of the tool housing or another indication of the erosion of the tool housing, and the communication unit communicates the information to surface, e.g. only when the indicator is above a certain extent of erosion.

35

In an embodiment, the tool housing may be electrically connected with the sacrificial anode.

Also, the downhole driving tool as described above may further comprise a power supply for creating an electrical potential across the anode and the tool housing. The power supply may have a negative pole connected with the tool housing and a positive pole connected with the anode.

5

Furthermore, the downhole driving tool may further comprise an acid detection sensor.

In an embodiment, the one or more anodes may cover at least 10% of a surface area of the tool housing.

10

Moreover, the downhole driving tool as described above may comprise several anodes arranged with at least one anode for each 10 metres of the downhole driving tool, preferably at least one anode for each 5 metres of the downhole driving tool, more preferably at least one anode for each 2 metres of the downhole driving tool, and even more preferably at least one anode for each 1 metre of the downhole driving tool.

15

In addition, the downhole driving tool as described above may further comprise an operational tool section, such as a drill bit, an anchor tool, a stroking tool, a key tool, a release tool or a milling tool.

20

The anodes may be arranged between the operation tool section and the tool housing.

25

Further, the driving tool may propel forward in the well at a velocity of at least 5 metres/hour.

Moreover, the tubing string may have a first end nearest the top of the well and a second end, the second end being connected with the driving tool.

30

The downhole system as described above may comprise several tools.

In an embodiment, anodes may be arranged between the tools.

35

The acid may be HCl, H₂S or H₂SO₄ or any combination thereof.

Also, the downhole system as described above may be coiled tubing or a drill pipe connected with the downhole driving tool for supplying acid.

The present invention also relates to a downhole operation method of operating the downhole driving tool of the downhole system as described above, the

5 method comprising the steps of:

- connecting an anode with the tool housing,
- submerging the downhole driving tool into the well for performing an operation downhole,
- retracting the downhole driving tool from the well,
- 10 - replacing the sacrificial anode, and
- submerging the downhole driving tool for performing another operation in the same well or another well.

Further, the downhole operation method as described above may further
15 comprise the step of cleaning the downhole driving tool before submerging the tool again.

In the step of replacing the anode, the anode may be replaced for another anode of a material which is different from that of the anode which is replaced.

20

Moreover, the downhole operation method as described above may further comprise the step of detecting which acid is present in the well.

Finally, the downhole operation method may further comprise the step of
25 measuring the erosion of the housing.

Brief description of the drawings

The invention and its many advantages will be described in more detail below
30 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 well in which a downhole driving tool according to the present invention is submerged,

35

Fig. 2 shows another embodiment of the downhole driving tool comprising anodes in both ends,

Fig. 3 shows yet another embodiment of the downhole driving tool comprising rod anodes arranged outside the tool housing,

Fig. 4 shows the downhole driving tool of Fig. 3 seen from one end,

5

Fig. 5 shows a downhole driving tool having a mesh anode, and

Fig. 6 shows a downhole system according to the invention.

- 10 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

15

- Fig. 1 shows a downhole driving tool 1 submerged into a well 2 containing an acid-containing fluid 18. The downhole driving tool 1 comprises a tool housing 3 made of a first metal and a sacrificial anode 4 made of a second metal. The anode 4 is arranged in connection with one first end 22 of the tool housing 3 being the end furthest away from the top of the well 2. In order to prevent erosion or etching of the tool housing 3 when submerged in the acid-containing fluid 18, the second metal of the anode 4 has a more negative electrochemical potential than the first metal of the tool housing.
- 20

- When performing an operation in an acid-containing well 2, the acid erodes the metal tool housing 3 to such an extent that the downhole driving tool 1 cannot be reused for another operation. Downhole driving tools cannot be made in disposable materials, such as plastic, since the operations often require a significant amount of force. The tools therefore have a robust design and are made of robust materials, such as stainless steel. This means that the tools are quite expensive to manufacture, and hence, being able to avoid discarding a tool after having performed one operation in an acid-containing well is very beneficial. The well 2 may contain acid before the tool enters the well, or the tool may be used to perform the acid stimulation. By arranging a sacrificial anode 4 in connection with the tool housing 3, the anode material is eroded or sacrificed in favour of the metal of the tool itself, and thus, operations in the acid environment may be performed without having to compromise the tool itself. Typical acids in an acid-containing well may be HCl (hydrogen chloride) which is typically injected
- 25
- 30
- 35

into the well 2 for performing a stimulation operation, or H_2S (hydrogen sulphide) and H_2SO_4 (hydrogen sulphate) which develop in the well. Furthermore, inhibitors are added to the fluid in the well 2 for protecting for example the metal casing, and the sacrificial anode 4 therefore has to be designed to match the specific well 2 in which the tool is to operate.

In Fig. 1, the tool is a driving tool 5 which is self-propelling, meaning that the tool is able to propel itself forward in the well 2. The tool is connected with the top of the well via a wireline 24 and is thus a so-called wireline tool. The well 2 is a cased well but may also be an openhole well. The driving tool comprises four wheels 6, and each wheel is arranged on a wheel arm 7 which is radially projectable from the tool housing, as shown also shown in Fig. 4.

In Fig. 2, a sacrificial anode 4 is arranged in both the first end 22 and a second end 25 of the tool housing 3. The downhole driving tool comprises two tool parts 1a, 1b constituted by two operational tool sections being an anchor tool 20 and a key tool 21. The anchor tool 20 has four radially projectable anchors 27 anchoring the tool in the longitudinal direction of the well so that the key tool 21 can project its keys 28 and engage a sliding sleeve 29 for opening or closing the sleeve. A third anode is arranged between the anchor tool 20 and the key tool 21, and the anodes 4 are thus able to cover the entire tool surface so that the downhole driving tool is not eroded or etched and thus damaged. In another embodiment, the downhole driving tool comprises another operational tool section, such as a drill bit, a stroking tool, a release tool or a milling tool.

The anodes 4 are detachable and are threadedly connected with the ends of the housing of the anchor tool 20 and the ends of the housing of the key tool 21, as shown in Fig. 2. The anodes 4 are designed as cylindrical modules, also referred to as "subs", which can easily be connected to any tool by normal detachable connection means.

In Figs. 2 and 6, several sacrificial anodes are distributed along the tool housing at predetermined intervals. By having several sacrificial anodes arranged along the tool housing, the sacrificial anodes can be made of a metal having an electrical potential closer to the electrical potential of the first metal of the tool. When the tool is arranged in an acid-containing well, the fluid most often contains inhibitors in order to protect certain types of steels in the well, and when

such inhibitors are present, the sacrificial anodes must be made of a metal having an electrical potential higher than -0.9 V. Otherwise, it will not function as intended.

- 5 In Fig. 3, the downhole driving tool comprises several sacrificial anodes 4. The anodes 4 are shaped as elongated elements and are arranged on an outer face 8 of the tool housing 3 of the driving tool 5. The anodes 4 are shaped as solid rods and are arranged in a groove 9 in the tool housing 3, as shown in Fig. 4.
- 10 As shown in Fig. 5, the anodes 4 may also be shaped as a mesh 30 surrounding at least part of the outer surface 8 of the tool housing 3. In Fig. 5, the downhole driving tool 1 comprises a sensor unit 26 which e.g. comprises an acid-detecting sensor 16 which is submerged into an openhole well 2 containing acid 18. The sensor unit 26 may also be another kind of sensor, such as a casing collar
- 15 locator, a temperature measuring unit, a pressure measuring unit, a diagnostics related sensor or a similar sensor unit. In the event that the tool is not submergible all the way into the casing, a driving unit, such as a downhole tractor, can be used to push the tool all the way into position in the well.
- 20 The outer face of the tool is mostly made of the first metal which is a suitable stainless steel type. The anode is made of the second metal which may be chrome, bismuth, aluminium, molybdenum, cobalt, copper, or a combination thereof. The sacrificial anode is designed to match a specific well, the condition of which depends on the acid and inhibitor content of the well in which the tool is to
- 25 operate, and may therefore comprise any combination of suitable anode metals or metal alloys and even additives or other constituents for providing the most efficient sacrificial anode for the tool in that particular environment of the well. The second material may – apart from the suitable anode material – comprise additives or other kinds of metal. Even though the anode is very efficient, the
- 30 tool may still be attacked by the acid, but the tool will be less damaged than if no sacrificial anode is used and not to such an extent that the tool cannot be reused for another operation.

The first metal is substantially stainless steel or similar material and has an

35 electrical potential between -0.32 and -0.40 V. The second metal has an electrical potential between -0.82 and -0.60 V. Thus, the second metal has an electrical potential which is at least -0.3 V lower than that of the first metal, preferably at

least -0,40 V lower than that of the first metal, more preferably at least -0.5 V lower than that of the first metal.

5 The tool of Fig. 1 comprises an erosion detection sensor 12 for continuously detecting if the first metal of the tool housing 3 has been attacked by acid and thus has eroded. The erosion detection sensor 12 communicates with a communication unit 14 which communicates information from the erosion detection sensor 12 to the top of the well 2. By communicating erosion information to an operator at the top of the well 2, the operator is able to retract
10 the downhole driving tool before the tool is eroded to an extent that the tool cannot be reused. The erosion detection sensor 12 detects the thickness of the tool housing 3, e.g. by means of a magnetic sensor or an ultrasonic sensor, or by another indication of the erosion of the tool housing. The communication unit 14 communicates the information to surface, e.g. when the indicator is above a
15 certain amount of erosion so that the downhole driving tool may be retracted from the well before the tool is damaged too much. After retracting the tool from the well 2, the used anodes 4 may be replaced by new anodes made of the same material or anodes made of another anode material.

20 As mentioned, the anode 4 is replaceably arranged in connection with the tool housing 3, e.g. as rods in grooves or as detachable components or subs. The downhole driving tool may further comprise a compartment 11, such as a magazine or cassette, of a plurality of anodes, said compartment 11 being illustrated by dotted lines in Fig. 3. The compartment 11 may comprise anodes of
25 various metals, so that instead of having to retract the tool from the well 2 in order to replace the anodes 4, the replacement may occur downhole just by releasing the used anodes and collecting new anodes from the compartment 11. The anodes 4 in the compartment 11 may be used to push the used anodes radially outwards, and the used anodes just drop to the bottom of the well 2.

30

The tool housing 3 is electrically connected with the sacrificial anode 4, and the downhole driving tool may further comprise a power supply 15 for creating an electrical potential across the anode 4 and the tool housing 3, as shown in Fig. 2. Thus, the power supply 15 has a negative pole connected with the tool housing 3
35 and a positive pole connected with the anode 4.

In order to protect the downhole driving tool, the one or more anodes 4 cover(s), in some embodiments, at least 10% of a surface area of the tool housing 3. The amount of anode material depends on a variety of factors, such as acid type, acid concentration, period of time the tool is submerged, temperature and pressure, anode material, surface area of the anode and surface area of the tool. The optimal design of the anode, choice of anode material and arrangement of the anodes must be determined from operation to operation, but if the acid turns out to be more aggressive than expected, more anodes can easily be connected with the ends of the tool housing in the required number.

10

The anodes are arranged so that they are able to cover the entire tool housing 3, which is at least one anode for each 10 metres of the downhole driving tool, preferably at least one anode for each 5 metres of the downhole driving tool, more preferably at least one anode for each 2 metres of the downhole driving tool, and even more preferably at least one anode for each 1 meter of the downhole driving tool.

The invention further relates to a downhole system 100 comprising the downhole driving tool and the well containing acidic fluid 18, where the system may comprise several tools or operational tools. The acid is typically HCl or H₂SO₄, where HCl is particularly aggressive. The acid is typically used for stimulating the well by 2 injecting acid under high pressure into the well opposite the production zones. The injection of acid may be performed by inserting a tubing string 19, such as coiled tubing or similar pipe or tubing, at the top 23 of the well. The tubing string 19 may be connected with the downhole driving tool, such as a driving tool arranged in front of the tubing for dragging the tubing even further down the well, as shown in Fig. 6. When the tubing is positioned in the well, acid 18 is supplied down the tubing string 19 and injected through openings in the end of the tubing close to the driving tool. The acid is supplied while the tubing and thus the driving tool is retracted slowly from the well 2. During the acid treatment, the housing 8 of the driving tool is subjected to the acid, since the tool is retracted through the well which was just treated with acid. The anode 4 may thus be advantageously arranged in the end facing the tubing string 19. To further protect the tool, the propelling means, which in this embodiment are the wheels on the projectable wheel arms, may be retracted into the body of the tool while performing the acid treatment.

The downhole operation is initiated by connecting an anode 4 with the tool housing before submerging the tool into the well for performing an operation downhole. Then, the downhole driving tool is retracted from the well 2 and the sacrificial anode 4 is replaced, and then the downhole driving tool may be
5 submerged again and is ready to perform another operation in the same well or another well. Before submerging the tool again, the downhole driving tool may also be cleaned, e.g. flushed. The tool may detect what kind of acid is present in the well in order to insert the most suitable anode for protecting the tool.

10 A stroking tool is a tool providing an axial force. The stroking tool comprises an electrical motor for driving a pump. The pump pumps fluid into a piston housing to move a piston acting therein. The piston is arranged on the stoker shaft. The pump may pump fluid into the piston housing on one side and simultaneously suck fluid out on the other side of the piston.

15

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-
20 containing fluid, etc. Gas, oil, and water fluids may thus all comprise other elements or substances than gas, oil, and/or water, respectively.

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

25

The driving unit may be a downhole tractor with 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
30 Tractor®.

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

Claims

1. A downhole system 100 comprising:
 - a well containing acidic fluid (18), and
 - 5 - a self-propelling downhole driving tool (1, 5) for performing an operation in an acid-containing well (2), the driving tool comprising:
 - a tool housing (3) made of a first metal,
 - wheels (6), each wheel being arranged on a wheel arm (7) and being projectable from the tool housing, and
 - 10 - a sacrificial anode (4) made of a second metal and arranged in connection with the tool housing, the second metal having a more negative electrochemical potential than the first metal.
2. A downhole system according to claim 1, wherein the driving tool is
15 connected with a tubing string (19) adapted to supply the acidic fluid from a top of the well.
3. A downhole system according to claim 2, wherein the tubing string has openings for letting the acidic fluid into the well.
20
4. A downhole system according to any of the preceding claims, wherein the sacrificial anode is arranged in a first end (22) and/or a second end (25) of the tool housing.
- 25 5. A downhole system according to any of the preceding claims, wherein the self-propelling downhole driving tool comprises several sacrificial anodes arranged along the tool housing at predetermined intervals.
6. A downhole system according to any of the preceding claims, wherein the
30 sacrificial anode has an electrical potential higher than -0.9 V.
7. A downhole system according to any of the preceding claims, wherein the anode is shaped as a mesh surrounding at least part of the tool housing.
- 35 8. A downhole system according to any of the preceding claims, wherein the second metal comprises chrome, bismuth, aluminium, molybdenum, cobalt copper, or a combination thereof.

9. A downhole system according to any of the preceding claims, wherein the anode is replaceably arranged in connection with the tool housing.

10. A downhole system according to any of the preceding claims, further comprising a compartment (11), such as a magazine or cassette, of a plurality of anodes.

11. A downhole system according to any of the preceding claims, further comprising an erosion detection sensor (12) for detection of erosion of the first metal of the tool housing.

12. A downhole system according to any of claims 2-11, wherein the tubing string has a first end nearest the top of the well and a second end, the second end being connected with the driving tool.

15

13. A downhole system according to any of the preceding claims, wherein the system comprises several tools.

14. A downhole system according to any of claims 2-13, wherein the tubing string (19) is coiled tubing or a drill pipe connected with the downhole driving tool for supplying acid.

15. A downhole operation method for operating the downhole driving tool of the downhole system according to any of claims 1-14, the method comprising the steps of:

- connecting an anode with the tool housing,
- submerging the downhole driving tool into the well for performing an operation downhole,
- retracting the downhole driving tool from the well,
- replacing the sacrificial anode, and
- submerging the downhole driving tool for performing another operation in the same well or another well.

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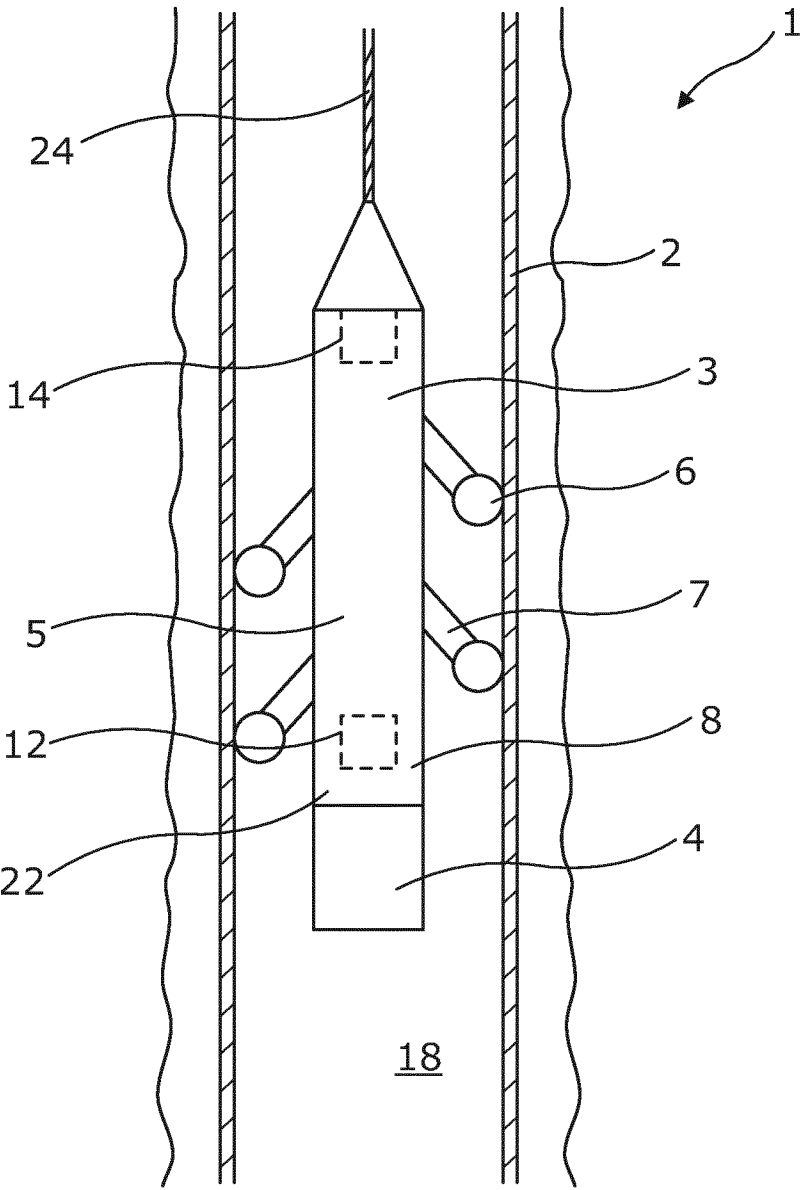


Fig. 1

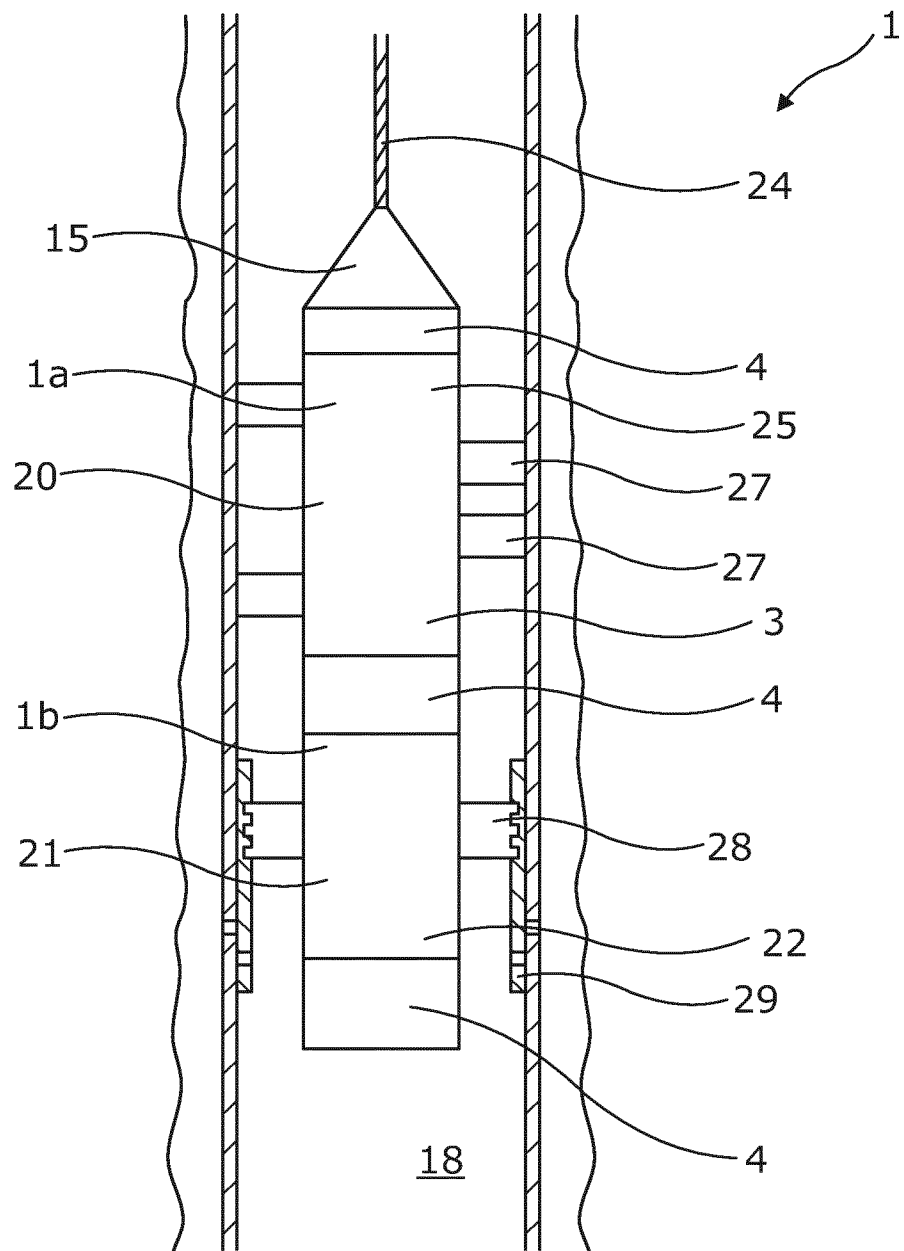


Fig. 2

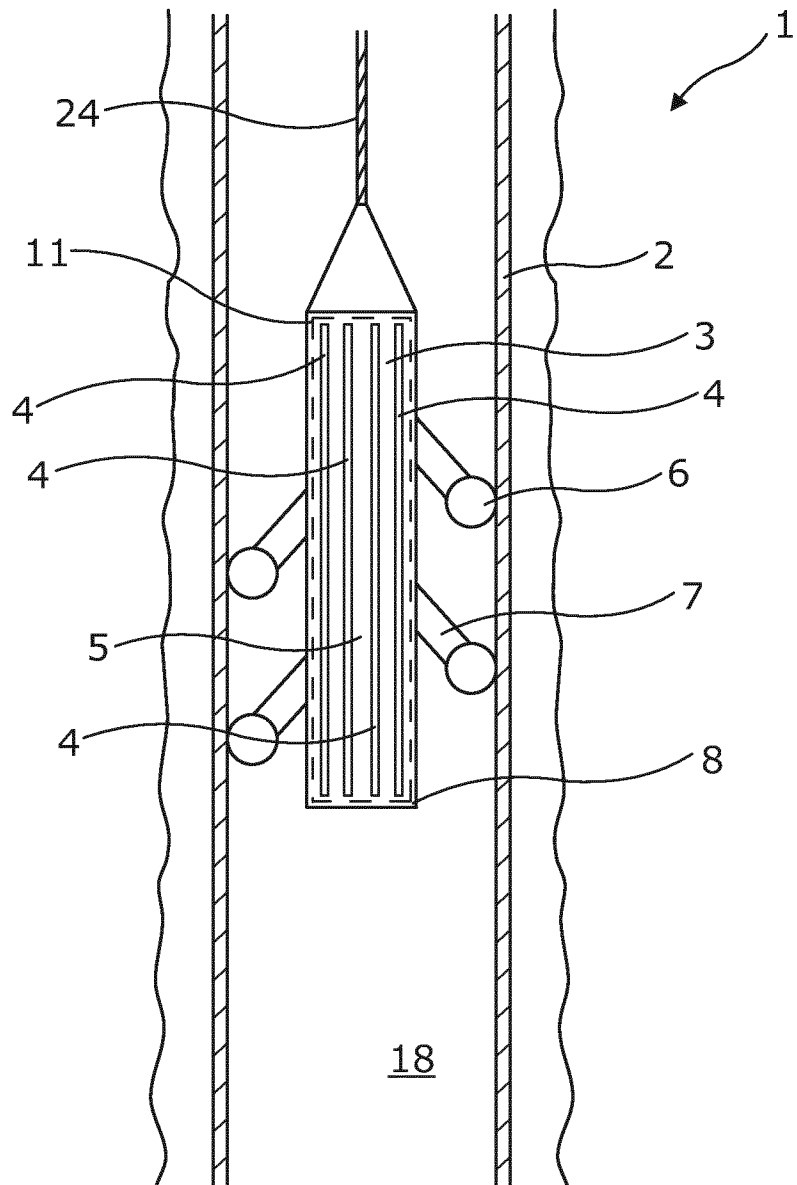


Fig. 3

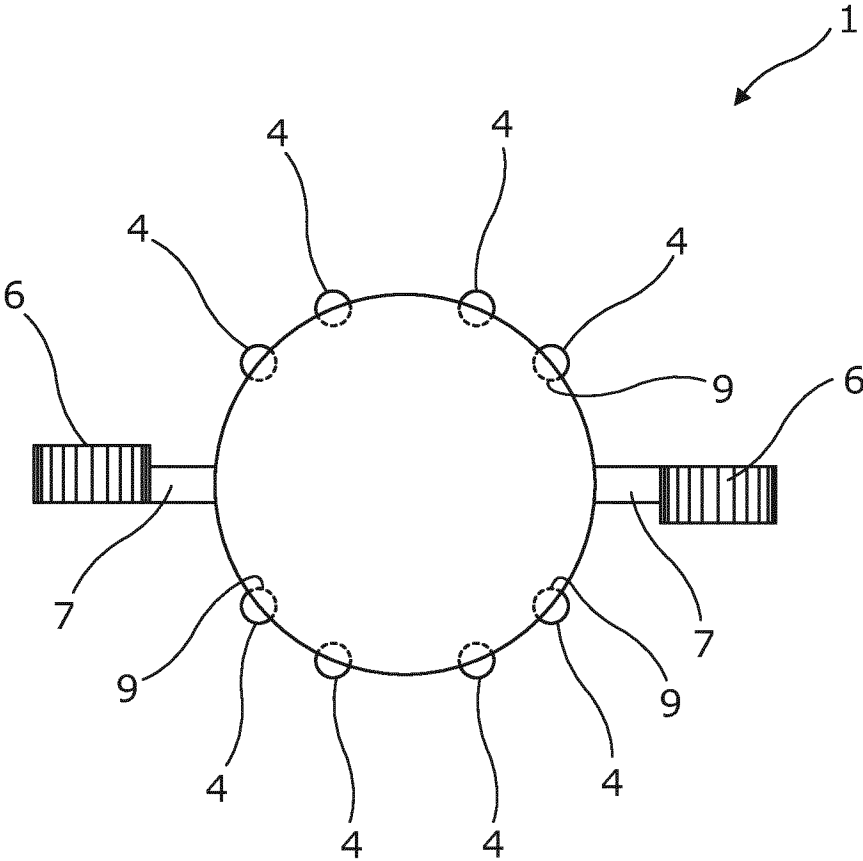


Fig. 4

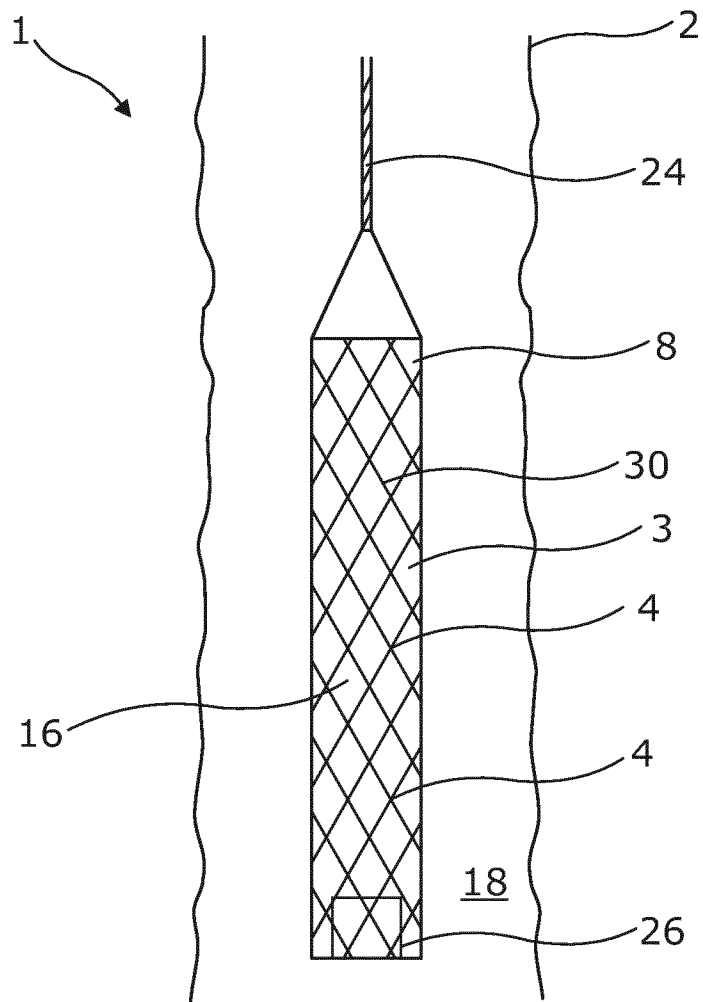


Fig. 5

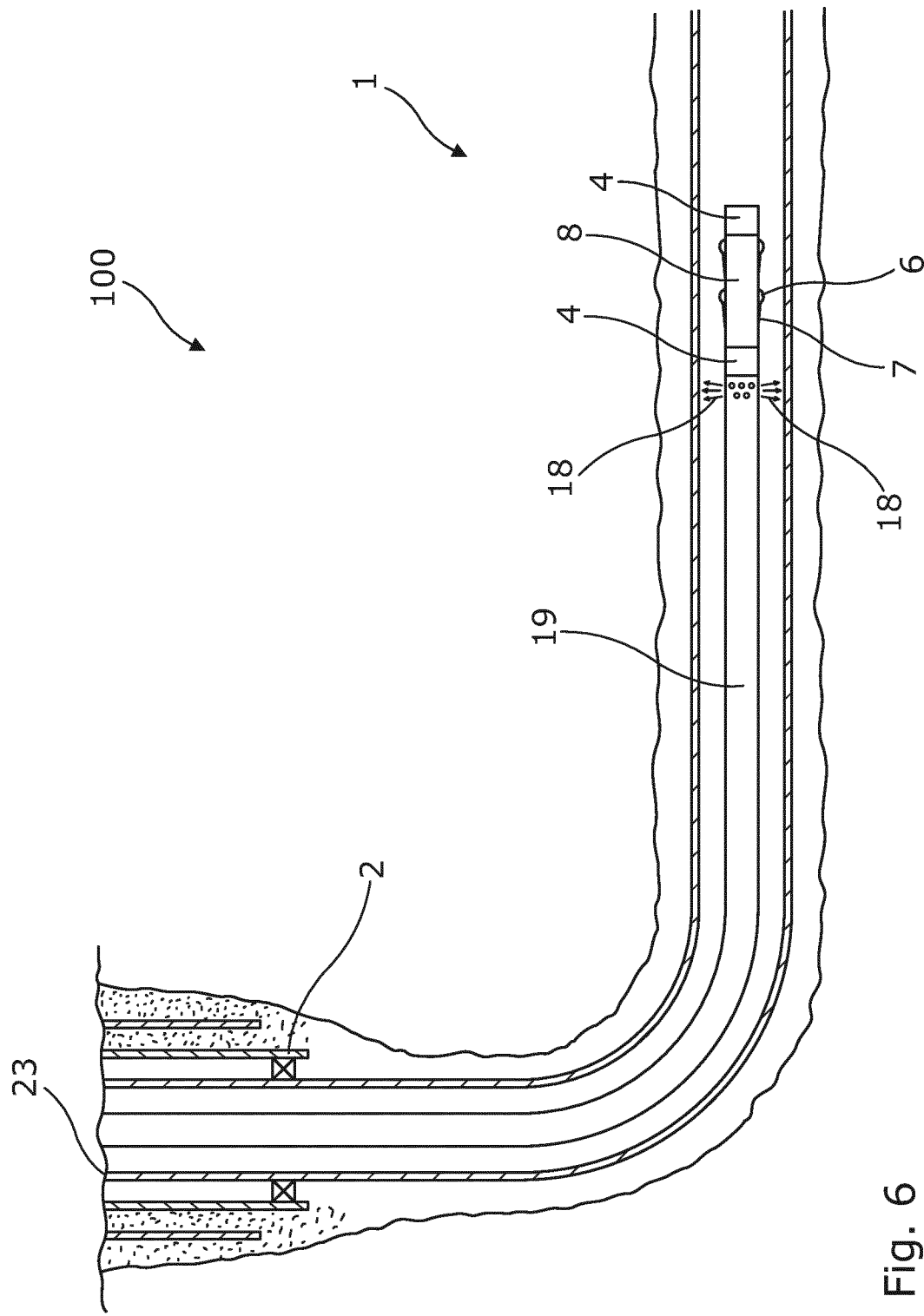


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/074443

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B41/02 E21B47/01
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	----- US 6 331 242 B1 (HORTON A MICHAEL [US]) 18 December 2001 (2001-12-18) column 10, line 45 - column 11, line 10 figure 5	1-15
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Further documents are listed in the continuation of Box C.



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