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(54) Title: REAMING TOOL AND METHODS OF USING THE REAMING TOOL IN A WELLBORE

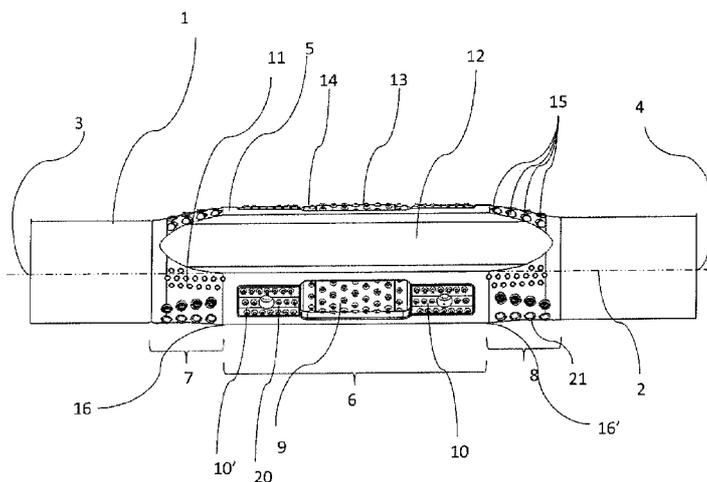


Fig. 1

(57) Abstract: A reaming tool includes a tool body having a longitudinal axis and an upper end opposite a lower end and at least one blade extending outwardly from the external surface of the tool body. The blade includes a rolling element defining the gauge of the reaming tool, and a blade surface arranged undergauge of the rolling element and comprising a cutting surface.



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**REAMING TOOL AND METHODS OF USING
THE REAMING TOOL IN A WELLBORE**

FIELD

10 The present invention relates to the field of oil and gas exploration and development, and in particular to reaming tools and to the use of such reaming tools in a method of operation in a wellbore.

BACKGROUND

15 In the oil and gas industry, wells are formed using vertical and directional drilling techniques. The drilling process involves initially drilling a pilot borehole using a drill string with a drilling bottom hole assembly (BHA) having a drill bit at the leading end thereof. The pilot borehole must be subsequently reamed so as to accommodate casing, production pipe, etc., and to improve borehole gauge, shape and condition, using one or more reaming tools. The so formed well is then "completed", i.e. made ready for production by installing casing
20 (if applicable), production pipes and associated tools and perforating and stimulating the bottom hole.

 Generally, the drill bit is advanced downward until the drill bit has reached the target depth. The drillstring is then pulled out and a reaming BHA is attached at the leading end of the drillstring. This reaming BHA is then pushed downhole, reaming and conditioning the
25 borehole prior to well completion and subsequently pulled out while at the same time reaming the borehole on the way out. As discussed above, this type of reaming requires a specific reaming run after the pilot hole has been created and prior to performing well completion, which is inconvenient and inefficient. The necessity to pull the drilling BHA out of borehole to replace it with a reaming BHA results in expensive non-production time.

30 Certain reaming tools currently available are only suitable for improving the borehole gauge in soft formations, and are less suitable for reaming hard formations. In most

5 wellbores, the formation generally changes from soft to hard formation and vice-versa. Therefore there is a need for a tool and method providing a high borehole quality for both soft and hard formations. There is also a need for reducing excess torque caused while rotating the drillstring while the reaming surface is contacting the formation. Further, there is a need for a reaming tool that can be easily replaced or repaired after being subject to wear
10 from use in a wellbore.

SUMMARY

According to a first aspect, the present invention relates to a reaming tool comprising a tool body having a longitudinal axis and an upper end opposite to a lower end, and at least one blade rising from the external surface of the tool body, said blade comprising a rolling
15 element forming the gauge of the reaming tool and a blade surface arranged undergauge of the rolling element and comprising a cutting surface.

Preferably, the offset between the gauge of the reaming tool and the gauge of the blade surface is comprised between 1mm and 20mm.

Preferably, the blade surface comprises a first section comprising the rolling element
20 and a second section gradually decreasing from an end of the first section towards the tool body.

Preferably, the blade further comprises a third section opposite to the second section, the third section comprising a second cutting surface, the third section gradually decreasing from a second end of the first section opposite to said first end, towards the tool body.

25 Preferably, the first section of the blade surface extends along the blade at a distance relative to the central axis of the tool comprised between a first point of the blade surface which is at the larger distance relative to the central axis and a second point of the blade surface which is comprised between the first point and at least 50% of the height of said gauge of the blade surface relative to the external surface of the tool body. In other words, a

5 portion of the first section of the blade surface extends along the blade between two points: a first point of the blade surface which is at the larger distance relative to the central axis (2) on a first side of the rolling element and a second point of the blade surface which is comprised between the first point and at least 50% of the height of the gauge of the blade surface relative to the external surface of the tool body on the same side of the rolling element.

10 Preferably, the first section of the blade surface is substantially parallel to the central axis.

Preferably, the second section of the blade surface comprises the cutting surface provided with one or more cutting elements disposed on at least a portion thereof, configured on said cutting surface at a radial distance from said longitudinal axis of the tool body less
15 than or equal to the largest radial distance between the first section of the blade surface and the longitudinal axis of the tool body.

Preferably, the cutting surface comprises an arrangement of cutting elements extending from the vicinity of the external surface of the tool body to the vicinity of the first section of the blade surface.

20 Preferably, one or more cutting elements are configured on said cutting surface so that an extended longitudinal axis of said cutting element is positioned at an angle comprised between 0° and 85° with respect to a plane perpendicular to the longitudinal axis of said body.

Preferably, the cutting elements are positioned at a negative back rake angle.

25 Preferably, the rolling element comprises reaming elements.

Preferably, the first section of the blade surface comprises reaming elements which are undergauge relative to the gauge of the reaming tool.

Preferably, the rolling element has a rotation axis comprised in a plane parallel to the longitudinal axis of the tool body.

5 Preferably, the blade comprises a pocket in which is secured a cartridge comprising said rolling element.

Preferably, the cartridge comprises a first block and a second block supporting a shaft around which is arranged said rolling element.

10 Preferably, the first block and/or the second block is/are provided with reaming elements or hard material coating.

Preferably, the reaming elements are reaming inserts with a flat top.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a side view of a reaming tool according to an embodiment of the present invention.

15 Figure 2 is a simplified view of a reaming tool according to another embodiment of the present invention, wherein details including the reaming elements and the cutting elements are not shown.

DETAILED DESCRIPTION

Figure 1 illustrates a reaming tool according to an embodiment of the present invention. The reaming tool includes a tool body 1 having a longitudinal axis 2, an upper end 3 opposite from a lower end 4, and at least one blade 5 extending outwardly from the external surface of the tool body 1. Preferably, the tool body 1 is substantially cylindrical. Figure 1 shows a preferred embodiment of a reaming tool comprising three blades, preferably equally spaced by flutes 12. Alternatively, the blades may be unequally spaced. The reaming tool 20 may have any number of blades. Each blade 5 comprises a rolling element 9 and a blade surface defining the outermost surface of the blade. The rolling element 9 defines the gauge of the reaming tool. The blade surface includes a cutting surface apart from the rolling element 9. The cutting surface has a smaller outer diameter than the rolling element 9. Preferably, the gauge of the reaming tool is offset from the gauge of the blade surface by 25

5 between 1mm and 20 mm, preferably between 1mm and 10mm, and more preferably between 2mm and 8mm.

The blade surface includes a first section 6 which includes the rolling element 9, and second and third sections 7, 8 gradually decreasing in diameter from ends of the first section 6 towards the tool body 1. As shown in Figure 2, the first section 6 of the blade surface extends along the blade at a distance (D) relative to the central axis 2 of the tool. Distance (D) may vary between (1) a distance from the central axis to a first point of the blade surface at the largest diameter, and (2) a distance from the central axis to a second point of the blade surface, where the second point is located between the first point and at least 50% of the height (H) of the gauge of the blade surface relative to the external surface of the tool body 1, or preferably between the first point and at least 75% of the height (H) of the gauge of the blade surface relative to the external surface of the tool body 1, or more preferably between the first point and at least 90% of the height (H) of the gauge of the blade surface relative to the external surface of the tool body 1. Figure 1 illustrates an embodiment of a first section 6 of the blade surface that is substantially parallel to the central axis 2 of the reaming tool, thus, the second point is at substantially the same height as the first point on the blade surface.

The rolling element 9 reduces friction between the blades 5 of the reaming tool and the walls of the borehole, thereby reducing the torque while rotating the drillstring in the wellbore. The rolling element 9 has a substantially cylindrical shape to stabilize the drillstring while rotating in the wellbore. Preferably, the rolling element 9 comprises reaming elements such that the reaming elements indent the formation and break the formation by crushing the formation. More preferably, the reaming elements are tungsten carbide inserts. Alternatively, the rolling element comprises milled teeth as reaming elements. The milled teeth rolling element is preferably made of steel and hardened by means of heat treatment such as a carburizing process or by means of a hardfacing treatment or by a combination of both

5 treatments. In both types of rolling elements, the major force component on the reaming element while crushing the formation is radial rather than tangential. Alternatively, the rolling element 9 may be devoid of any reaming elements. In one embodiment, the rolling element has a smaller diameter on both of its extremities 14 to engage the formation.

10 Preferably, the cutting surface 7, 8 comprises one or more cutting elements 15 disposed on at least a portion thereof. Preferably, the cutting elements 15 are polycrystalline diamond cutters (PDC). More preferably, the cutting elements 15 are configured on the cutting surface 7, 8 at a radial distance from the longitudinal central axis 2 of the tool body 1 less than or equal to the radial distance between the first section 6 of the blade surface and the longitudinal central axis 2 of the tool body. Reserve holes are located behind each cutting
15 element 15 and are typically plugged by a dowel-pin 21. In the event a cutting element 15 is damaged, the dowel-pin 21 immediately behind the damaged cutting element is removed and a new cutting element is installed in the reserve hole. In this way, the cutting elements are one-time field redressable. Once most of the reserve cutting elements are damaged, the tool is sent to maintenance for major repair.

20 In one embodiment, the cutting elements 15 may be disposed at the vicinity of the edge of the blade in the direction of rotation of the reaming tool. For example, if the reaming tool comprises a cutting surface oriented towards the direction of drilling, the cutting elements are positioned at the vicinity of the edge of the blade entering the first in contact with the formation. If the reaming tool further comprises a cutting surface oriented towards
25 the direction of pulling out of the hole, the cutting elements are disposed at the vicinity of the edge of the blade entering the first in contact with the formation. Preferably, the reaming tool comprises a first cutting surface 7 oriented towards the direction of drilling and a second cutting surface oriented towards the direction of pulling out of the hole. The reaming tool is preferably rotated following the same radial direction for both operations of drilling and

5 pulling out of the hole, therefore the cutting elements are arranged at the vicinity of the edge of the blade at the same side of the blade.

Preferably, the cutting elements 15 are arranged on the cutting surface such that a first cutting element is provided at the vicinity of the external surface of the tool body and a second cutting element is provided at the vicinity of the first section of the blade surface.

10 Preferably, the cutting surface comprises an arrangement of a plurality of cutting elements extending along the cutting surface from the vicinity of the external surface of the tool body to the vicinity of the first section of the blade surface. This arrangement of the plurality of cutting elements allows cutting any remaining ledges or tight spots before the walls of the borehole enters into contact with the first section of the blade surface and the rolling element.

15 This arrangement of the plurality of cutting elements further prevents wear of the cutting surface. Advantageously, another arrangement of inserts 11 such as tungsten carbide inserts or diamond impregnated inserts or PDC inserts is provided on the cutting surface 7, 8 and behind the cutting elements 15 following the direction of rotation of the reaming tool, for reinforcing the cutting surface 7, 8 and preventing premature wear of the cutting surface.

20 Preferably, the cutting elements have a longitudinal axis and are oriented so that their longitudinal axis forms an angle comprised between 0° to 85° , preferably 10° to 45° , more preferably 15° to 30° with a plane perpendicular to the axis of the reaming tool.

More preferably, the cutting elements are positioned at a negative backrake angle, preferably comprises between 5° and 30° , the back rake angle that is the angle between a

25 cutter's face and a line perpendicular to the formation being drilled. When the leading edge of the cutting element is ahead of the perpendicular, the angle is, by definition, negative. When the cutter element has a positive back rake angle the angle between its cutting face and the surface of the formation to be drilled is more than 90° . When the cutter element has a

5 negative back rake angle, the angle between its cutting face and the surface of the formation to be drilled is less than 90°.

Preferably, the blade comprises a first cutting surface for cutting towards the direction of drilling and a second cutting surface for cutting towards the direction of pulling out of the hole, the first cutting surface and the second cutting surface being located respectively at both
10 opposite first end and second end of the blade, on both side of the first section of the blade surface.

Preferably, the first section of the blade surface further comprises stationary reaming elements, preferably tungsten carbide inserts or milled teeth, which are slightly undergauge relative to the outermost exposed reaming elements of the rolling element. Preferably, the top
15 of the reaming elements of the rolling elements are contained into a cylindrical envelope of constant diameter. Preferably, the outermost reaming elements of the rolling elements forms the gauge of the reaming tool and are located at a radial offset from the top of the stationary reaming elements comprised between 1 mm and 20 mm, preferably 1 mm and 10 mm, more preferably 2mm and 8 mm.

20 Preferably, the rolling element has a rotation axis comprised in a plane parallel to the longitudinal axis of the tool body.

Preferably, the blade comprises a pocket in which is secured a cartridge comprising said rolling element.

Preferably, the cartridge comprises a first block and a second block supporting a shaft
25 around which is arranged said rolling element.

Preferably, the first block and/or the second block is/are provided with reaming inserts such as tungsten carbide inserts or milled teeth. Alternatively, the first and/or second block of the cartridge is coated with a hard material such as tungsten carbide.

5 Preferably, the reaming inserts have a flat top, for example a truncated dome shaped tungsten carbide insert.

According to a second aspect, the present invention is related to a method of operating in a wellbore comprising the steps of providing a bottom hole assembly to a string, the bottom hole assembly preferably comprising a drill bit and providing a reaming tool as
10 disclosed herein above in at least one location in the string upwards to the drill bit.

Preferably, the reaming tool used in the method comprises two cutting surfaces on both sides of a reaming section. A first cutting surface is oriented towards the direction of drilling for cutting the remaining ledges or tight spots or collapsed formation after the passage of the drill bit and before the reaming of the borehole with the reaming section upon
15 rotation of the drill string. A second cutting surface is oriented towards the direction of pulling out of the hole for cutting the remaining ledges or tight spots or collapsed formation once that the drill bit has reached a certain location and that the drill string is pull out of the hole and before the reaming section reams a second time the borehole upon rotation of the drill string.

20 Advantageously, the reaming tool disclosed herein consumes less torque than currently available reaming tools while still providing the ability to cut any ledges or tight spots or collapsed formations. Another advantage of the present invention is that the reaming structure is now field-redressable. Once the rolling element is worn, the cartridge is unscrewed and a new cartridge is installed. Another advantage provided by the present
25 invention is that the lifetime of the tool is longer as the reaming of the wellbore is mainly done by the cutting elements with the cutting surface. Any large ledges will be first cut by the cutting elements.

The claimed subject matter is not to be limited in scope by the specific embodiments described herein. Indeed, various modifications of the invention in addition to those

5 described herein will become apparent to those skilled in the art from the foregoing description. Such modifications are intended to fall within the scope of the appended claims.

CLAIMS

What is claimed is:

1. A reaming tool comprising:
a tool body having a longitudinal axis and an upper end opposite a lower end; and
at least one blade extending outwardly from the external surface of the tool body, the
10 at least one blade comprising:
a rolling element defining the gauge of the reaming tool, and
a blade surface arranged undergauge of the rolling element and comprising a cutting
surface.
2. A reaming tool according to claim 1 wherein an offset between the gauge of the
15 reaming tool and the gauge of the blade surface is between 1 mm and 20 mm.
3. A reaming tool according to claim 1 wherein the blade surface further comprises:
a first section comprising the rolling element; and
a second section gradually decreasing from a first end of the first section towards the
tool body, the second section comprising a first cutting surface.
- 20 4. A reaming tool according to claim 3, wherein the blade further comprises a third
section opposite to the second section, the third section comprising a second cutting surface,
the third section gradually decreasing from a second end of the first section opposite to the
first end towards the tool body.
5. A reaming tool according to claim 3, wherein the first section of the blade surface
25 extends along the blade at a distance (D) relative to the central axis of the tool comprised
between:
a first point of the blade surface which is at the larger distance relative to the central
axis; and

- 5 a second point of the blade surface which is comprised between the first point and at least 50% of the height (H) of the gauge of the blade surface relative to the external surface of the tool body.
6. A reaming tool according to claim 3, wherein the first section of the blade surface is substantially parallel to the central axis.
- 10 7. A reaming tool according to claim 1, wherein the cutting surface is provided with one or more cutting elements disposed on at least a portion thereof, arranged on the cutting surfaces such that the tip of the cutting elements are at a radial distance from the longitudinal axis of the tool body less than or equal to the gauge of the reaming tool.
8. A reaming tool according to claim 7, wherein the cutting surface comprises an
15 arrangement of cutting elements extending from the vicinity of the external surface of the tool body to the vicinity of the first section of the blade surface.
9. A reaming tool according to claim 7, wherein one or more cutting elements are configured on the cutting surfaces so that an extended longitudinal axis of the cutting element is positioned at an angle comprised between 0° and 85° with respect to a plane perpendicular
20 to the longitudinal axis of the body.
10. A reaming tool according to claim 7, wherein the cutting elements are positioned at a negative back rake angle.
11. A reaming tool according to claim 1, wherein the rolling element comprises reaming elements.
- 25 12. A reaming tool according to claim 3, wherein the first section of the blade surface comprises reaming elements which are undergauge relative to the gauge of the reaming tool.
13. A reaming tool according to claim 1, wherein the rolling element has a rotation axis comprised in a plane parallel to the longitudinal axis of the tool body.

- 5 14. A reaming tool according to claim 1, wherein the blade comprises a pocket in which is secured a cartridge comprising said rolling element.
15. A reaming tool according to claim 14, wherein the cartridge comprises a first block and a second block supporting a shaft around which is arranged the rolling element.
16. A reaming tool according to claim 15, wherein one of the first block and the second
10 block are provided with reaming elements or hard material coating.
17. A reaming tool according to claim 12, wherein the reaming elements are reaming inserts with a flat top.
18. A method of operating in a wellbore comprising the steps of:
providing a bottom hole assembly to a string;
15 providing a reaming tool in at least one location in the string within or above the bottom hole assembly, the reaming tool comprising:
a tool body having a longitudinal axis and an upper end opposite a lower end; and
at least one blade extending outwardly from the external surface of the tool body, the
at least one blade comprising:
20 a rolling element defining the gauge of the reaming tool, and
a blade surface arranged undergauge of the rolling element and comprising a cutting surface.

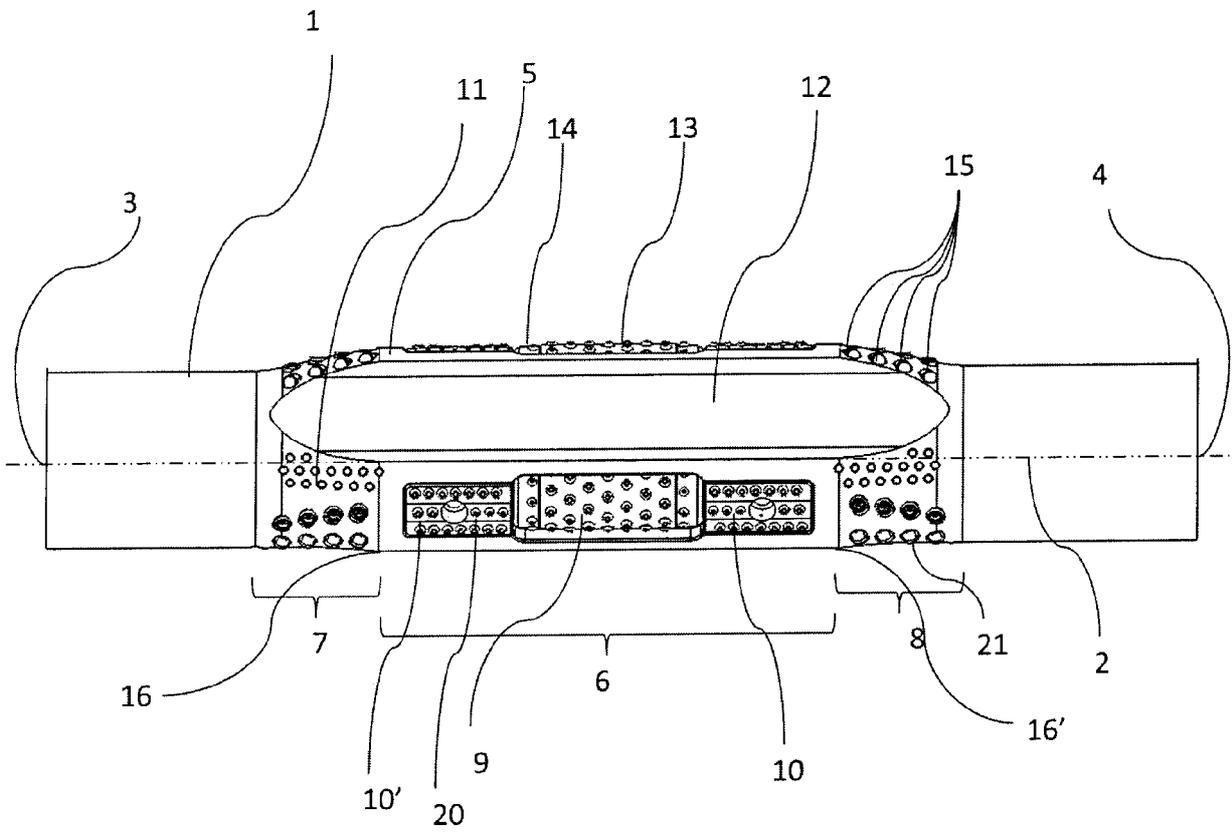


Fig. 1

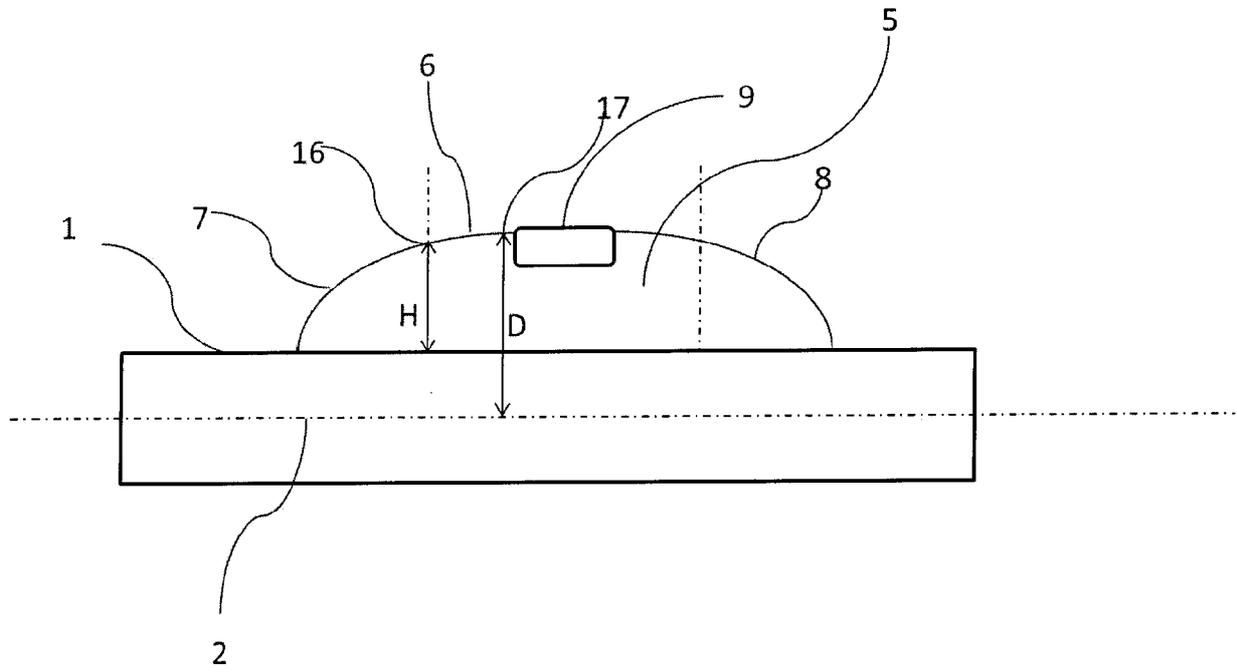


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No PCT/IB2015/051732
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A. CLASSIFICATION OF SUBJECT MATTER
 INV. E21B10/30
 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

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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Y	paragraph [0005] paragraph [0053] - paragraph [0055] figures 1,27,28 paragraph [0108] - paragraph [0108] -----	16
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A	figures 3,5 page 2, line 90 - line 122 -----	7-12, 14-17
Y	US 2008/202818 A1 (MCMANUS TERRY MICHAEL [AU]) 28 August 2008 (2008-08-28)	16
A	paragraph [0019] - paragraph [0021] figure 1 -----	1-15, 17, 18

Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>
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Date of the actual completion of the international search 25 June 2015	Date of mailing of the international search report 07/07/2015
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Altamura, Alessandra
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/IB2015/051732
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