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- (81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

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- (54) Title: ACTUATOR BALL RETRIEVER AND VALVE ACTUATION TOOL

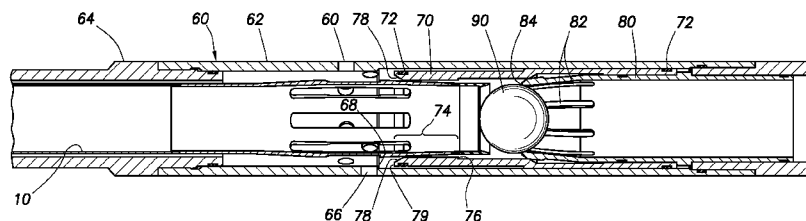


FIG.2

- (57) Abstract: Disclosed is a tool for changing a plurality of sleeve valves in a well from a ball catching restricted bored state to an open bore state and for retrieving sleeve valve actuator balls of substantially the same diameter from the well.

ACTUATOR BALL RETRIEVER AND VALVE ACTUATION TOOL

CROSS REFERENCE TO RELATED APPLICATIONS

None.

BACKGROUND

Technical Field

[0001] This invention relates to tools for recovering actuator elements, such as, balls and darts, inserted into wells from the surface to actuate subterranean well tools such as sliding sleeve valves and tools for shifting the well tools. More particularly, this invention relates to recovering actuator elements from sleeve valves and for shifting elements of the valves.

Background Art

[0002] It is common to assemble and install wellbores with a plurality of sleeve valves spaced along the length of the wellbore to provide access to selected formation areas along the wellbore. These sleeve valves are operated by inserting and pumping actuator elements down the wellbore. These balls engage a seat on the valve's sleeve allowing pressure to build up to force the ball and sleeve to shift to the open position. It is also common to use circular cross section shaped actuator darts instead of spherical balls. In the description herein, for simplicity the actuator elements will be referred to as actuator balls, but it is to be understood that the invention is applicable to recover actuator darts.

[0003] Typically when multiple valves are present in a well, balls and mating valve seats of different diameters were used. The valves were arranged with the smallest seat at the bottom of the well and with the largest valve seat nearest the well head. In

these configurations the number of valves in a well was limited by the number of ball diameters that could be used. In addition, the smaller valve seats presented undesirable flow restrictions in the well during production. After these balls are used to actuate the valves, they were either flowed back to the surface or drilled out.

[0004] New sleeve valve systems have been developed where multiple valves are actuated by balls of the same diameter. The valve seats, sometime called baffles, can be actuated by various means to change from an open-bore ball pass-through state to a restricted bore ball-catching state. The valves in these new valve systems are assembled with the bottom valve (farthest from the wellhead first) actuating to the ball-catching state first and then the valves progressing up the wellbore toward the well head actuating to the ball catching state in sequence. In these new systems, none of the actuator balls below except the top ball can be flowed back to the surface due to restricted wellbore in the valves above the actuator balls. Removal of the actuator balls requires expensive drilling procedures.

SUMMARY OF THE INVENTIONS

[0005] The present invention provide a down hole wellbore tool and method for attachment to wire line or tubing string to retrieve a plurality of actuator balls of the same size and for engaging and shifting elements of the valve.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The drawing is incorporated into and forms a part of the specification to illustrate at least one embodiment and example of the present invention. Together with the written description, the drawing serves to explain the principles of the invention. The drawing is only for the purpose of illustrating at least one preferred example of at least one embodiment of the invention and is not to be construed as limiting the invention to

only the illustrated and described example or examples. The various advantages and features of the various embodiments of the present invention will be apparent from a consideration of the drawing in which:

[0007] **Figure 1** is a diagram of a side elevation view partially in section of the tool of present invention; and

[0008] **Figure 2** is a longitudinal section view of the tool on of the present invention in a sleeve valve approaching an actuator ball.

DETAILED DESCRIPTION

[0009] The present invention provides an improved tool and method for retrieving actuator balls and engaging and shifting elements of the valves. The present invention's particular applicability is to multiple sleeve wellbores that are actuated by balls of the same diameter.

[0010] Referring more particularly to the drawings, wherein like reference characters are used throughout the various figures to refer to like or corresponding parts, there is shown in **Figure 1** one embodiment of the tool 10 of the present invention which is adapted to be lowered into a wellbore while connected to a wire line or tubular string . It should be understood by those skilled in the art that the use of directional terms, such as above, below, upper, lower, upward, downward and the like are used in relation to the illustrative embodiments as they are depicted in the figures, the upward direction being toward the left side of the corresponding figures and the down-hole direction being toward the right side of the corresponding figure.

[0011] The tool 10 has an elongated tubular body 12 of relatively rigid material with an actuator ball receiving cylindrical chamber 14 formed therein. The chamber is open at its down-hole end 16 to accommodate the entry of actuator balls into the chamber. Only a portion of the body 12 of tool 10 is illustrated, it being understood that the tool 10 is assembled in sections (not illustrated) extending from the up-hole end 18

such that the chamber 14 is of a sufficient axial length to retrieve and hold therein all of the plurality of actuator balls in a given wellbore. The up-hole end includes a wire line connection or threads (not illustrated) as is known in the art. In addition the internal diameter of the chamber is set to be of a size to receive the actuator balls therein.

[0012] An actuator section 20 of the body 14 is positioned adjacent the actuator ball receiving down-hole end 16. As will be described herein, section 20 is configured to engage a down-hole sleeve valve and change it to the open-bore state. Section 20 comprises a plurality of longitudinally extending sections 22 separated by slots 24. Sections 22 are slightly bowed radially outward and act as leaf springs which can be resiliently deflected radially inwardly. When the profiles 26 are forced to be deflected inwardly sections 22 bend or deform inwardly and sections 22 will snap back when the force is released. Tool engaging profiles 26 are formed on the exterior surface of the sections 22. Each profile 26 includes a slot 28 with an upwardly facing shoulder 30 at its lower end and a ramp surface 32 at its upper end.

[0013] The down-hole end 16 comprises a rubber element 40 bonded or otherwise attached to the body 12. The rubber element 40 has a hook shaped reduced internal diameter portion 42. The rubber element 40 is of a size that when it is forced downward onto an actuator ball it will stretch over the actuator ball and retain it in the chamber 14. The tool 10 is designed to be lowered into a wellbore and when it encounters an actuator ball, it will swallow it into its belly like chamber 14. Indeed, the chamber is large enough that it can hold a plurality of actuator balls.

[0014] Turning now to **Figure 2**, the operation of the tool 10 in a typical sleeve valve 60 will be described in detail. In this particular sleeve valve embodiment, the valve 60 has a tubular body 62 which is connected in the tubing string 64 of the wellbore. The valve 60 can be shifted from an open bore state to a ball catching state. In the ball catching state radially extending ports 66 in the wall of the valve can be opened by landing a ball 90 in the valve and increasing pressure in the well. These radially extending ports 66 provide a flow path through the wall of the well bore. A downwardly

directed annular shoulder 68 is formed on the internal surface of the body 62 axially below the ports 66.

[0015] A sleeve valve 70 with seals 72 acts as a valve element and is mounted in the valve body to axially slide from a position blocking or closing off the ports 66 to a position axially spaced from the ports 66, as is illustrated in Figure 2. An annular profile 74 is formed on the interior surface of sleeve valve 70. Profile 26 is designed to mate with profile 74. Profile 74 has a downward facing shoulder 76 of a size and shape to be engaged by upward facing shoulder 30 on tool 10. Profile 74 has an upward facing ramp 78 and an annular shaped end forming a face 79 of a size and shape to engage shoulder 68 on body 62. As will be explained, the shoulder 30 on tool 10 will engage the shoulder 76 on sleeve valve 70 as the tool 10 is pulled upward from below the valve. As the tool 10 moves up the well the engaged shoulders will shift the sleeve upward until stopped by the engagement of shoulder 68 with face 79.

[0016] A baffle 80 is located in the valve 60 axially below the sleeve valve 70. Baffle 80 is sleeve shape and is made of spring steel. One end of baffle 80 has slots 82 to form a collet that can radially contract from an expanded shape to form an annular ball catching seat 84. As illustrated in Figure 2, when the valve sleeve 70 is moved axially under the upper end of the baffle 80, the collet end contracts to form seat 84. When the valve sleeve 70 is moved to a position spaced from baffle 80; the collet end expands radially to create an open bore pathway through the valve 60.

[0017] The method of use of the tool 10 will be described with regard to the valve illustrated in **Figure 2**. Valve sleeve 70 is installed in the well in a closed position blocking flow through ports 66. Mechanisms known in the industry, are provided for shifting the valve sleeve 70 axially downward to slide under the collet end of baffle 80 contracting the internal diameter to form a ball engaging seat 84. Examples of such mechanisms include hydraulic lines actuating the valve seat and electronically controlled explosive devices actuating the seat. Examples are described in U.S. Patent Application Numbers: 2013219790 and 2013440727 and U.S. Patent Publications Numbers

20110203800; 20110240301; 20110067888 and 2011007332. Also, see examples in U.S. Patents Numbers: 7,637,323; 7,322,417; 7,644,772; 7,322,417; and 7,628,210. Each of the applications, publications and patents listed above are incorporated herein by reference for all purposes.

[0018] Once the valve moves to the ball catching state, an actuator ball can be dropped onto the seat and pressure in the well increased to move the sleeve 70 valve to the open position illustrated in Figure 2. Formation treatment can then be conducted through the open ports 66. Once, treatments are completed the process can be repeated for the remaining valves located higher up in the well.

[0019] When well treatments are completed the tool 10 of the present invention can be used to retrieve the actuator balls and to return the valve 60 to the open bore state. Tool 10 is lowered into the well until the down-hole end 16 engages and captures the first actuator ball 90 in the chamber 14. The tool 10 is lifted with the hook shaped reduced internal diameter portion 42 of the rubber element 40 retaining the ball 90 in the chamber 14.

[0020] As the tool moves through each valve 60, the valve is changed to the open bore state with the valve sleeve 70 positioned spaced away from baffle 80. In this position the collet end of baffle 80 expands radially to create an open bore pathway through the valve 60.

[0021] To move the valve sleeve 70 to a position axially spaced away from the baffle, the tool is raised. The interior annular profile 74 formed on the interior surface of sleeve valve 70 engages the corresponding exterior profile 26 on tool 10. As the tool 10 raised the downward facing shoulder 76 on profile 74 contacts the upward facing shoulder 30 on tool 10 and axially forces the valve sleeve 70 to shift upward. As the tool 10 moves up the well the engaged shoulders will shift the sleeve upward until stopped by the engagement of shoulder 68 with face 79. With the sleeve shifted into contact with shoulder 68 the shape and/or size of the profiles 26 and 74 are selected to cause the exterior profile on the tool to deflect radially inward so that shoulders 76 and 30 to

disengage. Thus, with the valve sleeve 70 contacting shoulder 68 and in a position out from under the baffle 80, the collet end of baffle 80 is released to expand radially to create the open bore state.

[0022] With the baffle in the open bore position the tool 10 can be lowered down into the well through the valve 60 to engage and capture the remaining actuator balls 90 in the well. The downward facing ramp surfaces on the tool 10 and upward facing ramp surfaces on sleeve valve 60 prevent downward shifting of the sleeve valve as the tool moves down through the valve. The tool 10 can be retrieved from the well through each valve.

[0023] The present inventions have been described by way of example by referring to a valve configuration wherein the sleeve is shifted upward to retract the baffle. It should be understood, that the present inventions are also applicable to valves wherein the sleeve is shifted downward to change the valve to the open bore state. In addition to changing the valve to the open bore state, the tool could be used to shift the baffle and shift the valve between the open and closed positions.

[0024] While compositions and methods are described in terms of “comprising,” “containing,” or “including” various components or steps, the compositions and methods also can “consist essentially of” or “consist of” the various components and steps. As used herein, the words “comprise,” “have,” “include,” and all grammatical variations thereof are each intended to have an open, non-limiting meaning that does not exclude additional elements or steps.

[0025] Therefore, the present inventions are well adapted to carry out the objects and attain the ends and advantages mentioned as well as those which are inherent therein. While the invention has been depicted, described, and is defined by reference to exemplary embodiments of the inventions, such a reference does not imply a limitation on the inventions, and no such limitation is to be inferred. The inventions are capable of considerable modification, alteration, and equivalents in form and function, as will occur to those ordinarily skilled in the pertinent arts and having the benefit of this disclosure.

The depicted and described embodiments of the inventions are exemplary only, and are not exhaustive of the scope of the inventions. Consequently, the inventions are intended to be limited only by the spirit and scope of the appended claims, giving full cognizance to equivalents in all respects.

[0026] Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. Moreover, the indefinite articles “a” or “an”, as used in the claims, are defined herein to mean one or more than one of the element that it introduces. If there is any conflict in the usages of a word or term in this specification and one or more patent(s) or other documents that may be incorporated herein by reference, the definitions that are consistent with this specification should be adopted.

Claims:

1. A tool for use in a wellbore containing a plurality of subterranean sleeve valves with substantially the same size actuator elements contacting radially constricted annular baffles, the tool comprising:

an elongated tubular body, a chamber in the body of a size to receive at least one of a plurality of actuator elements of substantially the same outer diameter, an opening on one end of the body extending from the chamber to the exterior of the body, the opening being of a size for the actuator elements to pass there through,

means on the other end of the body for supporting the tool in the wellbore at a subterranean location, and

surface structure on the exterior of the tubular body, the surface structure being of a size and shape to contact and shift an element of the sleeve valves.

2. The tool according to **Claim 1**, wherein the chamber in the body of a size to receive a plurality of spherical ball shaped actuator elements of substantially the same outer diameter.

3. The tool according to **Claim 1**, wherein the valve element shifted changes the annular valve baffles to the unconstricted state when the tool is moved.

4. The tool according to **Claim 1**, additionally comprising a resilient member at the body opening forming a second size opening which is smaller in cross section area than the actuator element.

5. The tool according to **Claim 4**, wherein the resilient member at the body opening comprises from elastomeric material.

6. The tool according to **Claim 1**, wherein surface structure comprises a plurality of circumferentially spaced shoulders.

7. The tool according to **Claim 6**, wherein the shoulders are formed on an element of the body that is radially inwardly deformable.
8. The tool according to **Claim 1**, wherein the surface structure comprises a shoulder on a leaf spring.
9. The tool according to **Claim 7**, wherein the body elements extend longitudinally and are separated by longitudinally extending slots in the body.
10. A method for retrieving from a wellbore a plurality of spherical shaped actuator elements having substantially the same cross section diameter and for shifting an element in the valve, the method comprising:
 - providing a tool with an elongated tubular body, a chamber in the body of a size to receive therein a plurality of the actuator elements, an opening on one end of the body extending from the chamber to the exterior of the body, the opening being of a size for the actuator elements to pass there through, and surface structure on the exterior of the tubular body;
 - attaching the tool to a wireline and installing the tool into the wellbore with the one end preceding into the well first;
 - lowering the tool into the wellbore until it comes into contact with an actuator element on the first valve;
 - moving the actuator element into the chamber and retaining it in the chamber;
 - next, engaging the surface structure on the tool with valve to shift an element of the valve;
 - moving the tool through the first valve;
 - lowering the tool into contact with the actuator element of the next valve, and
 - repeating the actuator element moving and retaining step and the valve shifting steps comprise changing the valve to a larger internal diameter open bore state.

11. The method according to **Claim 10**, wherein the step of valve shifting step comprises engaging a surface on the exterior of the tool with an interior surface in the valve sleeve and moving the tool to shift the element.
12. The method according to **Claim 10**, wherein the providing step comprises providing a sleeve valve and wherein the valve element shifting steps comprises shifting the valve sleeve valve
13. The method according to **Claim 10**, wherein the tool in the providing step comprise a chamber in the body of a size to receive a plurality of spherical ball shaped actuator elements of substantially the same outer diameter.
14. The method according to **Claim 10**, wherein the tool in the providing step comprises a chamber in the body of a size to receive a plurality of circular cross section dart shaped actuator elements of substantially the same outer diameter.
15. The method according to **Claim 10**, wherein the tool in the providing step comprises a resilient member at the body opening forming a second size opening which is smaller in cross section area than the actuator element.
16. The method according to **Claim 10**, wherein the resilient member at the body opening comprises from elastomeric material.
17. The method according to **Claim 10**, wherein the surface structure in the tool of the providing step comprises a plurality of circumferentially spaced shoulders.
18. The tool according to **Claim 17**, wherein the shoulders are formed on an element of the body that is radially inwardly deformable.

19. The method according to **Claim 10**, wherein the surface structure on the tool in the providing step comprises a shoulder on a leaf spring.
20. The tool according to **Claim 18**, wherein the body elements extend longitudinally and are separated by longitudinally extending slots in the body.

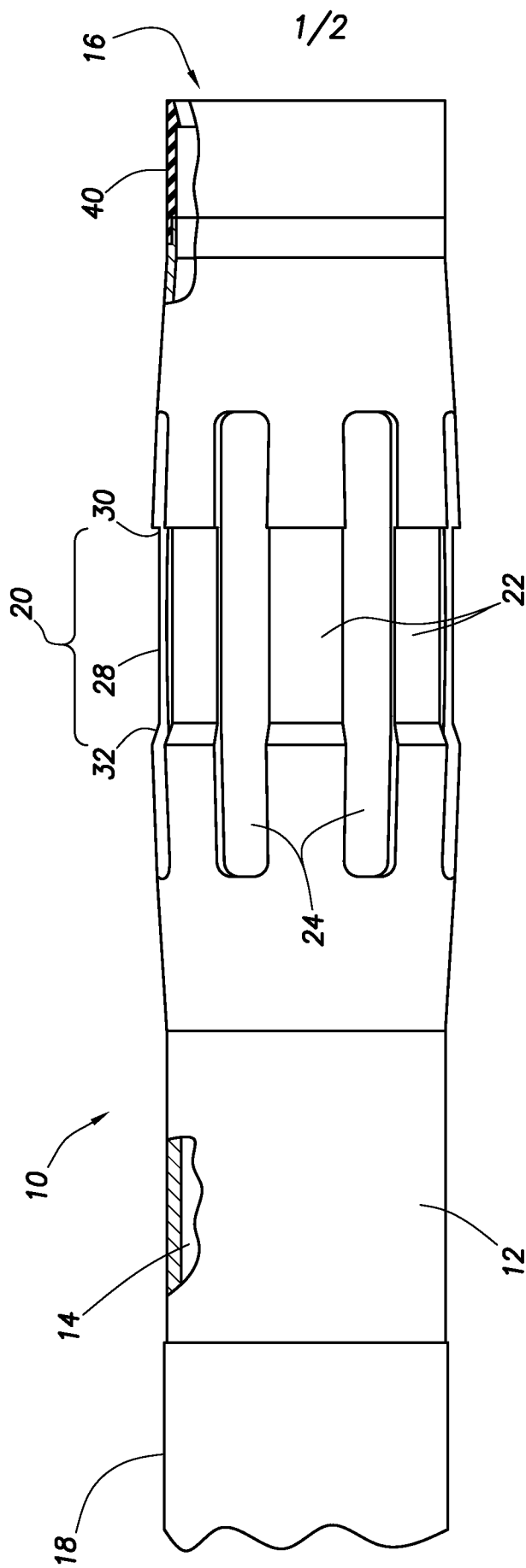


FIG. 1

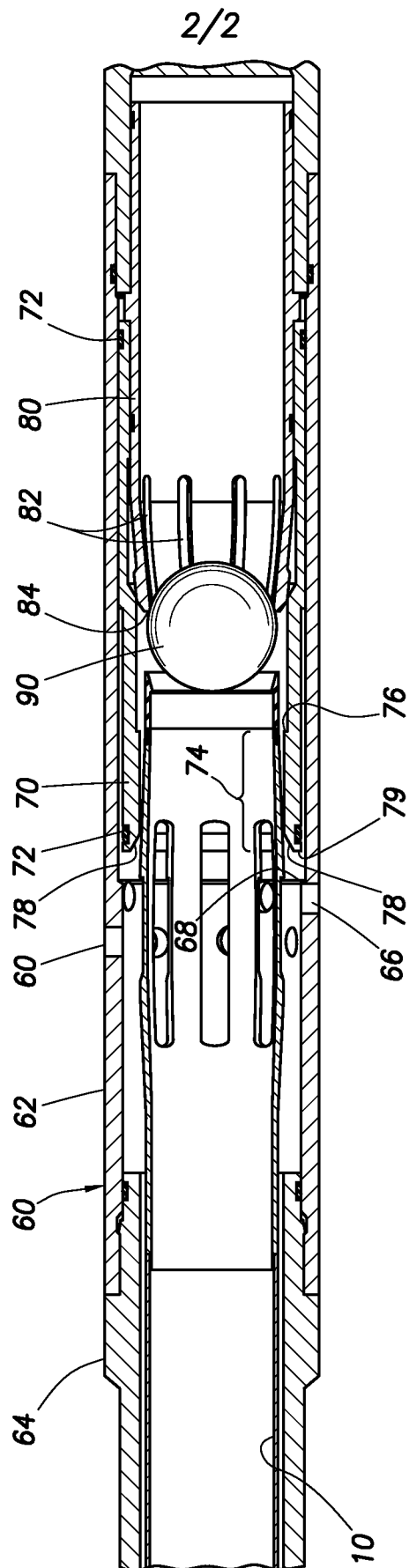


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/032724**A. CLASSIFICATION OF SUBJECT MATTER****E21B 19/16(2006.01)i, E21B 17/02(2006.01)i**

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 19/16; E21B 23/04; E21B 34/06; E21B 44/00; E21B 34/12; E21B 43/26; E21B 34/14; E21B 17/02

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords:actuator, valve, tubular, sleeve, chamber, ball, and tool

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013-0025868 A1 (SMITH et al.) 31 January 2013 See paragraphs [0015]-[0050] and figures 2-7.	1-9
A		10-20
A	US 2006-0124312 A1 (RYTLEWSKI et al.) 15 June 2006 See paragraphs [0023]-[0052] and figures 2-7.	1-20
A	US 2012-0205120 A1 (HOWELL, MATTHEW TODD) 16 August 2012 See paragraphs [0028]-[0045] and figures 2-6.	1-20
A	US 4893678 A (STOKLEY et al.) 16 January 1990 See column 5, line 20 - column 8, line 45 and figures 1-6.	1-20
A	US 2011-0278017 A1 (THEMIG et al.) 17 November 2011 See paragraphs [0046]-[0056] and figures 2A-2F.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"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

"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

"&" document member of the same patent family

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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