

Downhole tool

The present invention relates to a downhole tool comprising

- 5 - a tubular body provided with an axial cavity,
- a hollow piston capable of sliding in the axial cavity and subjected to variable differential hydraulic pressures, and
- 10 - a device for activating the hollow piston.

Downhole tools of this type are known, for example underreaming and stabilisation tools to be used in a bore hole (see for example WO 2005/124094).

- 15 Drilling, underreaming or other tools must be lowered with the hollow piston held fixedly inside the tubular body and then, when the tool is in position, the hollow piston can be activated. A system for locking the piston has already been envisaged which, in a closed position, holds the hollow piston
- 20 axially in an immobilisation position and which is brought into the release position by electrical control.

- However, in general terms, it is more usual to control the activation of the hollow piston hydraulically, by means of a fluid formed by drilling mud.
- 25 When the latter circulates in the string connecting the tool to the surface, the piston immobilised by the activation device is subjected to a differential pressure that acts on the piston upwards or downwards. The activation device provides a tubular extension extending the piston. The end of this extension is kept fixed in a tubular sleeve by shear pins. A sleeve bears on
- 30 a ring forming a stop and fixed to the tubular body of the tool. This stop prevents the movement of the piston subjected to a differential pressure and

therefore producing a traction force on the tubular sleeve, as long as this pressure remains below a predetermined threshold.

5 The shear pins are calibrated so that a traction force of the piston greater than the above-mentioned threshold causes a shearing of the pins and releases the hollow piston, which can then slide in the axial cavity in the tubular body of the tool. In the case of an underreaming tool, the piston, which has become driving, then allows the deployment of a cutting arm.

10 The calibrated value of the shear pins is a compromise between on the one hand the limit of use of the tool in its dormant mode, that is to say when the hollow piston is not activated, and the limit of the maximum pressure acceptable for the tool or available through the drilling pumps.

15 In order not to limit the working capacities of the tool in dormant mode and to prevent, which is not always possible, risks of accidental activation that might be caused for example by a pressure jolt, the calibre of the shear pins is designed so as to be as high as possible. The shearing is caused by a temporary closure of the tubular sleeve by a ball and/or a very significant
20 increase in the pressure of the drilling mud. The substantial energy stored by the driving piston must then be dissipated on the release of the piston caused by the rupture of the pins. The shock that results from this may cause deformation of parts and impair the subsequent functioning of the tool.

25 Moreover, experience has shown that dead volumes and play between parts could present an obstacle to the correct function of the mechanism of the tool. This is because the particles present in drilling mud may compact or cement at these places so as to interfere with or prevent the movement
30 of the parts.

The aim of the present invention is to develop an activation device that is not subject to the risks of accidental activation of the hollow piston and that allows selective activation of the latter without significant release of energy

so as to free the hollow piston in the axial cavity of the drilling tool, in a manner that is always appropriate. Advantageously, safety measures will be provided in order to avoid the movement of the parts of the tool being prevented or interfered with by the drilling mud.

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These problems are resolved by a device as indicated at the start, which comprises

- a trigger element integral with the hollow piston, which is movable from a position of immobilisation of the hollow piston, in which the trigger element is held in abutment, counter to the said differential pressures, against a support on the tubular body, towards a retracted position in which the trigger element is not in abutment against the said support and releases the hollow piston,

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- a tubular relief sleeve for the trigger element which, in the said position of immobilisation of the said trigger element, is connected to the hollow piston by at least one shear pin and prevents movement of the trigger element from its position of immobilisation of the hollow piston to its retracted position, and

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- a means of temporary closure of the tubular relief sleeve which, in a closed position, causes a rise in hydraulic pressure on the tubular sleeve, above a predetermined threshold where shearing of the said at least one shear pin takes place, and a sliding of the tubular relief sleeve into a release position allowing movement of the trigger element from its position of immobilisation of the hollow piston to its retracted position.

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It can be seen that, in the dormant mode of the tool, the traction forces exerted by the hollow piston under the action of a differential pressure are not directly transmitted to the shear pins of the activation device. On the contrary, it is the trigger element that keeps the hollow piston immobilised, by abutment on a fixed ring, integral with the tubular body of the tool, the trigger element and the support being in no way intended to be ruptured

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during use. The risks of accidental activation during the working phase in dormant mode of the tool are thus eliminated. Moreover, a hydraulic pressure can be applied to the sleeve only when the latter is closed. There is therefore selective activation of the piston, since it can take place only
5 through an intended closure of the sleeve, which is controlled from the surface. Since there is no direct link between the traction forces exerted by the piston and the shear forces of the pins, the latter can be calibrated to a much lower resistance value than before and the activation pressure necessary for rupturing them can be relatively low, which makes it possible
10 to avoid excessive involvement of energy and therefore potential damage to the equipment.

According to one embodiment of the invention, the tubular relief sleeve is inserted between the trigger element integral with the hollow piston and an
15 extension of the hollow piston, so as to be able to slide between them after shearing of the said at least one shear pin.

According to an advantageous embodiment of the invention, the tubular sleeve comprises a first part with a wall having a first thickness and a
20 second part with a wall having a second thickness less than the first and, in its position of immobilisation of the hollow piston, the trigger element is in abutment radially on the said first wall part of the tubular sleeve and, in its retracted position, it is in abutment radially on the said second wall part.

25 According to an improved embodiment of the invention, the trigger element is formed by a ring of blades that extend axially around the first part of the tubular sleeve in the position of immobilisation of the trigger element and that come into abutment radially on the said second part of the tubular sleeve when the trigger element is in the retracted position.

30 The tubular extension extending the hollow piston is therefore provided with a ring of blades, preferably metal, advantageously made from spring steel. The rigid tubular sleeve is held so as to be fixed to this extension by shear pins. In this position the blades rest on the thick part of the sleeve and are

therefore kept distant from one another. The ends of these blades, which are advantageously thick and project radially towards the outside, are therefore in axial abutment against a retaining ring projecting radially inside the tubular body. This arrangement prevents any movement of the piston
 5 and the tool is kept in its dormant mode.

According to yet another embodiment of the invention the temporary closure means is a ball launched in the said axial cavity, the tubular relief sleeve comprising a seat for receiving this ball and lateral openings for re-
 10 establishing a circulation of hydraulic fluid when the tubular sleeve is in its release position.

A hydraulic pressure obtained by closure of the drilling mud passage by means of the said ball exerts a force on the sleeve. This force, which may
 15 be minimal, causes the shearing of the shear pins and releases the sleeve, which is able to move away. The blades of the trigger element are then opposite the thin part of the sleeve and can flex radially inwards, for example under a radial thrust of the retaining ring or under the action of an elastic return force. In this flexed position, the blades can slide inside the
 20 retaining ring under the action of the traction of the released hollow piston. The tool is then activated.

According to another embodiment of the invention, the tool also comprises

- 25 - a chamber in a dead end that extends annularly between the said tubular body and the said hollow piston and/or a tubular extension thereof where drilling mud passes, a surface of the hollow piston axially delimiting this dead-end chamber, on a first side,
- 30 - an annular ring that axially delimits the dead-end chamber, on a second side opposite to the above-mentioned first side, and which is connected to the tubular body by at least one shear pin,

- communication for a fluid between the inside of the hollow piston and/or its tubular extension and the dead-end chamber, the said surface of the hollow piston being thus subjected to the said variable differential hydraulic pressures of the said drilling mud,

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- the hollow piston, released by retraction of the said trigger element, being capable of sliding between the first position in which the dead-end chamber has a first volume and a second position in which the dead-end chamber has a second volume greater than the first, as well as

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- return means that act on the hollow piston in order to return it to its first position, the said at least one shear pin, when an obstacle prevents the hollow piston returning to its first position and thus increases the pressure applied to the annular ring beyond a predetermined threshold, being sheared, releasing the annular ring and thus allowing the hollow piston to return to its first position.

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Other particularities of the invention are indicated in the accompanying claims.

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Other details of the invention will emerge from the description given below, non-limitingly, of an embodiment of the downhole tool provided with an activation device according to the invention.

25 Figures 1 and 2 depict a view in axial section of the same underreaming tool provided with an activation device according to the invention.

Figure 3 depicts a view in axial section of an activation device according to the invention, in which the tool is functioning in dormant mode.

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Figure 4 depicts a view in axial section of the activation device according to figure 3, in which the tool is in activated mode.

Figure 5 depicts a partially broken perspective view of the activation device illustrated in figures 3 and 4.

Figure 6 depicts a view to an enlarged scale of the detail A in figure 2.

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In the various drawings the identical or similar elements bear the same references.

10 The description of figures 1 and 2 relates to an example of a downhole tool according to the invention on which an activation device can be arranged. Provision has been made here, by way of example, for the tool to be a underreaming and stabilisation tool to be used in a borehole. It could however be any tool using a driving piston that must be activated only when the tool is in position in the borehole and which is immobilised during
15 descent.

The tool illustrated in figures 1 and 2 comprises a tubular body 1 to be mounted between a first section of a string and a second section thereof. This tubular body 1 has an axial cavity 2 in which the drilling mud circulates.
20 At the periphery the tubular body 1 comprises housings 3 with an opening to the outside.

In the example illustrated, a knife element 4 is housed in each housing 3 and comprises two cutting arms 5 and 6 articulated on each other and on a transmission means in the form of a slide 7. In the position illustrated the
25 arms 5 and 6 are retracted into their housing and the tool is in dormant mode.

In the example illustrated, a drive means designed in the form of a hollow piston 8 is arranged inside the tubular body 1, allowing circulation of the mud without hindrance inside the tubular body. The hollow piston 8 is
30 connected to the slide 7.

As is clear from figures 1, 2 and 6, the drilling mud can accumulate in an annular chamber or dead-end 10 where the piston 8 is, through its surface 11, in contact with the hydraulic fluid under pressure formed by the drilling mud. The piston is, in the case illustrated, indirectly in abutment on a return spring 12 which, at its opposite end, abuts on an element integral with the tubular body 1 and acts in the opposite direction to the aforementioned pressure of the hydraulic fluid passing through the axial cavity 2.

As depicted in more detail in the example embodiment illustrated in figures 3 to 5, the piston 8 is provided with a tubular extension 13 on the downstream side around which the return spring is arranged, whilst bearing on it, which allows an off-centre arrangement of the spring 12 with respect to the cutting arms. This extension is provided with a trigger element 14 that is therefore integral with the piston 8. In the example illustrated, the trigger element is formed by a ring of blades 15, advantageously flexible, for example made from spring steel, which extend axially in the downstream direction, around a part of the tubular extension 13.

A tubular relief sleeve 16 is inserted between the blades 15 of the trigger element 14 and the said tubular extension 13 of the hollow piston 8. This sleeve is connected to the extension 13 by shear pins 17, only one of which is shown.

In the example illustrated, in its downstream part 18, the tubular sleeve 16 has a greater thickness than in its upstream part 19 and advantageously the transition between the downstream and upstream parts is effected on a slope. In the position illustrated in figure 3, when the tubular sleeve 16 is immobilised on the tubular extension 13, the blades 15 of the trigger element 14 are in abutment on the thicker downstream part 18 of the sleeve and are therefore kept separated radially outwards.

In this separation position, the free end 20, advantageously thickened, of the blades 15 comes axially into abutment against a retaining ring 21, integral with the tubular body 1 of the tool.

When the tool has descended in dormant mode, even if the hydraulic pressure of the mud exerted on the piston 8 is high and develops an upward traction force, this is counteracted by the abutment of the blades 15 against
 5 the retaining ring 21.

At its downstream end the tubular relief sleeve 16 is provided with a reception seat 22 intended to receive a closure means 23, a ball in the case illustrated, which is launched from the surface. The sleeve 16 is also
 10 provided with lateral openings 24, only one of which is depicted in figure 3. When a ball is caused to close off the passage of the mud in the axial cavity, the abrupt increase in pressure exerted on the tubular sleeve 16 has the effect of shearing the pins 17, releasing the sleeve. The latter can then
 15 slide downstream between the blades 15 of the trigger element and the tubular extension 13 of the hollow piston. In this position illustrated in figure 4, the lateral openings 24 make it possible to re-establish the circulation of mud in the axial cavity.

As is clear from figure 4, the blades 15 have, by elastic return, arrived in
 20 radial abutment against the thin part 19 of the tubular relief sleeve 16. It would also be possible to make provision for this flexing of the blades 15 to result in an elastic deformation under a thrust in the radial direction of the slanting end of the retaining ring 21. The blades 15 have thus passed into a retracted position in which they are no longer in axial abutment against the
 25 retaining ring 21. Under the action of the hollow piston 8 subjected to a hydraulic pressure that pushes it upstream, the blades 15 of the trigger element 14 in the retracted position can pass inside the said ring 21. The hollow piston 8 is now released and the tool is activated. In the present case the piston can control a deployment of the cutting arms 5 and 6 in
 30 order to proceed for example with an underreaming of the borehole.

As is clear from figure 6, and as already indicated previously, the tool has an annular dead-end chamber 10 that extends between on the one hand the tubular body 1 and on the other hand the hollow piston 8 and its tubular

extension 13 through which the drilling mud passes. The surface 11 of the piston axially delimits the chamber 10 on one side and on the opposite side it is delimited by an annular ring 26. This annular ring 26 is connected to the tubular body 1 by means of at least one shear pin 27.

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A communication for fluid, in the form of orifices 25, enables the drilling mud inside the hollow piston 8 to enter the annular chamber 10. The surface 11 of the piston 8 is thus subjected to the variations in pressure of the drilling mud passing through the tool. The hollow piston 8, released by retraction of
 10 the trigger element, is thus capable of sliding between a first position depicted in figure 6, which corresponds to the immobilisation position of the non-released piston, and a position where the annular chamber 10 has a volume greater than that of the first position, the piston being pushed upwards under the pressure of the drilling mud. The piston can be returned
 15 towards its first position by the return spring 12 in the case of a reduction in the pressure of the drilling mud that has passed through the body of the tool.

Each movement of the drive piston 8 causes a phenomenon of suction (an
 20 increase in the volume of the chamber 10 when the piston is in the high position) and rejection (a reduction in the volume 10 when the piston is in the lowered position) of the drilling mud through the orifices 25 into and respectively out of the dead-end chamber 10. These movements of mud, associated with the effects of settling of solid particles from the mud and/or
 25 centrifugal effects of the solid particles in the mud, may cause excessive fouling of the volume of the chamber 10. In addition, the percentage of the volume of stagnant mud, which is not renewed, may present a cementation phenomenon. The packing of the volume of the chamber 10 may thus prevent complete travel of the movement of the drive piston, by impeding
 30 the complete withdrawal of the cutting arms 5 and 6.

In this configuration, the cutting arms partially exposed outside the principal tubular body 1 form an obstacle to the rising of the tool, when passing a restriction in the diameter of the well. The reaction on the cutting arms due

to the traction force of the tool blocked by the restriction in the diameter of the hole, transmits, by means of the slides 7, an additional return force to the drive piston. The increase in the effect of compacting of the particles in the dead space of the chamber 10 generates a pressure on the ring 26.

5 This pressure force on the ring 26 causes, beyond a predetermined threshold, a shearing of the pins 27 of this ring 26. The ring, no longer being integral with the principal tubular body 1, may, under the effect of the pressure of the compacting, move downwards, then allowing complete movement of the drive piston and consequently the complete withdrawal of

10 the cutting arms.

Advantageously, provision can be made for filling in the clearances between parts and the dead volumes of the mechanism with a given grease or gel. This prevents the drilling mud from coming to occupy these spaces and

15 interfering with the functioning of the tool. It may be advantageous consequently to fill the annular dead-end chamber 10 with such a material, this chamber being able to be considered as a dead space.

Moreover, it can be seen that the longitudinal movements of the mechanism

20 cause variations in volume at various places on the tool, as is the case for example in the annular chamber 10. These variations in volume cause effects of suction and discharge of the drilling mud with the aforementioned known drawbacks.

25 It is therefore advantageous to size the part so as to obtain a dead space as large as possible in comparison with the variation in volume caused by the mechanical movements, in order to limit the effects of compacting of the mud.

30 It must be understood that the present invention is in no way limited to the embodiment described above and that many modifications can be made thereto without departing from the scope of the accompanying claims.

It is for example possible to provide for the piston and its tubular extension to be arranged so as to undergo, on the part of the drilling mud, a pressure directed downwards.

CLAIMS

1. Downhole tool comprising

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- a tubular body (1) provided with an axial cavity (2),

- a hollow piston (8) capable of sliding in the said axial cavity and subjected to variable differential hydraulic pressures, and

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- a device for activating the hollow piston,

characterised in that the activation device comprises

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- a trigger element (14) integral with the hollow piston (8), which is movable from a position of immobilisation of the hollow piston, in which the trigger element is held in abutment, counter to the said differential pressures, against a support on the tubular body, towards a retracted position in which the trigger element (14) is not in abutment against the said support and releases the hollow piston,

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- a tubular relief sleeve (16) for the trigger element (14) which, in the said position of immobilisation of the said trigger element, is connected to the hollow piston (8) by at least one shear pin (17) and prevents movement of the trigger element from its position of immobilisation of the hollow piston to its retracted position, and

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- a means (23) of temporary closure of the tubular relief sleeve (16) which, in the blocked position, causes a rise in hydraulic pressure on the tubular sleeve (16), above a predetermined threshold where shearing of the said at least one shear pin (17) takes place, and a sliding of the tubular relief sleeve (16) into a release position allowing movement of the trigger element (14) from its position of immobilisation of the hollow piston (8) to its retracted position.

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2. Tool according to claim 1, characterised in that the tubular relief sleeve (16) is inserted between the trigger element (14) integral with the hollow piston (8) and an extension (13) of the hollow piston, so as to be able to
5 slide between them after shearing of the said at least one shear pin (17).

3. Tool according to claim 2, characterised in that the tubular sleeve (16) comprises a first part (18) with a wall having a first thickness and a second part (19) with a wall having a second thickness less than the first and in
10 that, in its position of immobilisation of the hollow piston, the trigger element (14) is in abutment radially on the said first wall part (18) of the tubular sleeve and, in its retracted position, it is in abutment radially on the said second wall part (19).

15 4. Tool according to claim 3, characterised in that, as the aforesaid support, the tubular body comprises a retaining ring (21) projecting radially towards the inside of the said axial cavity and in that, in its position of immobilisation of the hollow piston (8), the trigger element (14) is in abutment axially against the said ring and, in its retracted position, it is driven by the hollow
20 piston released inside the said ring (21).

5. Tool according to one of claims 3 and 4, characterised in that the trigger element (14) is formed by a ring of blades (15) that extend axially around the first part (18) of the tubular sleeve (16) in the position of immobilisation
25 of the trigger element (14) and that come into abutment radially on the said second wall part (19) when the trigger element (14) is in the retracted position.

6. Tool according to claim 5, characterised in that the blades (15) of the
30 said ring are made from spring steel.

7. Tool according to one of claims 5 and 6, characterised in that the above mentioned blades (15) have a thickened free end (20) that projects radially towards the outside and which, in the position of immobilisation of the

trigger element (14), are in axial abutment against the said retaining ring (21).

5 8. Tool according to any one of claims 1 to 7, characterised in that the temporary closure means (23) is a ball launched in the said axial cavity (2), and in that the tubular relief sleeve (16) comprises a seat (22) for receiving this ball and lateral openings (24) for re-establishing a circulation of hydraulic fluid when the tubular sleeve (16) is in its release position.

10 9. Tool according to any one of claims 1 to 8, characterised in that it is an underreamer provided with knife elements (4) formed by cutting arms (5, 6) articulated on one another and in that the hollow piston (8) is a drive means allowing an extension of the cutting arms out of the tubular body (1) of the tool.

15 10. Tool according to claim 9, characterised in that it also comprises a return spring (12) that acts on the hollow piston (8) in order to return it in the direction of its immobilisation position, in which the said cutting arms are in the retracted position.

20 11. Tool according to claim 10, characterised in that the return spring (12) is arranged around a tubular extension (13) of the hollow piston so as to bear on it.

25 12. Tool according to any one of claims 1 to 11, characterised in that the said variable hydraulic pressures acting on the hollow piston (8) are directed upwards.

30 13. Tool according to any one of claims 1 to 12, characterised in that it also comprises

- a dead end chamber (10) that extends annularly between the said tubular body (1) and the said hollow piston (8) and/or a tubular extension (13)

thereof where drilling mud passes, a surface (11) of the hollow piston axially delimiting this dead-end chamber, on a first side,

- 5 - an annular ring (26) that axially delimits the dead-end chamber (10), on a second side opposite to the above-mentioned first side, and which is connected to the tubular body by at least one shear pin (27),
- 10 - communication for a fluid (25) between the inside of the hollow piston (8) and/or its tubular extension (13) and the dead-end chamber (10), the said surface (11) of the hollow piston being thus subjected to the said variable differential hydraulic pressures of the said drilling mud,
- 15 - the hollow piston (8), released by retraction of the said trigger element (14), being capable of sliding between a first position in which the dead-end chamber (10) has a first volume and a second position in which the dead-end chamber has a second volume greater than the first, as well as
- 20 - return means (4, 5, 6, 7, 12) that act on the hollow piston in order to return it to its first position, the said at least one shear pin (27), when an obstacle prevents the hollow piston returning to its first position and thus increases the pressure applied to the annular ring beyond a predetermined threshold, being sheared, releasing the annular ring (26) and thus allowing the hollow piston to return to its first position.
- 25 14. Tool according to claim 13, characterised in that it has clearances between parts and dead spaces and in that these clearances and dead spaces are filled with a grease or gel.
- 30 15. Tool according to claim 14, characterised in that the aforementioned dead-end chamber (10) is a dead space in the tool.