Tool and method for locking and releasing a plug

Introduction

The present invention relates to a tool for locking and releasing a plug in a well, for example, a hydrocarbon well, as specified in the independent apparatus claim. The invention further relates to methods for locking and releasing the plug, as specified in the preamble of the independent method claims.

Background for the invention

It is usual to use rotation of the drill string when a running tool is to be fastened to or released from a plug in a well. Examples of such solutions can be found, for example, in US 3509940 A and US 2008/0128132 A1. US 3509940 A relates to a well tool that can be reused for retrieving and setting of a plug in a well. The plug has provided at its upper end a transverse bar for retrieving and setting of the plug. The running tool has at its lower end two corresponding "J-slots" for receiving the transverse bar on the plug. The bar is fastened to, and released from, the running tool by rotation.
US 2008/0128132 A1 shows another plug with associated running tool for retrieving and setting a plug. In this document, the upper end of the plug is provided with recesses, in the form of "J-slots", which correspond with pins arranged on the inside of a lower sleeve on the running tool, for setting and retrieving the plug. The fastening and release of the running tool from the plug takes place by rotation.

Plugs are usually set and released by rotation of the drill string, but it can be difficult to achieve controlled rotation at great well depths. There are several potential sources of error which render the setting and release hazardous. One such source of error could be left-hand (anti-clockwise) rotation, which may result in equipment such as the drill pipe or plugs being unscrewed from one another.

It is an object of the invention to resolve some of the drawbacks of the prior art. The object is achieved by means of a plug and methods for its setting and release according to the independent claims, with embodiments of the invention specified in the dependent claims. The setting and release take place essentially by means of axial movement of the pipe. Another object is to provide a plug which can be used for several operations in a well with little call for maintenance of the plug between the different operations.

Summary of the invention

In the present invention, according to independent claim 1, a tool for locking and releasing a plug in a hydrocarbon well is defined, wherein the plug has at least one pin element, and wherein the tool comprises: a sleeve having at least one pocket for receiving the plug's pin element, at least one locking element that can be moved between a release position in which the pocket is open, and a locking position in which the pocket is closed; and

- when locking the tool to the plug, the tool is moved in the hydrocarbon well to facilitate positioning of the pin element in abutment with the locking element, wherein further movement of the tool moves the locking element to an open position for receiving the pin element in the pocket, and the locking element is brought into a locking position such that the plug's pin element is locked in the pocket; and

- when releasing the tool from the plug, fluid means are used for movement of the locking element into a release position for release of the plug's pin element from the pocket.

Fluid means may be any fluid that is suitable for being be pressurised, such as hydraulic fluid.

The invention relates also to a method for releasing the plug, where the plug comprises a sleeve-like part which is in abutment with the at least one spring at one of its ends and connected to the locking element at its other end, and where the plug's pin element is released from the pocket by applying a fluid pressure which acts on a piston face in the sleeve-like part, such that the sleeve-like part is moved, and the at least one spring is compressed thereby and moves the locking element into the release position. Any resilient element having the same properties as a spring can be used, as, for instance, resilient packers.

The invention relates further to a method for locking the plug to the tool, where the plug's at least one pin element, when the tool is run downhole, moves the at least one locking element into an open position at the same time as the at least one spring is compressed, and where the pin element is inserted into the pocket, after which each spring, with connected locking element, returns to its unloaded position and the locking element is moved into the locking position.

In connection with the locking element there may be provided at least one spring, which spring is in an unloaded position when the locking element is in the locking position.

The locking element may be connected to at least one sleeve-like part enclosing a movable sleeve which encloses an inner bore, the inner bore and the movable sleeve may have openings for fluid communication between the inner bore and a piston face formed in an axial space in the sleeve-like part.

The sleeve in the tool may be configured with an oblique guiding portion for insertion of the pin element into the pocket.

In an embodiment, the pocket may be provided with at least one oblique side face.

The sleeve-like part in an embodiment is moved axially. A cavity may be arranged in connection with the movable sleeve, which cavity is suitable for fluid communication with the inner bore through the openings. An applied weight on the

tool can move the movable sleeve in order to permit fluid communication between the cavity and the axial space through the openings.

In another embodiment, the method for releasing the plug from the tool further comprises that the sleeve-like part encloss an axially movable sleeve which encloses an internal bore. A weight that is applied to the tool is able to move the movable sleeve such that a fluid can migrate between the inner bore, via openings to a cavity, and further from the cavity through openings into an axial space in towards the piston face in the sleeve-like part. The force of the fluid is exerted on the piston face and is sufficient to compress the at least one spring, and move the locking element into the release position.

Description of the invention

An example of an embodiment of the invention will now be described with reference to the figures, wherein:

Figure 1 is a perspective view of a tool coupled to a plug.
Figures 2A-2C show an axial section of the tool in Figure 1, in the area B, wherein:
Figure 2A shows a sleeve on a lower part of the tool where a pin element on a plug is locked to the tool;
Figure 2B shows the sleeve on the lower part of the tool, where the locking element is in a release position and the plug's pin element can be released from the tool; and
Figure 2C shows the sleeve on the lower part of the tool, where the plug's pin element is in the process of being released from the tool.
Figures 3A and 3B show a section of Figure 1, in the area A, wherein:
Figure 3A shows the tool locked to the plug's pin element;
Figure 3B shows the tool when the plug's pin element and the locking element are in a releasing position from the tool.
Figure 4A-4H show, step by step, the tool on the way down on the plug to the locking position.

Figure 1 shows a tool 1 according to the present invention, connected to a plug 2.

Figures 2A-2C, sections of the area B in Figure 1, show, step by step, the release of a pin element 5 on a plug 2 from a pocket 4 in a sleeve 3 on the tool 1.
Figure 2A shows the plug's 2 pin element 5 in a locking position in the sleeve 3. At least one locking element 6 arranged in a respective locking groove 32 in the sleeve 3 prevents release of the plug's 2 pin element 5. The locking element 6 is connected to a spring 7 (see Figure 3A) at one of its ends and follows the movement of the spring 7. In Figure 2A the spring 7 is shown in an unloaded position. The locking element 6 is in a locking position in a lower position in the locking groove 32 and the plug's 2 pin element 5 is locked in the pocket 4. In the pocket 4 in the sleeve 3, oblique side faces 18, 19 are provided to allow the plug's 2 pin element 5 more easily to slide into and out of the pocket 4. Arranged flush with the oblique side

faces 18, 19 in the sleeve 3 is an oblique guide portion 40. On the lower part of the sleeve 3 is arranged at least one oblique portion 31 which guides the plug's 2 pin element 5 into and out of the sleeve 3. When the plug's 2 pin element 5 is to be released from the locking position, a fluid pressure is applied, for example, hydraulic, which causes the spring 7, with the connected locking element 6, to be pressed back. The locking element 6 is then moved to an upper position in the locking groove 32, as shown in Figure 2B and Figure 2C, and is in a release position. The plug's 2 pin element 5 can now be released. An axial movement of the tool 1 towards the surface has the result that, whilst the plug 2 with the pin element 5 is anchored in the well, the plug's 2 pin element 5 will follow the oblique side faces 19 in the pocket 4, and out of the pocket 4, until the plug 2 is released.

Figures 3A and 3B are axial sections of Figure 1, at area A, and show the tool 1 with the locking element 6 in the locking position (Figure 3A) and the release position (Figure 3B). The tool 1 has an inner bore 9 containing fluid, for example, hydraulic fluid.

The inner bore 9 has first radial openings 8 so as to allow the fluid to flow into a cavity 17 radially exterior to the inner bore 9. A movable sleeve 16 is arranged radially exterior to the inner bore 9. The movable sleeve 16 can be moved to permit the fluid to flow from the inner bore 9 to the cavity 17, through the openings 8, and on from the cavity 17 through radial openings 23 in the movable sleeve 16 to a first axial space 11 exterior to the movable sleeve 16. The movable sleeve 16 has on its radial outer surface a piston 33 that can be moved in a groove 34 in a sleeve-like part 10, the piston 33 dividing the groove 34 into the axial space 11 and an inner space 20. The sleeve-like part 10 is connected to the spring 7 on one side and to the locking element 6 on the other side.

Release

When releasing the plug's 2 pin element 5, a weight is first applied to the tool 1 which is able to move the movable sleeve 16 axially. This can be seen in Figures 3A and 3B where the movable sleeve 16 has moved towards the right relative to the inner bore 9 in Figure 3B. When the piston 33 of the movable sleeve 16 has moved to the end position in the groove 34, see Figure 3B, fluid communication will be facilitated between the interior of the bore 9 and the axial space 11 exterior to the movable sleeve 16, in that the openings 8 and 23 are in a position in which fluid can flow from the inner bore 9 to the cavity 17 and into the axial space 11. When pressure is applied to the fluid in the inner bore 9, the sleeve-like part 10 will be pressed against the spring 7 by a piston face 24 in the sleeve-like part 10, and overcome the spring force of the spring 7. As the locking element 6 is connected to the spring 7 via the sleeve-like part 10, compression of the spring 7 will cause the locking element 6 to be moved with the spring 7 and come into the release position. The tool 1 is now free to leave the plug 2 in the well. When the tool 1 is pulled

towards the surface, the plug 2 and pin element 5 will remain stationary whilst the lower sleeve 3 on the tool 1 follows the recess in the lower sleeve 3 when the tool is released from the plug 2.

Locking

Figures 4A-4H show, step by step, the locking of the plug's 2 pin element to the sleeve 3 on the tool 1. In Figure 4A, the tool and the plug 2 are separated, which is the situation before the tool has come down to the plug 2. In Figure 4B the plug 2 is on the way into the sleeve 3 as a result of the tool 1 having been moved in the direction of the plug. In Figure 4C, the pin element 5 on the plug 2 has come into contact with the locking element 6, and in Figures 4D-4E the pin element 5 has started to move/push on the locking element 6. In Figure 4F, the pin element 5 has come into contact with the oblique side face 18 in the sleeve 3. This is also shown in Figure 2C. On further movement of the tool 1, the pin element 5 will enter into the pocket 4, and be locked in that the spring 7 which is connected to the locking element 6, returns to its starting position because the pin element 5 no longer pushes against the locking element 6 (see also Figure 3A). The plug's 2 pin element 5 is now locked to the sleeve 3 of the tool 1, and the plug 2 can be taken out.

The invention has now been explained by means of one embodiment. A person of skill in the art will understand that changes and modifications may be made to the embodiment described which are within the scope of the invention as defined in the attached claims.

PATENT CLAIMS

1. A tool (1) for locking and releasing a plug (2) in a hydrocarbon well, wherein the plug (2) has at least one pin element (5), and wherein the tool (1) is *characterized in* that it comprises;
- a sleeve (3) with at least one pocket (4) for receiving the plug's (2) pin element (5);
- at least one locking element (6) that can be moved between a release position in which the pocket (4) is open, and a locking position in which the pocket (4) is closed; and
- when locking the tool (1) to the plug (2), the tool (1) is moved in the hydrocarbon well to facilitate positioning of the pin element (5) in abutment with the locking element (6), wherein further movement of the tool (1) moves the locking element (6) into an open position for receiving the pin element (5) in the pocket (4), and the locking element (6) is brought into a locking position such that the plug's (2) pin element (5) is locked in the pocket (4); and
- when releasing the tool (1) from the plug (2), fluid means are used for movement of the locking element (6) into a release position for release of the plug's (2) pin element (5) from the pocket (4).

2. A tool according to claim 1, *characterized in* that the locking element (6) is provided with at least one spring (7), wherein the spring (7) is in an unloaded position when the locking element (6) is in the locking position.

3. A tool according to claim 1 or claim 2, *characterized in* that the locking element (6) is connected to at least one sleeve-like part (10) enclosing a movable sleeve (16) which encloses an inner bore (9), the inner bore (9) and the movable sleeve (16) having openings (8, 23) for fluid communication between the inner bore (9) and a piston face (24) formed in an axial space (11) in the sleeve-like part (10).

4. A tool according to one of claims 1-3, *characterized in* that the sleeve (3) has an oblique guide portion (40) for insertion of the pin element (5) into the pocket (4).

5. A tool according to one of claims 1-4, *characterized in* that the pocket (4) is provided with at least one oblique side face (18, 19).

6. A tool according to claim 3, *characterized in* that the sleeve-like part (10) can be moved axially, and where there is provided a cavity (17) in connection with the movable sleeve (16), which cavity (17) is suitable for fluid communication with the inner bore (9) through the openings (8), and where an applied weight on the tool (1) is able to move the movable sleeve (16) in order to permit fluid communication between the cavity (17) and the axial space (11) through the openings (23).

7. A method for releasing the plug (2) according to claim 2, *characterized in* that it comprises a sleeve-like part (10) which is in abutment with the at least one

spring (7) at one end and connected to the locking element (6) at the other end, and where the plug's (2) pin element (5) is released from the pocket (4) by applying a fluid pressure which acts on a piston face (24) in the sleeve-like part (10) such that the sleeve-like part (10) is moved, and the at least one spring (7) is thereby compressed and moves the locking element (6) into the release position.

8. A method according to claim 7, *characterized in* that the sleeve-like part (10) encloses an axially movable sleeve (16) which encloses an inner bore (9), in that a weight is applied to the tool (1) and moves the movable sleeve (16) so as to allow fluid to migrate between the inner bore (9), via openings (8) to a cavity (17), and further from the cavity (17) through openings (23) into an axial space (11) in towards the piston face (24) in the sleeve-like part (10) and, in that the force from the fluid which is exerted against the piston face (24) is sufficient to compress the at least one spring (7), and move the locking element (6) into the release position.

9. A method for locking the plug (2) according to claim 2, *characterized in* that the plug's (2) at least one pin element (5), upon movement of the tool (1), moves the at least one locking element (6) into an open position whilst the at least one spring (7) is compressed, and where the pin element (5) is inserted into the pocket (4), after which each spring (7), with the connected locking element (6), returns to its unloaded position and the locking element (6) is moved to the locking position.