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(54) ADJUSTABLE STABILISER FOR DIRECTIONAL DRILLING

VERSTELLBARER STABILISATOR ZUM RICHTUNGSBOHREN

STABILISATEUR REGLABLE POUR FORAGE DIRIGE

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(73) Proprietor: **Toolbox Drilling Solutions Ltd**
Aberdeen AB15 5EP (GB)

(72) Inventors:
- **RUSSELL, Mark Alexander**
  Low Bradfield,
  Sheffield S61 LB (GB)
- **OLLERENSHAW, Andrew**
  Loxley,
  Sheffield S6 6RB (GB)

(74) Representative: **Lunt, Mark George Francis et al**
Harrison Goddard Foote,
Fountain Precinct
Balm Green
Sheffield S1 2JA (GB)

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Description

[0001] The present invention relates to down-hole tools and particularly to stabilisers for drill strings, especially near-bit stabilisers.

[0002] Directional drilling is either sophisticated, expensive and unreliable or simple, reliable but rather limited. For the most part, the latter type meets all requirements. This type relies entirely on gravity and can only adjust the inclination of a hole, rather than its horizontal direction.

[0003] An adjustable stabiliser has a base diameter larger than the drill string, but not as large as the hole bore being drilled. It prevents the drill string from contacting the sides of the bore. When actuated however, its diameter increases and so the drill string is constrained to run concentric with the hole being drilled. Thus an adjustable stabiliser near the drill bit steers the drill bit depending on its actuation.

[0004] Down-hole motors are frequently used in drilling. The string itself is not rotated. Instead, the motor near the end of the string rotates just the bit at the end. The motor is hydraulically driven by drilling mud pumped from the surface. The down-hole motor should be as close to the drill bit as possible, but a stabiliser can be interposed between them in order to provide steerage.

[0005] Thus a short stabiliser is called for. Down-hole stabilisers have been actuated in a number of different ways.

[0006] In EP-A-0251543, a fairly short stabiliser is disclosed, but it involves using mechanical compressive forces on the drill string to set and unset it.

[0007] In US-A-4951760, a stabiliser is hydraulically operated, employing fluid pressure of pressurised drilling mud to actuate the stabiliser by a piston mandrel moving axially in a bore of the body of the stabiliser and having ramps or cams which move a stabiliser bar radially outward. A long, and strong, spring returns the stabiliser to a deactivated position when the fluid pressure is released.

[0008] In the same patent a throttle member increases the pressure drop across the tool, serving both to accelerate movement of the mandrel for actuation of the tool and to signal to the surface the state of actuation of the tool.

[0009] In GB-A-2346443, a control piston that is hydraulically actuated rotates a sleeve which, in one position, permits movement of a mandrel to actuate the tool, and in another position inhibits such movement, despite the same hydraulic forces being applied to the mandrel in either case.

[0010] It is an object, at least in one aspect of the present invention, to provide a down-hole tool which is relatively short and does not suffer the disadvantages of the prior art, or at least mitigates their effects.

[0011] In another aspect, it is an object of the present invention to provide a down hole tool which minimises mechanical contact between components in order to reduce opportunity for jamming, as well as wear.

[0012] US-A-3974886 discloses a down hole tool comprising:

a body having a through-bore;
a mandrel having a through bore, being axially slidable in the body bore to actuate and de-actuate the tool; and
a valve having an actuate and a deactuate position, wherein, in the actuate position, drilling mud pumped under pressure along said body bore (16) actuates the tool and in the deactuate position, drilling mud pumped under pressure along said body bore (16) does not actuate the tool.

[0013] In accordance with the present invention there is provided a down-hole as defined above, characterised in that:

said valve is switchable by change in pressure of said drilling mud, thereby to control hydraulically the movement of the mandrel,

wherein the valve comprises a control piston slidable in the mandrel bore, against the force of a return spring, by drilling mud pressure from a low-pressure position to a pressure position.

[0014] Preferably said valve controls the drilling mud to drive the mandrel hydraulically both to actuate and de-actuate the tool. Thus, by hydraulically driving the mandrel in both directions, the need for a strong return spring is avoided.

[0015] Said pressure position may alternately be one of an actuate position and a de-actuate position axially spaced along the mandrel bore from said actuate position, the tool being actuated by mud pressure when the piston is in said actuate position and de-actuated when in said de-actuate position. The actuate position may be between the de-actuate and low-pressure positions of the piston.

[0016] A return step is preferably formed in the body and mandrel to define annular chambers between them on either side of the return step, one chamber, when pressurised with mud, serving to actuate the tool while the other serves to de-actuate the tool.

[0017] Said control piston may have an axially disposed passage and a seal against the mandrel at both ends of the passage, the mandrel having two ports communicating each of said annular chambers with the mandrel bore and an intermediate port venting said passage, the piston in the actuate position connecting one chamber with the passage and the other chamber with the piston bore beyond the seals, and vice-versa in said de-actuate position.

[0018] Preferably, the mandrel bore and piston are stepped, the annular piston chamber formed by said step between them being vented so that pressure of drilling mud in the body moves the piston along the mandrel to

close said piston chamber.

[0019] The piston and mandrel between them preferably define a barrel cam so that the piston rotates on axial movement thereof relative to the mandrel, the cam permitting different strokes of the piston in dependence upon the angular position of the piston in the mandrel.

[0020] The piston and mandrel may have inter-digitating castellations which, when they oppose one another in a first angular position of the piston with respect to the mandrel, as determined by the barrel cam, permit the piston to move to one of said actuate and de-actuate positions and, when they inter-digitate, permit the piston to move to the other of said actuate and de-actuate positions.

[0021] The barrel cam may comprise a pin in a track and the track is arranged so that rotation of the piston with respect to the mandrel is complete before the castellations engage one another. The track may be on the piston and the pin on the mandrel.

[0022] The track is preferably so arranged that the castellations abut in either the actuate or de-actuate positions and transmit axial hydraulic forces between the piston and mandrel before the pin reaches the end of the track.

[0023] Preferably, the return step is inward of the body and comprises two rings interconnected and captivating between them ring sectors received in an annular groove in the body.

[0024] A passage through the return step may be vented and communicate with said intermediate port of the mandrel, the mandrel being sealed to the return step on either side of said passage and intermediate port.

[0025] The diameter of the chambers are preferably different, the chamber serving to actuate the tool when pressurised having the larger diameter.

[0026] Additionally, or alternatively, the diameter of the mandrel in the body on the sides of the chambers remote from the return step is larger on the side where hydraulic pressure moves the mandrel to actuate the tool.

[0027] Both these differences serve to increase the force with which the tool is actuated which, in the case of a stabiliser, may be necessary if the drill string is not already central in the hole being drilled.

[0028] A choke may be activated when the tool is actuated, such activation to change the pressure drop of the drilling mud across the tool so as to signal the states of actuation of the tool. The piston may carry a piston restrictor plate across the piston bore in face to face contact with a mandrel restrictor plate, the restrictor plates being angularly fixed with respect to the piston and mandrel respectively and restricting mud flow through the tool in dependence upon their relative angular position.

[0029] Preferably, the mandrel restrictor plate is angularly fixed with respect to the body, the body being angularly fixed with respect of the mandrel.

[0030] Preferably, the restrictor plates have a central aperture in register with one another and alternating sector spaces and sector lobes so that, when the lobes on the piston and mandrel plates are in register with one another, mud flows through both the central aperture and spaces, and when the lobes and spaces are in register, mud flows through the central aperture.

[0031] In a different aspect of the present invention, said mandrel is moved to actuate the tool by hydraulic pressure of said drilling mud when said valve permits bleeding of a bleed chamber. Preferably, in this event, the mandrel is moved to de-actuate the tool, on release of said hydraulic pressure, by a mandrel return spring.

[0032] Said bleed chamber may be formed by a step between the mandrel and body.

[0033] Said piston may serve to open and close a port between said bleed chamber and the body bore. Preferably, said piston, when it moves from said low-pressure position to said pressure position, only opens said port when it moves to said actuate position.

[0034] Preferably, said body defines, with the ends of said piston and mandrel, a valve chamber, said choke comprising a path between said piston and body which is opened when said piston moves to said actuate position and the mandrel moves to actuate the tool, and which is restricted when the piston moves to said de-actuate position.

[0035] In one application of the present invention, the tool is a stabiliser and comprises members radially disposed in the body and pressed outwardly during actuation of the tool to increase the effective diameter of the stabiliser.

[0036] Indeed, the invention provides a drill string comprising a drill bit and a near-bit stabiliser as defined above.

[0037] The invention is further described hereinafter, by way of example, with reference to the attached drawings, in which:

Figures 1a and 1b are a longitudinal section when joined end to end along lines X-X in each drawing through a stabiliser in accordance with the present invention;

Figure 1c is an end view of a restrictor plate;

Figures 2a to 2f are longitudinal sections through the stabiliser of Figure 1 in different states of actuation;

Figure 3 is a schematic diagram of the tool actuating arrangement of a tool in accordance with the present invention;

Figure. 4 is a schematic diagram of an alternative arrangement;

Figure: 5 is a schematic illustration similar to Figures 3 and 4 of a further preferred embodiment corresponding with the arrangement shown in Figures 1 and 2 above;

Figure 6a is a side profile of the barrel cam track employed on a control piston in accordance with the present invention, Figure 6b comprising an enlarged section through the control piston;

Figure 7 is an illustration of a down-hole drill string; and

Figures 8 a and b are sections through an alternative

arrangement of present invention.

[0038] Referring to Figures 1a and 1b, a drill string stabiliser 10 comprises a body 12 in two parts 12a, 12b. A mandrel 14 is slidable in bore 16 of the body 12. The mandrel likewise comprises two parts 14a, 14b. A control piston 18 is slidable in a bore 20 of the mandrel 14.

[0039] The body 12 has enlarged stabiliser bars 22 comprising spirally formed bars in which pistons 24 are disposed in radially directed bores 26 through the wall of the body 12. Springs 28 acting on cross pins 30 (fixed in the pistons 24) and studs 32 (fixed in the stabiliser bars 22), press the piston 24 radially inwardly against wedge surfaces 34 formed on the mandrel 14. When the mandrel 14 moves leftwardly in Figure 1, the pistons 24 are pressed radially outwardly to increase the effective diameter of the stabiliser 10. The angular position of the mandrel 14 is fixed by a pin 36 in the body 12 engaging a slot 38 in the side of the mandrel 14.

[0040] A return spring 40 is disposed in the bore 20 of the mandrel 14 and bears on a shoulder 42 of the mandrel at one end and, through a thrust-bearing 44, on the piston 18.

[0041] The piston 18 has its own through-bore 46 so that a clear passage extends from an upstream end 10a to a downstream end 10b of the tool 10. The piston 18 is sealed to the bore 20 of the mandrel 14 through ring seals 50, 52 which, it.will be noted, are of different diameters. Consequently, since piston chamber 54 is vented (as explained further below), any increase in hydraulic pressure in the bore 46 will result in leftward movement of the piston as shown in Figure 1.

[0042] Piston chamber 54 communicates with intermediate port 60 of mandrel 14, which in turn communicates with passage 62 in step ring 64, and then with aperture 66 in ring sectors 68 and finally vent port 70 in the wall of the body 12.

[0043] Thus, as is well known in the art, drilling mud pumped under pressure down the drill string and through the stabiliser 10. It returns under reduced pressure around the outside of the drill string and stabiliser 10. Consequently, when the drill string is pressurised with drilling mud the piston 18 moves leftwardly in the drawing compressing the spring 40. A barrel cam 72 is formed on dne end of the piston 18, the mandrel 14 being provided with pins 74 whose ends engage the barrel cam 72.

[0044] Turning to Figures 6a and 6b, the barrel cam 72 is shown having a cam track 76. The arrows in the drawing show the movement of the pins 74 as the piston moves backwards and forwards in the axial direction. If the pin 74 starts in the position Z as shown in Figure 6b, then as the barrel cam moves downwardly in the drawing, the pin will impact the side of track 76 at point A, whereupon further axial movement of the piston will result in rotation of the piston until point B is reached. The piston can continue axial movement until the pin reaches point C. When the mud pressure is reduced, the spring 40 returns the' piston, which moves axially until the pin 74 impacts the wall of the track 76 at D, whereupon the piston rotates in the same direction as when moving from A to B until it reaches point E. The next time the mud pressure is increased again, the piston will move axially until the pin 74 strikes the wall 76 of the track at point F, where again the piston will be turned to rotate in the same direction and until the pin reaches point G. On the next cycle, when the mud pressure is again reduced, the pin strikes the track 76 at H before turning the piston once more until the pin 74 reaches point I which is equivalent to the start position.

[0045] The piston 18 is provided with castellations 78a on an external surface thereof and which castellations match internal castellations 78b in the mandrel 14. Indeed, the castellations 78b may be provided on a separate element 80 bolted to the base of a step 82 in the mandrel 14, which step 82, in fact, defines the piston chamber 54.

[0046] The track 72 is so arranged in relation to the castellations 78a on the piston 18, and the castellations 78b in the mandrel 18 are so arranged in relation to the pins 74, that, when the pin reaches position B in the track 76, the castellations 78a, 78b inter-digitate, as shown in Figure 6b. This means that the piston can move down the bore 20 of the mandrel until chamfered edge 84 of the castellations 78a contact and abut chamfered base 86 of the castellation element 80. Indeed, the track 76 is so arranged that contact between the castellations occurs before the pin contacts the end of the track 76 at C, so that, when further load is imposed between the piston 18 and mandrel 14, it is transmitted through the more substantial abutments between castellation surfaces 84, 86 than through the pin 74 and track 76. On the other hand, when the pin is in position G, the castellations 78a, 78b face one another, so that the piston can only advance until chamfered edge 84 abuts chamfered face 88 of the castellations 78b. Likewise, the castellations 78a, 78b abut one another before the pin 76 impacts the base of the track 76 at G.

[0047] There are preferably three castellations 78a, 78b around the circumference of the piston and mandrel respectively, and likewise three repetitions of the cycle Z to I described above, so that a complete cycle represents a rotation of the piston in the mandrel of 120°, and a difference between inter-digitation and mutual opposition of the castellations 78a, 78b of 60°.

[0048] The internal return step 64 of the body 12 is provided in the bore 16 of the body 12 by two rings 90, 92 bolted together by evenly spaced bolts 94 around the peripheries of the rings 90, 92. An internal grove 96 is formed in the body 12 and three ring sectors 98, each of about 120° of arc, are captivated in the grove 96 by clamping together the step rings 90, 92. Shims 100 can be inserted on either side of the ring sectors 98 in order to adjust the axial position of the step 64 in the bore 16 of the body 12.

[0049] The step 82 in the mandrel 14 creates a first annular chamber 102. After assembly of the piston 18 in

the mandrel part 14b and insertion thereof in the bore 16, and after fixing of the step rings 64 in the bore 16, the second part 14a of the mandrel is connected to the first part 14b. This is effected by ring sectors 106 and pins 108 retained in engagement with inset holes 110 in the surface of the mandrel 14 by ring 112 retained on flange 14c of the mandrel part 14a by means not shown.

[0050] Mandrel part 14a defines with the step 64 a second annular chamber 104. The step 82 is a return step because the chambers 102, 104 oppose one another.

[0051] The mandrel 14 is provided with a first port 120 which communicates the bore 20 of the mandrel with the first annular chamber 102. The mandrel 14 has a second port 130 which communicates the second annular chamber 104 with the bore 20 of the mandrel.

[0052] However, with respect to the first chamber 102, the port 120 opens into the piston annular chamber 54 between the seals 50, 52 on the piston 18. Therefore, chamber 102 is isolated from the bore 46 of the piston 18 and the -pressure of the drilling mud therein. In fact, by virtue of intermediate port 60 in the mandrel 14, which is vented to the outside through passages 62, 66, 70, (and isolated by seals 63) the annular chamber 102 is likewise vented to the outside. On the other hand, chamber 104 is in communication with the drilling mud under pressure in bore 46 of the piston 18 by virtue of the second port 130 and a number of slots 122 in the piston 18.

[0053] Thus, from the position shown in Figure 1a, when the pressure of the drilling mud increases, the pressure in chamber 104 rises and begins to urge the mandrel 14 leftwardly in the drawing. The mandrel 14 is sealed at both ends to the bore 16 of the body 12 by seals 132, 135. The diameter of the bore 16 in body part 12b is slightly greater than the diameter of the mandrel in body part 12a. Therefore, there is net leftward force on the mandrel 14 which moves in that direction since the annular space 134 formed by the step between the body parts 12a, 12b is vented by radial outward movement of the piston members 24. At the same time the piston 18 also moves leftwardly with respect to the mandrel, and if the piston is in such a position that the castellations 78a, 78b oppose one another and abut through chamfered faces 84, 88, this leftward movement of the mandrel persists. In that event, the inclined surfaces 34 of the mandrel 14 press the piston members 24 radially outwardly until ring 112 abuts the end of the body part 12a. Indeed, the final diameter of the stabiliser 10 when actuated is determined by the axial extent of permitted movement of the mandrel 14, and this can be controlled by shimming out the ring 112.

[0054] However, if the castellations 78a, 78b are in a de-actuate position in which they inter-digitate, then the piston 18 continues leftward movement, and in this event two hydraulic switches occur. The first is that the seal 50 passes the first port 120 so that instead of communicating the first annular chamber 102 with a vent through intermediate port 60, the annular chamber 102 is connected to mud pressure behind the piston 18. Secondly, the seal 52 at the other end of the piston passes the second port 130 in the mandrel 14, so that, instead of the second annular chamber 104 being connected to mud pressure inside the bore of the piston 18, that chamber is instead put in communication with the intermediate port 60 and, thereby, the vent 62, 66, 70 to outside. There is, therefore, a reversal of the hydraulic forces acting on the mandrel 14 and it moves to the position shown in Figure 1a where the pistons 24 are fully retracted and the stabiliser 10 is de-actuated.

[0055] Figures 2a to 2f show the sequence of cycling. In Figure 2a the position is as shown in Figures 1a and 1b. In Figure 2b fluid pressure has moved the piston rightwardly in the drawing until the castellations 78a, 78b abut one another. In this position, the first chamber 102 is vented while second chamber 104 is connected to higher pressure. Therefore, the mandrel 14 moves rightwardly in the drawing to the position shown in Figure 2C. Here, second annular chamber 104 is fully developed and first annular chamber 102 is now closed. Moreover, the pistons 24 are now radially extended. In Figure 2D fluid pressure in the drill string has been switched off so that spring 40 returns piston 18 to its position in the mandrel it has in Figure 2a. However, because the spring 40 is acting between the piston and mandrel, the mandrel does not move in the body 12.

[0056] In Figure 2e, fluid pressure in the drill string is once again reinstated and accordingly the piston 18 moves rightwardly in the drawing and this time the castellations 78a, 78b inter-digitate so that the piston 18 moves further rightwardly in the mandrel than it did in the previous half-cycle (as shown in Figure 2C). There is therefore the reversal mentioned above in that the second annular chamber 104 is now vented and the first annular chamber 102 is connected to fluid pressure. In this event, the mandrel 18 moves leftwardly in the drawing to the position shown in Figure 1 where the pistons 24 are fully withdrawn and the stabiliser 10 has a minimum diameter. The spring 40 is nevertheless fully compressed.

[0057] Returning to Figure 1A, a piston restrictor plate 150 is fitted in the mouth of the bore 46 of the piston 18. A sleeve 153 is a sliding fit, without rotation, in bore 11 of the body 12. In the end of the sleeve 153 facing the piston restrictor plate 150 is a mandrel restrictor plate 152. Figure 1c is an end view of a restrictor plate which is circular but has three 60° open sectors 154. Both restrictor plates 150, 152 have identical profiles so that when they are perfectly aligned, a central bore 156 is open, as well as the 60° sectors 154. However, by rotating the piston through 60° with respect to the mandrel, and hence the body 12 and mandrel restrictor plate 152, open segments 154 of the restrictor plate coincide with closed segments 158 of the other restrictor plate 152. Consequently, in this arrangement, the only passage through the restrictor plates 150, 152 is the central opening 156. There is therefore a marked pressure difference across the restrictor plates which is detectable at the surface.

Since an increased pressure difference increases the leftward forces on the piston 18, and hence on the mandrel 14, the restrictor plates 150, 152 are arranged so that they are out of phase with one another (ie when only the passage 156 exists through them) when the piston castellations 84 abut the tips of the mandrel castellations 88 and in which the mandrel is urged leftwardly to its actuated position.

[0058] Figure 3 is a schematic representation showing the principle of operation of the tool shown in Figures 1 and 2. Phantom line 200 is the centre line of the down-hole tool 10'. Body 12 is provided with vent aperture 62 extending through return step 64. Mandrel 14 receives piston 18 and has first and second ports 120, 130. First and second annular chambers 102, 104 are here labelled a, b. Intermediate port 60 communicates vent port 62 with passage 54 between piston 18 and mandrel 14. The piston is shown in two axial positions 18a, 18b. In position 18a annular chamber 104(b) is vented to atmosphere through second port 130, passage 54, intermediate port 60 and vent 62, while first annular chamber 102(a) is connected to main pump pressure (P_1) through first port 120.

[0059] In Figure 3, the area of the mandrel 14 under the step 64 is A_2, which is dependent on the diameter of the step 64. Likewise, the areas A_1 of the mandrel under the chambers 102, 104 is determined by the diameter of those chambers. In Figure 3, the chambers have the same diameter. Thus, the forces acting on the mandrel 14 when the piston 18 is in the position 18a is given by

$$F_a = P_1 \ (A_1 - A_2)$$

[0060] On the other hand, when the piston is in position 18b, then the situation is reversed and it is second annular chamber 104(b) which is connected to high pressure, whereas first annular chamber 102 is vented. Thus, the force (F_b) acting on the mandrel 14 is given by

$$F_b = -P_1 \ (A_1 - A_2)$$

[0061] Thus, the value of the force on the mandrel 14 is the same in both positions of the piston 18, except that it is reversed in direction.

[0062] Figure 4 shows an alternative arrangement in which the step 64' is formed as part of the mandrel 14' so that the chambers 102', 104' are in a recess of the body 12' rather than in a recess of the mandrel 14'. While this creates different issues of construction, the operation is in principle identical with that described above in relation to Figure 3.

[0063] Figure 5 illustrates a preferred arrangement in which the forces acting in the direction of actuation (arrow F in Figure 5) is greater than in the reverse. In Figure 5,

$$F_a = P_1 \ (A_1 - A_3 + A_2 - A_4),$$

whereas

$$F_b = - P_1 \ (A_3 - A_4),$$

where

F_a and F_b are the forces acting in the direction of the arrow F when chambers a and b are respectively pressurised with mud pressure P_1. In this scenario F_a is in the direction of the arrow F because $(A_1 + A_2)$ is greater than $(A_3 + A_4)$, whereas F_b is in the opposition direction because A_3 is greater than A_4. However, the value of F_a is much larger than the value of F_b, which is desirable because the potential force required to push the pistons radially outward is much larger than that potentially required to release them.

[0064] Figure 7 is a schematic diagram of a drill string 200 in a well bore 210, the drill string terminating in a drill bit 220 driven by a down-hole motor 230 which is spaced from the drill bit by a near-bit stabiliser 240. A remote stabiliser 250 is spaced some distance from the motor 230. If the stabiliser 240 is de-actuated, then the weight of the motor 230 and drill bit 220 tends to drop the drill string vertically so that the drill tends to vertical. On the other hand, if the stabiliser 240, is actuated, then the drill string tends to follow a straight line.

[0065] Finally, Figures 8 a, b show an alternative arrangement, being a half longitudinal section through a tool 10". Here actuation of the tool 10" is effected by movement of the mandrel 14", which slides in a stepped body bore 16" of the body 12".

[0066] Figure 8b shows a de-actuated position of the piston 18" relative to the mandrel 14". The piston 18" is positioned between a body cup 12b forming an annular valve chamber 151. One or several apertures 152 connect the body bore up-stream (16a) and down-stream (16b) of the body cup 12b. When hydraulic pressure of drilling mud in the bore 16a rises, piston 18" is pressed leftwardly in the drawing against the force of return spring 40" to the position shown in Figure 8b. However, here, a sealing ring 153 has not passed over a bleed port 155 in the wall of the mandrel 14". Therefore a bleed chamber 157 cannot be vented, it being sealed at its ends by seal rings 132" and 135", and possibly intermediate seal ring 160.

[0067] Piston 18" is prevented from moving further than shown in Figure 8b by a barrel cam arrangement 72" similar to that described above. When the hydraulic pressure is lowered sufficient to permit the return spring 40" to urge the piston 18" to its low pressure position (not shown) then it rotates, as described above. Thus, when the hydraulic pressure again rises, the piston moves on the mandrel 14", under hydraulic action, to the position

shown in Figure 8a.

[0068] In this position, port 155 is exposed, so that hydraulic pressure urges the mandrel leftwardly in the drawing and pressurises bleed chamber 157. The fluid in it escapes into valve chamber 151 and permits the mandrel to move to the position in the body 12" shown in Figure 8a. Here, the piston members 24 are pressed outwardly.

[0069] Furthermore, the piston 18" clears internal edge 162 of the body cup 12b so that the fluid flow passage formed between the two is substantially enlarged and so that the pressure drop across the arrangement is substantially reduced. Such reduction in pressure drop, and maintenance of a high pressure drop in the case of the de-actuated position in Figure 8b, informs the user of the state of actuation bf the tool 10".

[0070] Nevertheless, while mud pressure remains high, the pressure drop across throat 162 is sufficient to keep the piston in the position shown. However, when the pressure drops, the piston moves rightwardly in the drawings. The mandrel likewise moves rightwardly, driven by a mandrel return spring 164. However, it may be possible for the piston 18" to cover the port 155 before the mandrel has moved all the way to the de-actuated position of Figure 8b. Consequently a non-return valve 166 may be provided in the end of the mandrel 14" to permit mud to enter the bleed chamber 157.

[0071] While this arrangement employs a mandrel return spring and is therefore necessarily longer than the previous embodiment, nevertheless it removes the necessity of employing mechanical detent means which must be shifted between the mandrel and body to permit and restrain the movement of the mandrel.

Claims

1. A down-hole tool (10) comprising;

a body (12) having a through-bore (16);
a mandrel (14) having a through bore (20), being axially slidable in the body bore to actuate and de-actuate the tool; and
a valve having an actuate and a deactuate position, wherein, in the actuate position, drilling mud pumped under pressure along said body bore (16) actuates the tool and in the deactuate position, drilling mud pumped under pressure along said body bore (16) does not actuate the tool,
characterised in that:

said valve (18) is switchable by change in pressure of said drilling mud, thereby to control hydraulically the movement of the mandrel (14),

wherein the valve comprises a control piston (18) slidable in the mandrel bore (20), against the force of a return spring (40), by drilling mud pressure from a low-pressure position to a pressure position.

2. A tool (10) as claimed in claim 1, wherein said valve controls the drilling mud to drive the mandrel (14) hydraulically both to actuate and de-actuate the tool.

3. A tool (10) as claimed in claim 2, wherein, said pressure position is alternately one of said actuate position and said de-actuate position axially spaced along the mandrel bore (20) from said actuate position, the tool (10) being actuated by mud pressure when the piston (18) is in said actuate position and de-actuated when in said de-actuate position.

4. A tool (10) as claimed in claim 3, in which the actuate position is between the de-actuate and low-pressure positions of the piston (18).

5. A tool (10) as claimed in claim 3 or 4, when dependent on claim 2, in which a return step (64) is formed in the body (12) and mandrel (14) to define annular chambers between them on either side of the return step, one chamber (102, 104), when pressurised with mud, serving to actuate the tool while the other serves to de-actuate the tool.

6. A tool (10) as claimed in claim 5, in which said control piston (18) has an axially disposed passage (46) and a seal (50, 52) against the mandrel at both ends of the passage, the mandrel (14) having two ports (120, 130) communicating each of said annular chambers (102, 104) with the mandrel bore (20) and an intermediate port (60) venting said passage (46), the piston (18) in the actuate position connecting one chamber with the passage and the other chamber with the piston bore beyond the seals (50, 52), and vice-versa in said de-actuate position.

7. A tool (10) as claimed in any of claims 4 to 6, in which the mandrel bore (20) and piston (18) are stepped, the annular piston chamber (46) formed by said step (64) between them being vented so that pressure of drilling mud in the body moves the piston along the mandrel to close said piston chamber.

8. A tool (10) as claimed in any of claims 4 to 7, in which the piston (18) and mandrel (14) between them define a barrel cam (72') so that the piston rotates on axial movement thereof relative to the mandrel (14), the cam permitting different strokes of the piston (18) in dependence upon the angular position (18) of the piston in the mandrel (14).

9. A tool (10) as claimed in claim 8, in which the piston (18) and mandrel (14) have inter-digitating castellations (78a, 78b) which, when they oppose one an-

other in a first angular position of the piston (18) with respect to the mandrel (14), as determined by the barrel cam (72'), permit the piston (18) to move to one of said actuate and de-actuate positions and, when they inter-digitate, permit the piston (18) to move to the other of said actuate and de-actuate positions.

10. A tool (10) as claim in claim 9, in which the barrel cam (72') comprises a pin (74) in a track (76) and the track (76) is arranged so that rotation of the piston (18) with respect to the mandrel (14) is complete before the castellations (78a, 78b) engage one another.

11. A tool (10) as claimed in claim 10, in which the track (76) is on the piston (18) and the pin (74) is on the mandrel (14).

12. A tool (10) as claimed in claim 10 or 11, in which the track (76) is so arranged that the castellations (78a, 78b) abut in either the actuate or de-actuate positions and transmit axial hydraulic forces between the piston (18) and mandrel (14) before the pin (74) reaches the end of the track (76).

13. A tool ('10) as claimed in claim 5, or any of claims 6 to 12 when dependent on claim 5, in which the return step (64) is inward of the body (12) and comprises two rings (90, 92) interconnected and captivating between them ring sectors (98) received in an annular groove (96) in the body (12).

14. A tool (10) as claimed in claims 6 and 13, in which a passage (62) through the return step (64) is vented and communicates with said intermediate port (60) of the mandrel '(14), the mandrel (14) being sealed to the return step (64) on either side of said passage and intermediate port (62).

15. A tool (10) as claimed in claim 5, or any of claims 6 to 14 when dependent on claim 5, in which the diameter of the chambers (102, 104) are different, the chamber (102, 104) serving to actuate the tool (10) when pressurised having the larger diameter.

16. A tool (10) as claimed in claim 5, or any of claims 6 to 15 when dependent on claim 5, in which the diameter of the mandrel (14) in the body (12) on the sides of the chambers (102, 104) remote from the return step (64) is larger on the side where hydraulic pressure moves the mandrel (14) to actuate the tool.

17. A tool (10) as claimed in any preceding claim, in which a choke is activated when the tool (10) is actuated, such activation to change the pressure drop of the drilling mud across the tool (10) so as to signal the states of actuation of the tool (10).

18. A tool (10) as claimed in claim 17, in which the piston carries a piston restrictor plate (150) across the piston bore (46) in face to face contact with a mandrel restrictor plate (152), the restrictor plates (150,152) being angularly fixed with respect to the piston (18) and mandrel (14) respectively and restricting mud flow through the tool in dependence upon their relative angular position.

19. A tool (10) as claimed in claim 18, in which the mandrel restrictor plate (152) is angularly fixed with respect to the body (12), the body being angularly fixed with respect of the mandrel (14).

20. A tool (10) as claimed in claim 18 or 19, in which the restrictor plates (150, 152) have a central aperture (156) in register with one another and alternating sector spaces (154) and sector lobes (158) so that, when the lobes (158) on the piston (18) and mandrel plates (150, 152) are in register with one another, mud flows through both the central aperture (156) and spaces (154), and when the lobes and spaces are in register, mud flows through the central aperture (156).

21. A tool (10) as claimed in claim 1, or in any of claims 2 to 20 when not dependent on claim 2, in which said mandrel (14) is moved to actuate the tool (10) by hydraulic pressure of said drilling mud when said valve permits bleeding of a bleed chamber (157).

22. A tool (10) as claimed in claim 21, in which said mandrel (14) is moved to de-actuate the tool (10), on release of said hydraulic pressure, by a mandrel return spring (164).

23. A tool (10) as claimed in claim 21 or 22, in which said bleed chamber (157) is formed by a step between the mandrel (14) and body (12).

24. A tool (10) as claimed in claim 23, in which said piston (18) serves to open and close a port (155) between said bleed chamber (157) and the body bore (16).

25. A tool (10) as claimed in claims 3 and 24, in which said piston (18), when it moves from said low-pressure position to said pressure position, only opens said port (16) when it moves to said actuate position.

26. A tool (10) as claimed in claim 17 and claim 24 or 25, in which said body (12) defines, with the ends of said piston (18) and mandrel (14), a valve chamber (15), said choke comprising a path between said piston (18) and body (12) which is opened when said piston (18) moves to said actuate position and the mandrel (14) moves to actuate the tool (10), and which is restricted when the piston (18) moves to said de-actuate position.

27. A stabiliser comprising a tool (10) as claimed in any preceding claim, and members radially disposed in the body (12) and pressed outwardly by the mandrel (14) during actuation of the tool to increase the effective diameter of the stabiliser.

28. A drill string comprising a drill bit (220), and a near-bit stabiliser (240) as claimed in claim 27.

Patentansprüche

1. Bohrwerkzeug (10), das aufweist:

einen Körper (12) mit einer Durchgangsbohrung (16),
einen Dorn (14) mit einer Durchgangsbohrung (20), der in der Körperbohrung axial verschiebbar ist, um das Werkzeug zu aktivieren und zu deaktivieren, und
ein Ventil mit einer Aktivierungs- und einer Deaktivierungsposition, wobei in der Aktivierungsposition unter Druck entlang der Körperbohrung (16) gepumpter Bohrschlamm das Werkzeug aktiviert und in der Deaktivierungsposition unter Druck entlang der Körperbohrung (16) gepumpter Bohrschlamm das Werkzeug nicht aktiviert,

dadurch gekennzeichnet, dass:

Das Ventil (18) durch eine Änderung in dem Druck des Bohrschlamms schaltbar ist, um **dadurch** die Bewegung des Dorns (14) hydraulisch zu steuern,

wobei das Ventil einen Steuerkolben (18) aufweist, der in der Dornbohrung (20) gegen die Kraft einer Rückstellfeder (40) durch Bohrschlammdruck aus einer Niederdruckposition in eine Druckposition verschiebbar ist.

2. Werkzeug (10) nach Anspruch 1, bei dem das Ventil den Bohrschlamm steuert, um den Dorn (14) hydraulisch anzutreiben, um das Werkzeug sowohl zu aktivieren als auch zu deaktivieren.

3. Werkzeug (10) nach Anspruch 2, bei dem die Druckposition abwechselnd eine von der Aktivierungsposition und der Deaktivierungsposition ist, die axial entlang der Dornbohrung (20) von der Aktivierungsposition beabstandet ist,
wobei das Werkzeug (10) durch Schlammdruck aktiviert wird, wenn der Kolben (18) in der Aktivierungsposition ist, und deaktiviert wird, wenn er in der Deaktivierungsposition ist.

4. Werkzeug (10) nach Anspruch 3, bei dem sich die Aktivierungsposition zwischen der Deaktivierungsposition und der Niederdruckposition des Kolbens (18) befindet.

5. Werkzeug (10) nach Anspruch 3 oder 4, wenn sie von Anspruch 2 abhängen, bei dem eine Rückführstufe (64) in dem Körper (12) und dem Dorn (14) ausgebildet ist, um ringförmige Kammern zwischen ihnen auf jeder Seite der Rückführstufe zu bilden, wobei eine Kammer (102, 104) dazu dient, das Werkzeug zu aktivieren, wenn sie mit Schlamm unter Druck gesetzt ist, während die andere dazu dient, das Werkzeug zu deaktivieren.

6. Werkzeug (10) nach Anspruch 5, bei dem der Steuerkolben (18) einen axial angeordneten Kanal (46) und eine Dichtung (50, 52) gegen den Dorn an beiden Enden des Kanals hat, wobei der Dorn (14) zwei Durchlassöffnungen (120, 130), die jede der ringförmigen Kammern (102, 104) mit der Dornbohrung (20) verbinden, und eine dazwischen liegende Durchlassöffnung (16) aufweist, die zum Druckausgleich des Kanals (46) dient, wobei der Kolben (18) in der Aktivierungsposition eine Kammer mit dem Kanal und die andere Kammer mit der Kolbenbohrung jenseits der Dichtungen (50, 52) verbindet, und umgekehrt in der Deaktivierungsposition.

7. Werkzeug (10) nach einem der Ansprüche 4 bis 6, bei dem die Dornbohrung (20) und der Kolben (18) gestuft sind, wobei die durch die Stufe (64) zwischen ihnen gebildete ringförmige Kolbenkammer (46) mit einem Druckausgleichsmittel versehen ist, so dass ein Druck von Bohrschlamm in dem Körper den Kolben entlang des Dorns bewegt, um die Kolbenkammer zu schließen.

8. Werkzeug (10) nach einem der Ansprüche 4 bis 7, bei dem der Kolben (18) und der Dorn (14) zwischen sich eine Mantelkurve (72') bilden, so dass sich der Kolben bei einer axialen Bewegung von ihm in Bezug auf den Dorn (14) dreht, wobei die Kurve in Abhängigkeit von der Winkelposition (18) des Kolbens in dem Dorn (14) unterschiedliche Hübe des Kolbens (18) zulässt.

9. Werkzeug (10) nach Anspruch 8, bei dem der Kolben (18) und der Dorn (14) ineinandergreifende Verzahnungen (78a, 78b) aufweisen, die, wenn sie einander in einer Winkelposition des Kolbens (18) in Bezug auf den Dorn (14) gegenüberstehen, wie es durch die Mantelkurve (72') festgelegt wird, dem Kolben (18) erlauben, sich in eine von der Aktivierungs- und der Deaktivierungsposition zu bewegen, und, wenn sie ineinandergreifen, dem Kolben (18) erlauben, sich in die andere von der Aktivierungs- und der Deaktivierungsposition zu bewegen.

10. Werkzeug (10) nach Anspruch 9, bei dem die Man-

telkurve (72') einen Stift (74) in einer Bahn (76) aufweist und die Bahn (76) so angeordnet ist, dass eine Drehung des Kolbens (18) in Bezug auf den Dorn (14) vollendet ist, bevor die Verzahnungen (78a, 78b) aneinander angreifen.

11. Werkzeug (10) nach Anspruch 10, bei dem sich die Bahn (76) an dem Kolben (18) befindet und der Stift (74) an dem Dorn (14) befindet.

12. Werkzeug (10) nach Anspruch 10 oder 11, bei dem die Bahn (76) so angeordnet ist, dass die Verzahnungen (78a, 78b) in entweder der Aktivierungs- oder der Deaktivierungsposition aneinander stoßen und axiale hydraulische Kräfte zwischen dem Kolben (18) und dem Dorn (14) übertragen, bevor der Stift (74) das Ende der Bahn (76) erreicht.

13. Werkzeug (10) nach Anspruch 5 oder einem der Ansprüche 6 bis 12, wenn sie von Anspruch 5 abhängen, bei dem sich die Rückführstufe (64) in Bezug auf den Körper (12) innen befindet und zwei Ringe (90, 92) aufweist, die verbunden sind und zwischen ihnen Ringsektoren (98) fangen, die in einer ringförmigen Vertiefung (96) in dem Körper (12) aufgenommen sind.

14. Werkzeug (10) nach Anspruch 6 und 13, bei dem ein Kanal (62) durch die Rückführstufe (64) mit einem Druckausgleichsmittel versehen ist und mit der Zwischen-Durchlassöffnung (60) des Dorns (14) in Verbindung steht, wobei der Dorn (14) gegen die Rückführstufe (64) auf jeder Seite des Kanals und der Zwischen-Durchlassöffnung (62) abgedichtet ist.

15. Werkzeug (10) nach Anspruch 5 oder einem der Ansprüche 6 bis 14, wenn sie von Anspruch 5 abhängen, bei dem der Durchmesser der Kammern (102, 104) unterschiedlich ist, wobei die Kammer (102, 104), die dazu dient, das Werkzeug (10) zu aktivieren, wenn sie unter Druck gesetzt ist, den größeren Durchmesser hat.

16. Werkzeug (10) nach Anspruch 5 oder einem der Ansprüche 6 bis 15, wenn sie von Anspruch 5 abhängen, bei dem der Durchmesser des Dorns (14) in dem Körper (12) auf den Seiten der Kammern (102, 104) entfernt von der Rückführstüfe (64) auf der Seite größer ist, auf der hydraulischer Druck den Dorn (14) bewegt, um das Werkzeug zu aktivieren.

17. Werkzeug (10) nach einem der vorhergehenden Ansprüche, bei dem ein Drosselventil betätigt wird, wenn das Werkzeug (10) aktiviert wird, wobei eine derartige Betätigung dazu dient, den Druckabfall des Bohrschlamms über das Werkzeug (10) zu ändern, um die Zustände der Aktivierung des Werkzeugs (10) anzuzeigen.

18. Werkzeug (10) nach Anspruch 17, bei dem der Kolben eine Kolbendrosselplatte (150) über die Kolbenbohrung (46) in Berührung Fläche an Fläche mit einer Kolbendrosselplatte (152) trägt, wobei die Drosselplatten (150, 152) in Bezug auf den Kolben (18) beziehungsweise den Dorn (14) winkelmäßig fixiert sind und einen Schlammfluss durch das Werkzeug in Abhängigkeit von ihren relativen Winkelpositionen drosseln.

19. Werkzeug (10) nach Anspruch 18, bei dem die Dorndrosselplatte (152) winkelmäßig in Bezug auf den Körper (12) fixiert ist, wobei der Körper in Bezug auf den Dorn (14) winkelmäßig fixiert ist.

20. Werkzeug (10) nach Anspruch 18 oder 19, bei dem die Drosselplatten (150, 152) eine zentrale Öffnung (156) in Ausrichtung miteinander und abwechselnde Sektorräume (154) und Sektorvorsprünge (158) haben, so dass dann, wenn die Vorsprünge (158) an den Platten (150, 152) des Kolbens (18) und des Dorns in Ausrichtung miteinander sind, Schlamm durch sowohl die zentrale Öffnung (156) als auch die Räume (154) fließt, und dann, wenn die Vorsprünge und Räume in Ausrichtung sind, Schlamm durch die zentrale Öffnung (156) fließt.

21. Werkzeug (10) nach Anspruch 1 oder einem der Ansprüche 2 bis 20, wenn sie nicht von Anspruch 2 abhängen, bei dem der Dorn (14) zur Betätigung des Werkzeugs (10) durch hydraulischen Druck des Bohrschlamms bewegt wird, wenn das Ventil ein Auslassen einer Auslasskammer (157) zulässt.

22. Werkzeug (10) nach Anspruch 21, bei dem der Dorn (14) zur Deaktivierung des Werkzeugs (10) bei einer Entlastung des hydraulischen Drucks durch eine Dornrückstellfeder (164) bewegt wird.

23. Werkzeug (10) nach Anspruch 21 oder 22, bei dem die Auslasskammer (157) durch eine Stufe zwischen dem Dorn (14) und dem Körper (12) gebildet wird.

24. Werkzeug (10) nach Anspruch 23, bei dem der Kolben (18) dazu dient, um eine Durchlassöffnung (155) zwischen der Auslasskammer (157) und der Körperbohrung (16) zu öffnen und zu schließen.

25. Werkzeug (10) nach den Ansprüchen 3 und 24, bei dem der Kolben (18) dann, wenn er sich von der Niederdruckposition in die Druckposition bewegt, die Durchlassöffnung (16) nur öffnet, wenn er sich in die Aktivierungsposition bewegt.

26. Werkzeug (10) nach Anspruch 17 und Anspruch 24 oder 25, bei dem der Körper (12) mit den Enden des

Kolbens (18) und des Dorns (14) eine Ventilkammer (15) bildet, wobei das Drosselventil einen Weg zwischen dem Kolben (18) und dem Körper (12) aufweist, der geöffnet ist, wenn sich der Kolben (18) in die Aktivierungsposition bewegt und sich der Dorn (14) bewegt, um das Werkzeug (10) zu aktivieren, und der verengt wird, wenn sich der Kolben (18) in die Deaktivierungsposition ist.

27. Stabilisator mit einem Werkzeug (10) nach einem der vorhergehenden Ansprüche und Komponenten, die in dem Körper (12) radial angeordnet und von dem Dorn (14) während der Aktivierung des Werkzeugs nach außen gedrückt werden, um den effektiven Durchmesser des Stabilisators zu erhöhen.

28. Bohrstrang mit einer Bohrmeißel (220) und einem Meißelstabilisator (240), wie er in Anspruch 27 beansprucht ist.

Revendications

1. Outil de fond de puits (10) comprenant :

- un corps (12) ayant un alésage traversant (16);
- un mandrin (14) ayant un alésage traversant (20), étant apte à coulisser axialement dans l'alésage du corps pour activer et désactiver l'outil ; et
- une soupape ayant une position d'activation et de désactivation, dans laquelle, dans la position d'activation, la boue de forage aspirée sous pression le long dudit alésage du corps (16) active l'outil et dans la position de désactivation, la boue de forage aspirée sous pression le long dudit alésage du corps (16) n'active pas l'outil,

caractérisé par le fait que :

ladite soupape (18) est commutable par changement de pression de ladite boue de forage, pour contrôler ainsi par voie hydraulique le mouvement de mandrin (14),
la soupape comprenant un piston de commande (18) apte à coulisser dans l'alésage du mandrin (20), à l'encontre de la force d'un ressort de rappel (40), entre une position de pression faible et une position de pression sous l'effet de la pression de la boue de forage.

2. Outil (10) selon la revendication 1, dans lequel ladite soupape commande la boue de forage pour entraîner le mandrin (14) par voie hydraulique à la fois pour activer et désactiver l'outil.

3. Outil (10) selon la revendication 2, dans lequel ladite position de pression est de façon alternée l'une parmi ladite position d'activation et ladite position de désactivation espacées axialement le long de l'alésage du mandrin (20) à partir de ladite position d'activation, l'outil (10) étant activé par la pression de la boue lorsque le piston (18) est dans ladite position d'activation et désactivé lorsque qu'il est dans ladite position de désactivation.

4. Outil (10) selon la revendication 3, dans lequel la position d'activation est entre les positions de désactivation et de pression faible du piston (18).

5. Outil (10) selon la revendication 3 ou la revendication 4 lorsqu'elles dépendent de la revendication 2, dans lequel un gradin de rappel (64) est formé dans le corps (12) et le mandrin (14) pour définir des chambres annulaires entre eux sur l'un ou l'autre côté du gradin de rappel, une chambre (102, 104), lorsqu'elle est pressurisée par la boue, servant à activer l'outil tandis que l'autre sert à désactiver l'outil.

6. Outil (10) selon la revendication 5, dans lequel ledit piston de commande (18) a un passage (46) disposé axialement et un joint d'étanchéité (50, 52) contre le mandrin au niveau des deux extrémités du passage, le mandrin (14) ayant deux orifices (120, 130) communiquant chacun avec lesdites chambres annulaires (102, 104) avec l'alésage du mandrin (20) et un orifice intermédiaire (60) ventilant ledit passage (46), le piston (18) dans la position d'activation connectant une chambre avec le passage et l'autre chambre avec l'alésage du piston au-delà des joints d'étanchéité (50, 52), et réciproquement dans ladite position de désactivation.

7. Outil (10) selon l'une quelconque des revendications 4 à 6, dans lequel l'alésage du mandrin (20) et le piston (18) sont disposés en gradins, la chambre du piston annulaire (46) formée par ledit gradin (64) entre eux étant ventilée de telle sorte que la pression de la boue de forage dans le corps déplace le piston le long du mandrin pour fermer ladite chambre du piston.

8. Outil (10) selon l'une quelconque des revendications 4 à 7, dans lequel le piston (18) et le mandrin (14) entre eux définissent une came cylindrique (72') de telle sorte que le piston tourne lors d'un mouvement axial de celui-ci par rapport au mandrin (14), la came permettant différentes courses du piston (18) en fonction de la position angulaire (18) du piston dans le mandrin (14).

9. Outil (10) selon la revendication 8, dans lequel le piston (18) et le mandrin (14) ont des créneaux interdigités (78a, 78b) qui, lorsqu'ils s'opposent l'un à l'autre dans une première position angulaire du piston (18) par rapport au mandrin (14), comme déter-

miné par la came périphérique (72'), permettent au piston (18) de se déplacer vers l'une desdites positions d'activation et de désactivation et, lorsqu'elles s'interdigitent, permettent au piston (18) de se déplacer vers l'autre desdites positions d'activation et de désactivation.

10. Outil (10) selon la revendication 9, dans lequel la came périphérique (72') comprend une broche (74) dans une piste (76) et la piste (76) est arrangée de telle sorte que la rotation du piston (18) par rapport au mandrin (14) est complète avant que les créneaux (78a, 78b) ne s'emboîtent l'un avec l'autre.

11. Outil (10) selon la revendication 10, dans lequel la piste (76) est sur le piston (18) et la broche (74) est sur le mandrin (14).

12. Outil (10) selon la revendication 10 ou la revendication 11, dans lequel la piste (76) est arrangée de telle sorte que les créneaux (78a, 78b) viennent en butée dans l'une ou l'autre des positions d'activation ou de désactivation et transmettent des forces hydrauliques axiales entre le piston (18) et le mandrin (14) avant que la broche (74) n'atteigne l'extrémité de la piste (76).

13. Outil (10) selon la revendication 5 ou l'une quelconque des revendications 6 à 12 lorsqu'elles dépendent de la revendication 5, dans lequel le gradin de rappel (64) est vers l'intérieur du corps (12) et comprend deux anneaux (90, 92) interconnectés et capturant entre eux des secteurs d'anneau (98) reçus dans une rainure annulaire (96) dans le corps (12).

14. Outil (10) selon l'une quelconque des revendications 6 à 13, dans lequel le passage (62) à travers le gradin de rappel (64) est ventilé et communique avec ledit orifice intermédiaire (60) du mandrin (14), le mandrin (14) étant scellé de façon étanche au gradin de rappel (64) sur l'un ou l'autre côté dudit passage et de l'orifice intermédiaire (62).

15. Outil (10) selon la revendication 5 ou l'une quelconque des revendications 6 à 14 lorsqu'elles dépendent de la revendication 5, dans lequel les diamètres des chambres (102, 104) sont différents, la chambre (102, 104) ayant le diamètre le plus grand servant à activer l'outil (10) lorsqu'elle est pressurisée.

16. Outil (10) selon la revendication 5 ou l'une quelconque des revendications 6 à 15 lorsqu'elles dépendent de la revendication 5, dans lequel le diamètre du mandrin (14) dans le corps (12) sur les côtés des chambres (102, 104) éloignés du gradin de rappel (64) est plus grand sur le côté où la pression hydraulique déplace le mandrin (14) pour activer l'outil.

17. Outil (10) selon l'une quelconque des revendications précédentes, dans lequel un étrangleur est activé lorsque l'outil (10) est activé, une telle activation étant pour changer la chute de pression de la boue de forage à travers l'outil (10) de façon à signaler les états d'activation de l'outil (10).

18. Outil (10) selon la revendication 17, dans lequel le piston porte une plaque (150) de restriction du piston à travers l'alésage du piston (46) en contact de face à face avec une plaque (152) de restriction du mandrin, les plaques de restriction (150, 152) étant fixées de façon angulaire par rapport au piston (18) et au mandrin (14) respectivement et restreignant l'écoulement de la boue à travers l'outil en fonction de leur position angulaire relative.

19. Outil (10) selon la revendication 18, dans lequel la plaque (152) de restriction du mandrin est fixée de façon angulaire par rapport au corps (12), le corps étant fixé de façon angulaire par rapport au mandrin (14).

20. Outil (10) selon la revendication 18 ou la revendication 19, dans lequel les plaques de restriction (150, 152) ont une ouverture centrale (156) en correspondance l'une avec l'autre et des espaces de secteur (154) et des lobes de secteur (158) en alternance de telle sorte que, lorsque les lobes (158) sur les plaques (150, 152) du piston (18) et du mandrin sont en correspondance l'une avec l'autre, la boue s'écoule à travers à la fois l'ouverture centrale (156) et les espaces (154), et lorsque les lobes et les espaces sont en correspondance, la boue s'écoule à travers l'ouverture centrale (156).

21. Outil (10) selon la revendication 1 ou l'une quelconque des revendications 2 à 20 lorsqu'elles ne dépendent pas de la revendication 2, dans lequel ledit mandrin (14) est déplacé pour activer l'outil (10) par pression hydraulique de ladite boue de forage lorsque ladite soupape permet la purge d'une chambre de purge (157).

22. Outil (10) selon la revendication 21, dans lequel ledit mandrin (14) est déplacé pour désactiver l'outil (10), lors de la libération de ladite pression hydraulique, par un ressort de rappel du mandrin (164).

23. Outil (10) selon la revendication 21 ou la revendication 22, dans lequel ladite chambre de purge (157) est formée par un gradin entre le mandrin (14) et le corps (12).

24. Outil (10) selon la revendication 23, dans lequel ledit piston (18) sert à ouvrir et fermer un orifice (155) entre ladite chambre de purge (157) et l'alésage du corps (16).

25. Outil (10) selon la revendication 3 et la revendication 24, dans lequel ledit piston (18), lorsqu'il se déplace de ladite position de pression faible à ladite position de pression, ouvre uniquement ledit orifice (16) lorsqu'il se déplace vers ladite position d'activation.

26. Outil (10) selon la revendication 17 et la revendication 24 ou la revendication 25, dans lequel ledit corps (12) définit, avec les extrémités dudit piston (18) et dudit mandrin (14), une chambre de soupape (15), ledit étrangleur comprenant un trajet entre ledit piston (18) et ledit corps (12) qui est ouvert lorsque ledit piston (18) se déplace vers ladite position d'activation et le mandrin (14) se déplace pour activer l'outil (10), et qui est restreint lorsque le piston (18) se déplace vers ladite position de désactivation.

27. Stabilisateur comprenant un outil (10) selon l'une quelconque des revendications précédentes, et des éléments disposés radialement dans le corps (12) et pressés vers l'extérieur par le mandrin (14) pendant l'activation de l'outil pour augmenter le diamètre effectif du stabilisateur.

28. Train de tiges de forage comprenant un foret (220) et un stabilisateur (240) proche du foret selon la revendication 27.

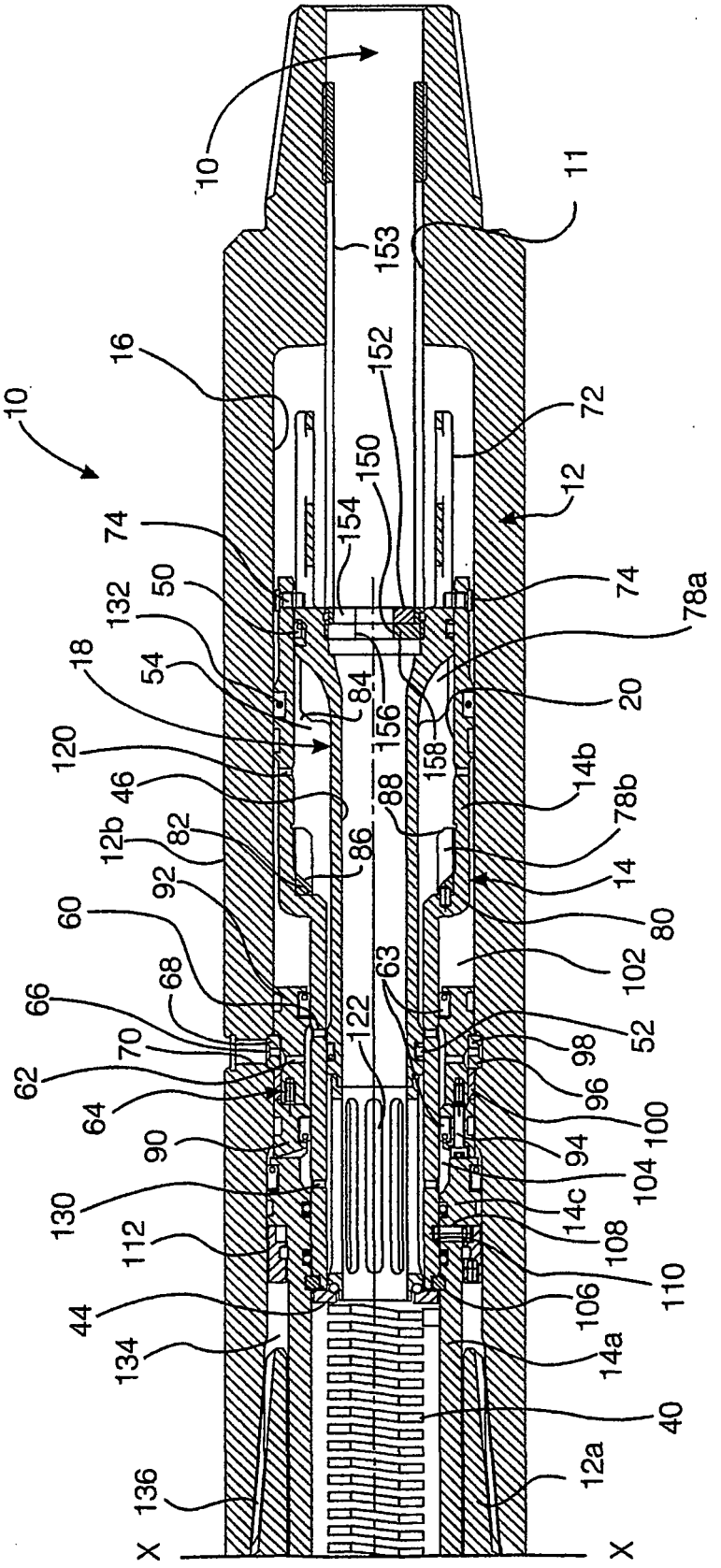
10
11
153
16
152
72
12
150
154
74
50
132
74
78a
18
54
84
20
120
156
158
46
14b
88
78b
12b
82
86
14
92
60
80
68
102
63
66
122
52
70
98
62
96
64
100
90
94
104
130
14c
112
108
110
106
44
14a
134
40
12a
136
X
X

Fig. 1a

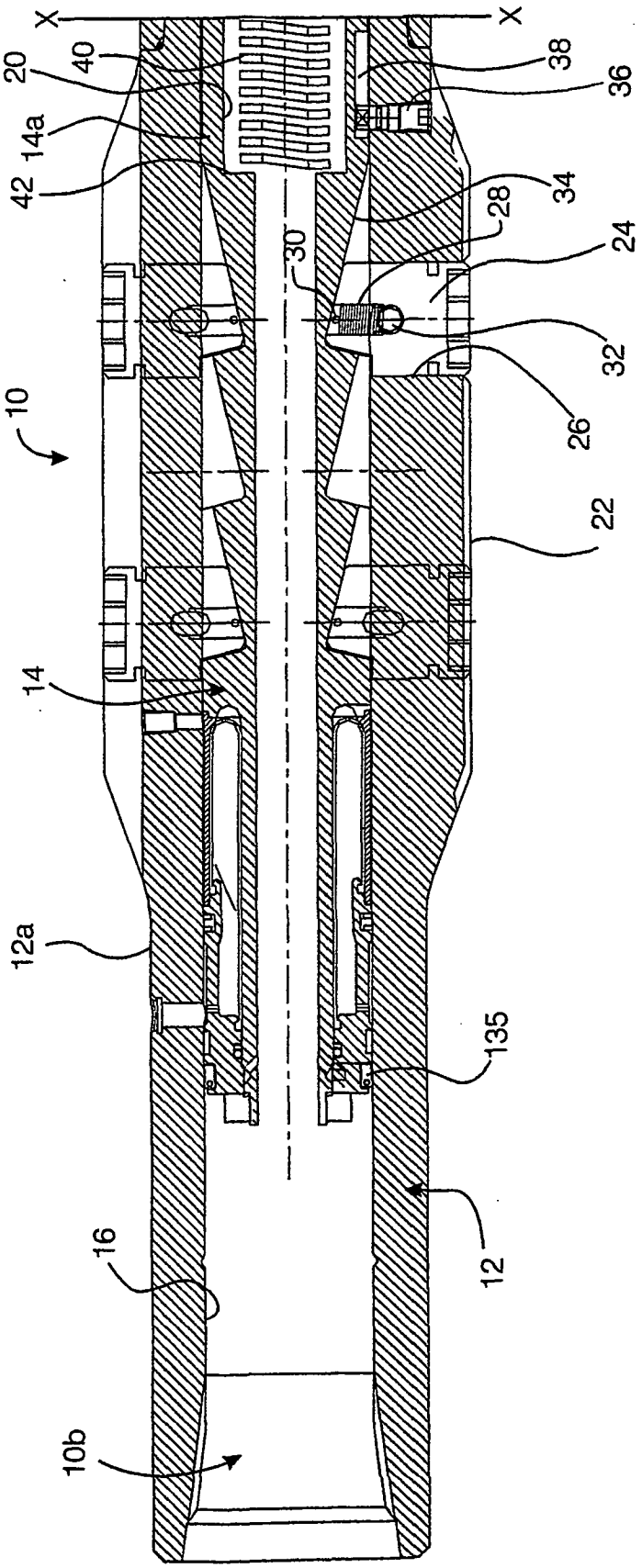

Fig. 1b

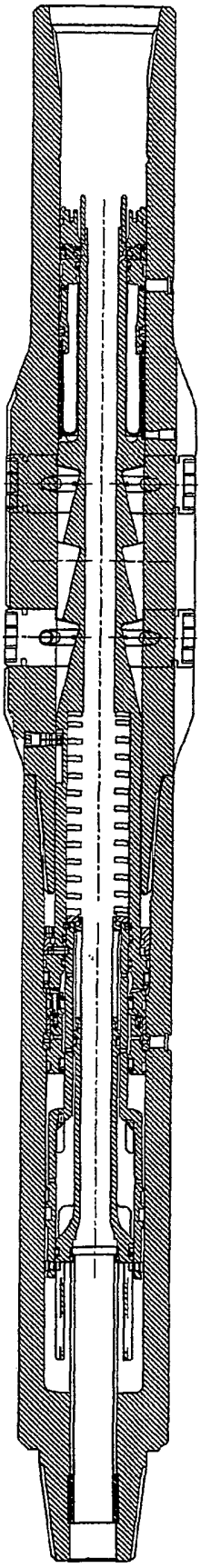

Fig. 2a

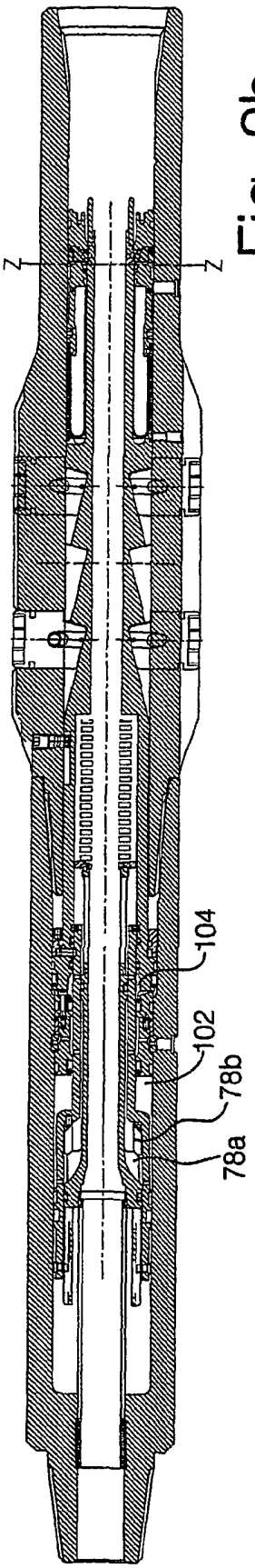

Fig. 2b

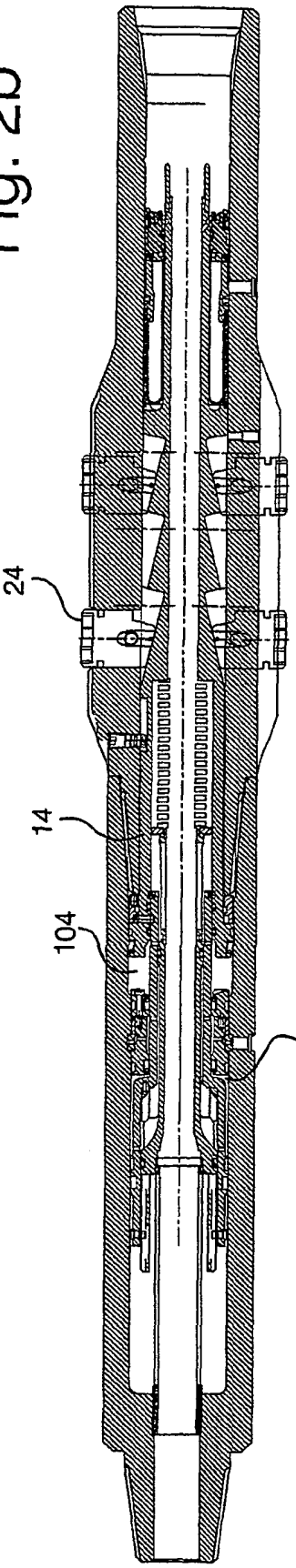

Fig. 2c

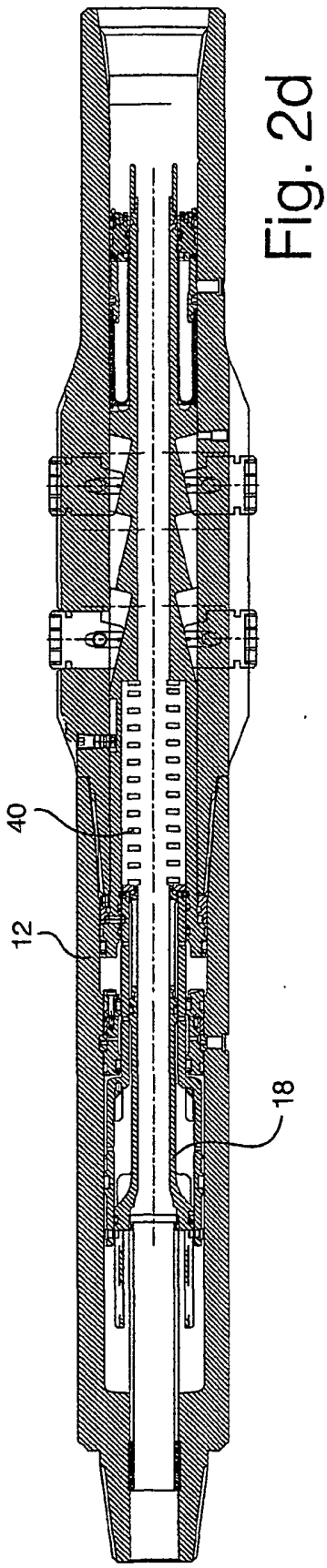

Fig. 2d

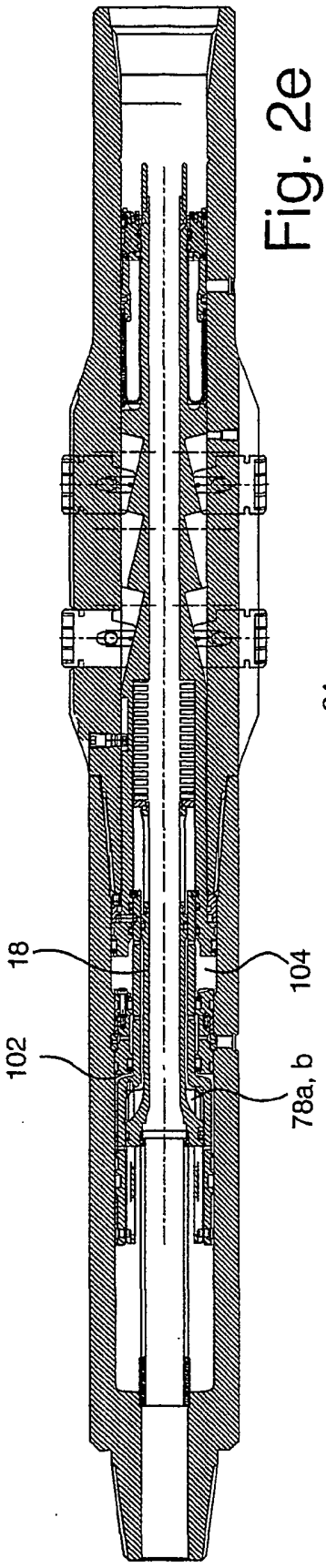

Fig. 2e

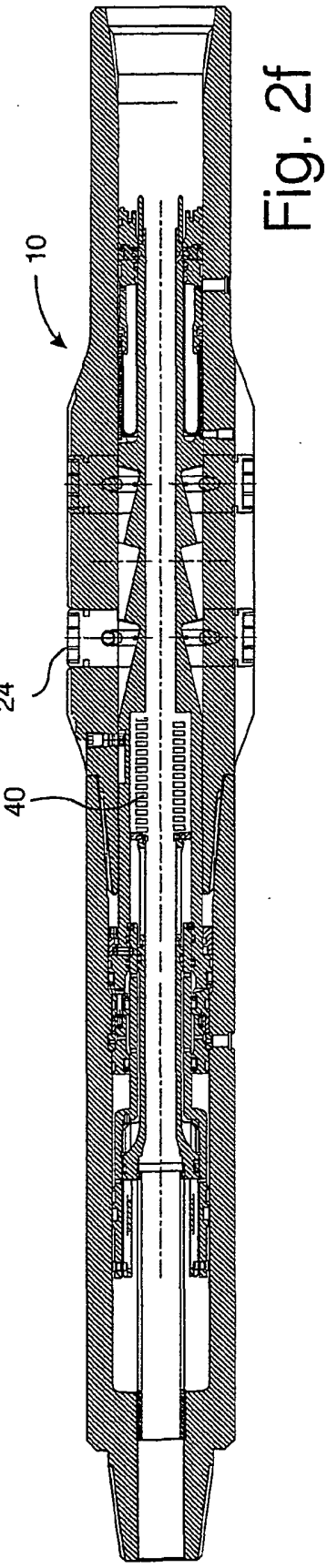

Fig. 2f

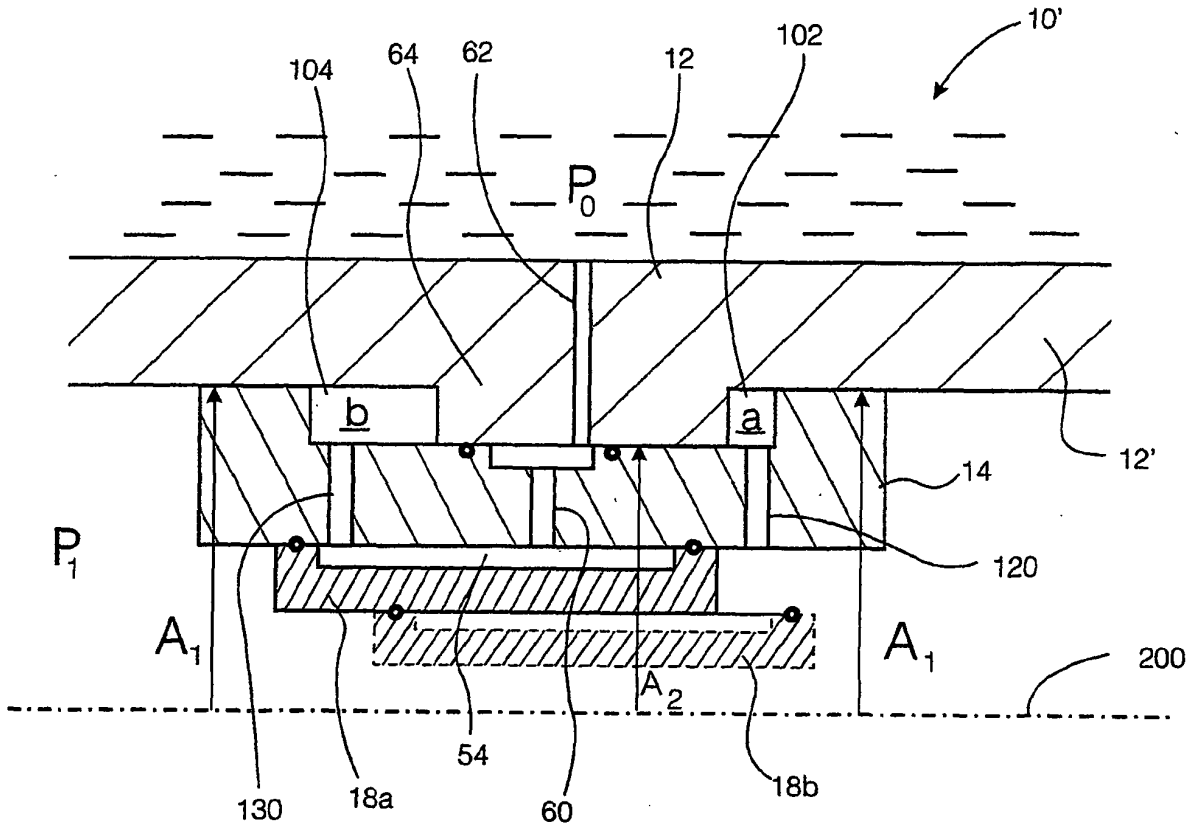
10'
104
64
62
12
102
P_0
b
a
12'
14
P_1
120
A_1
A_1
200
A_2
54
130
18a
60
18b

Fig. 3

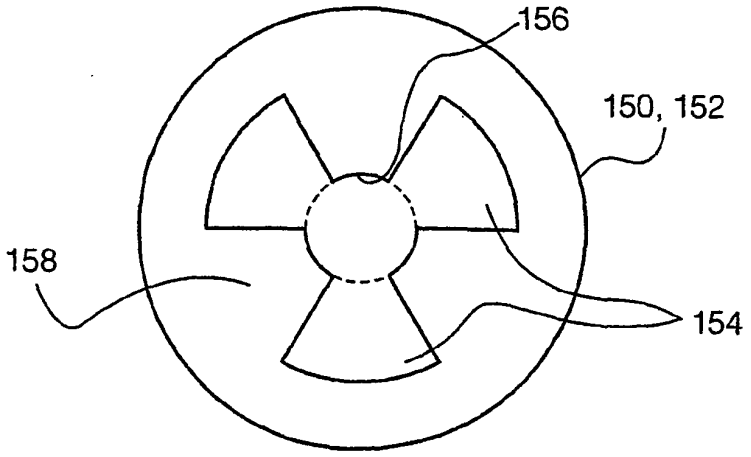
156
150, 152
158
154

Fig. 1c

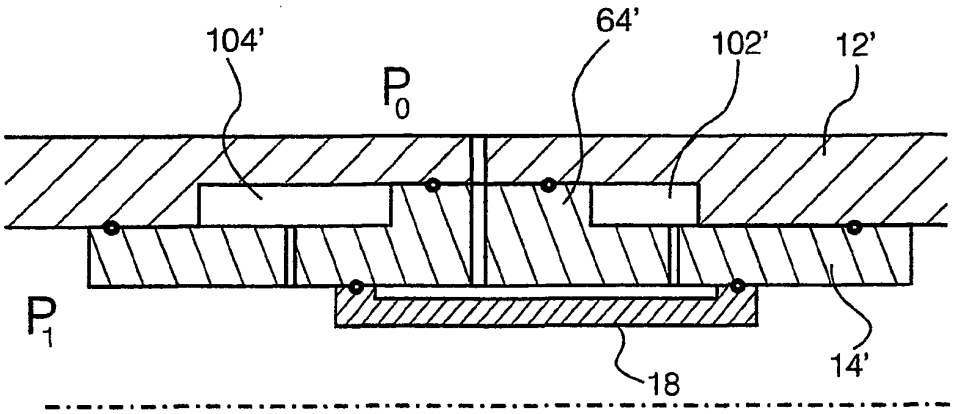
104'
64'
102'
12'
P0
P1
18
14'

Fig. 4

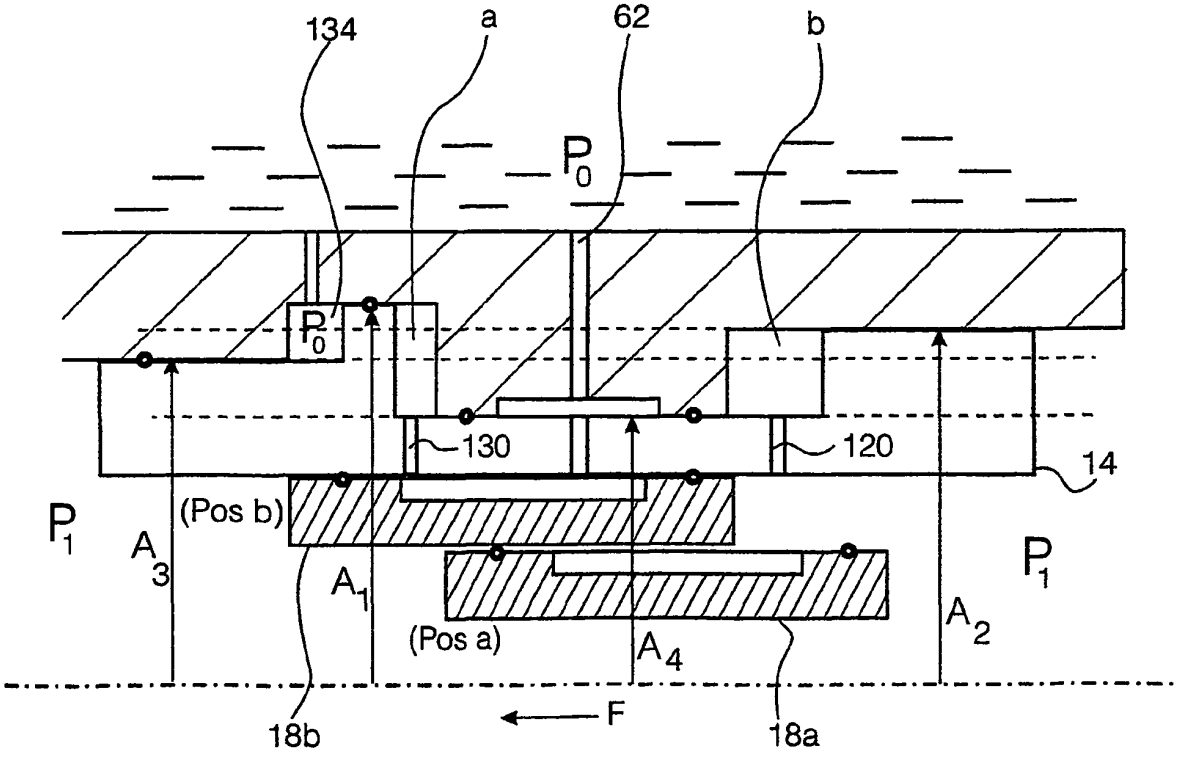
134
a
62
b
P0
P0
130
120
14
P1
(Pos b)
A3
A1
(Pos a)
A4
A2
P1
F
18b
18a

Fig. 5

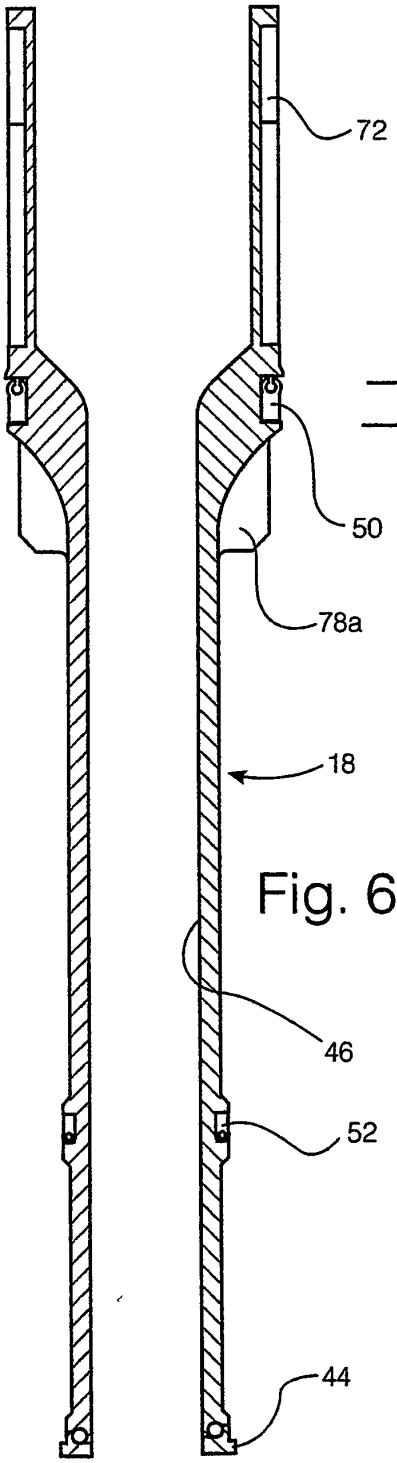

Fig. 6a

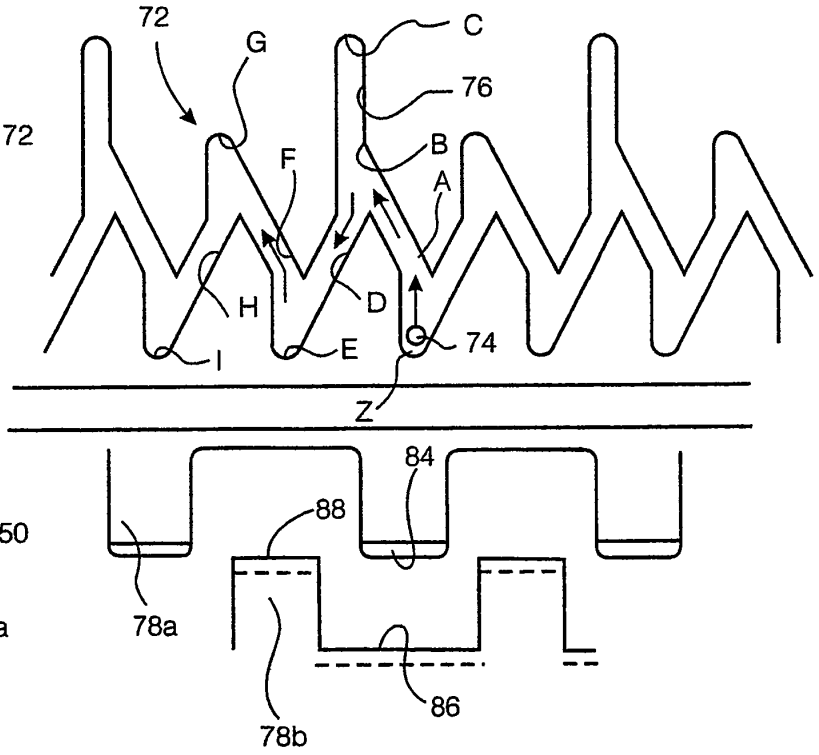

Fig. 6b

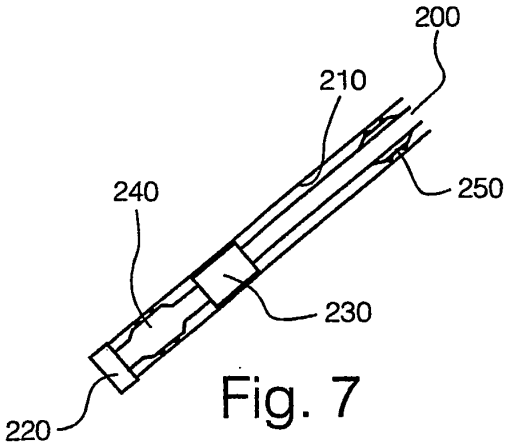

Fig. 7

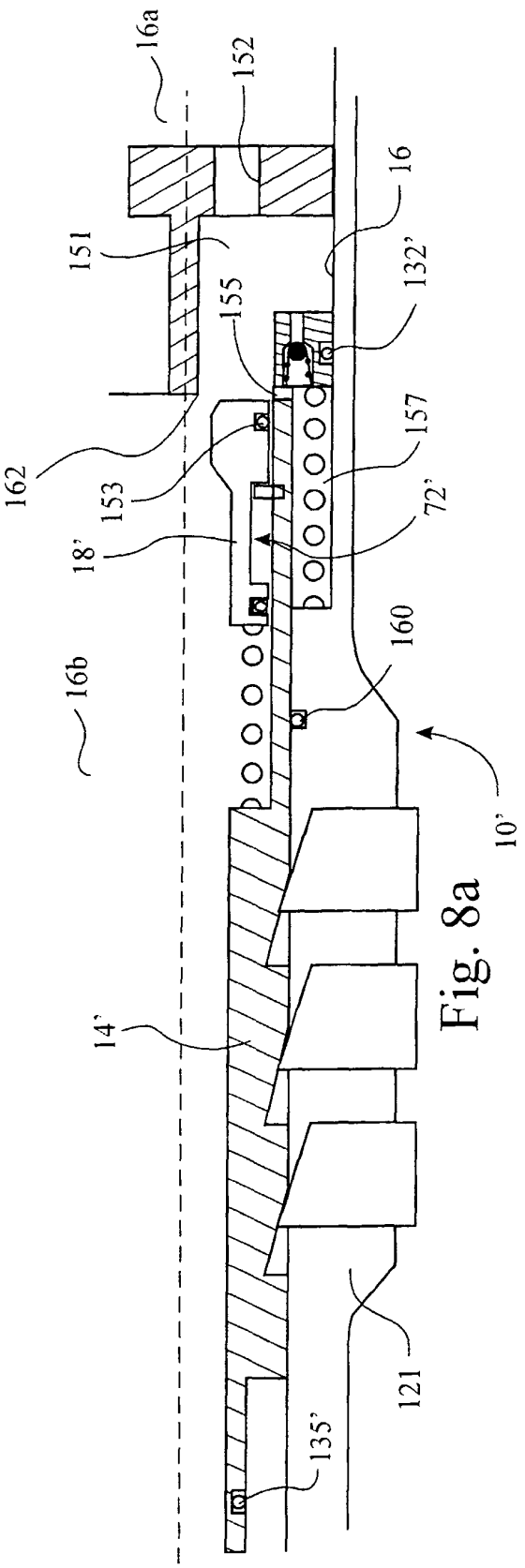
16a
152
16
151
132'
155
162
153
157
18'
72'
160
16b
10'
14'
135'
121

Fig. 8a

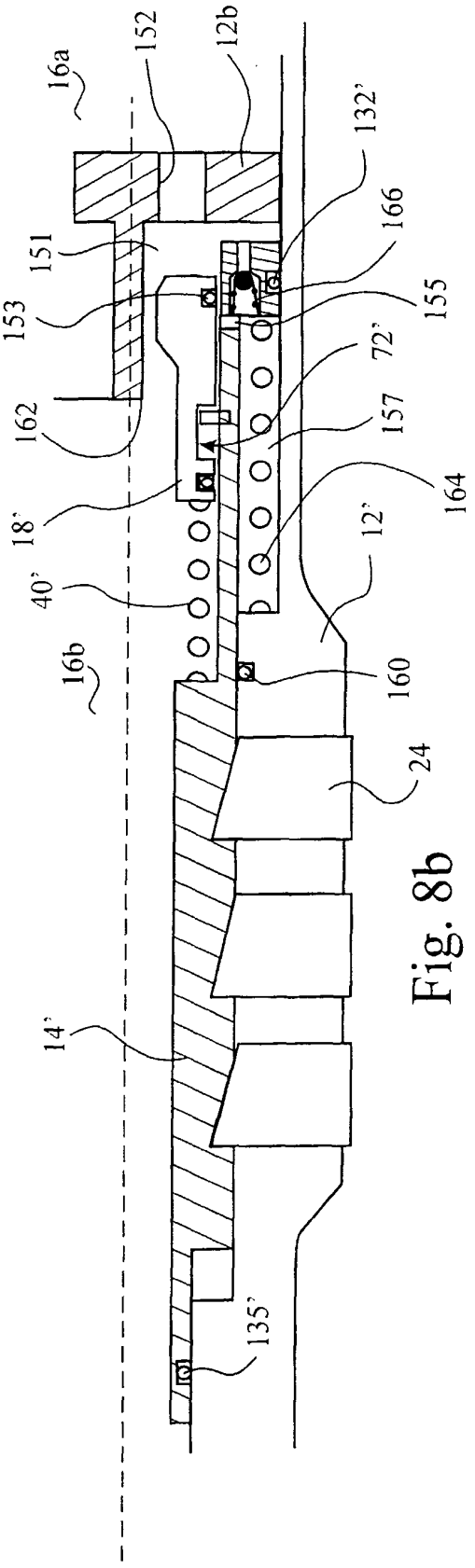
16a
152
12b
132'
166
151
153
155
72'
162
157
18'
164
12'
40'
160
16b
24
14'
135'

Fig. 8b

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0251543 A **[0006]**
- US 4951760 A **[0007]**
- GB 2346443 A **[0009]**
- US 3974886 A **[0012]**