April 17, 1951 R. C. BAKER 2,548,931

UNDERREAMER

Filed April 4, 1947

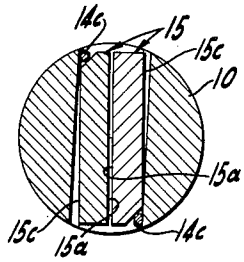

FIG. 3

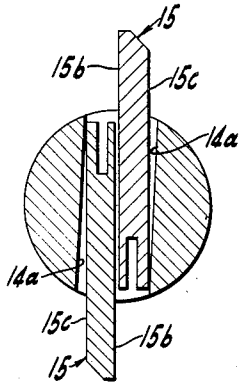

FIG. 4

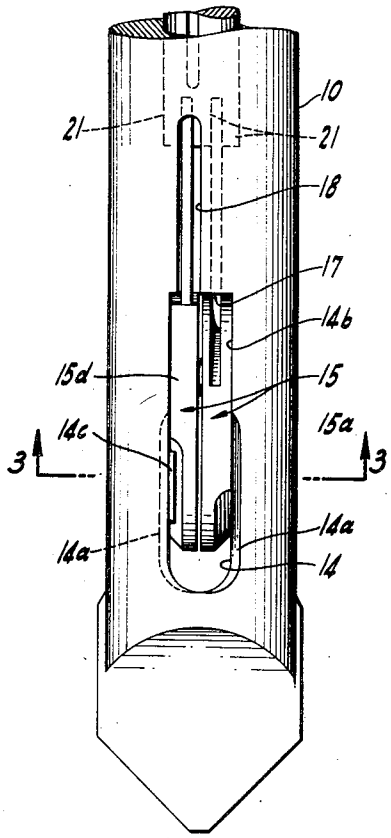

FIG. 2

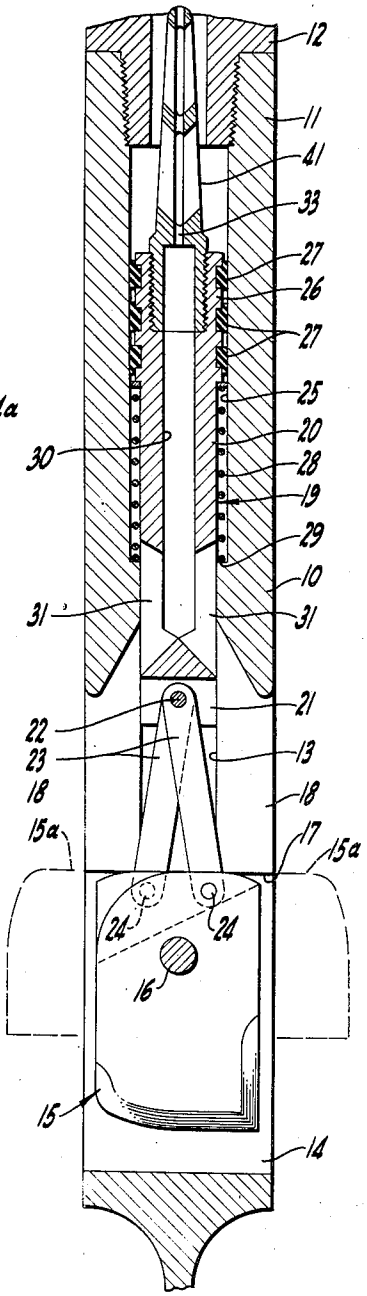

FIG. 1

INVENTOR
Reuben C. Baker

BY

Mellin & Hanscom
ATTORNEYS

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UNDERREAMER

Reuben C. Baker, Coalinga, Calif., assignor to Baker Oil Tools, Inc., Vernon, Calif., a corporation of California

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14 Claims. (Cl. 255—76)

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The present invention relates to underreamers for enlarging the diameters of well bores.

Underreamers for enlarging the diameters of well bores usually have one or more cutters held within the main body of the underreamer in retracted position during lowering of the tool through the well bore to the location at which the underreaming operation is to commence. Upon reaching this location the cutters are expanded outwardly for the purpose of enlarging the well bore. In certain wells, the hole condition is such that the drilling mud packs around the cutters and prevents their outward expansion. This is particularly true of cutters of the drag type, which are held confined within slots in the underreamer body, and in which the rotary drilling mud tends to pack firmly between the cutters and the sides of the slot, in effect freezing the cutters to the body.

Accordingly, it is an object of the present invention to provide an underreamer whose cutting elements can be expanded outwardly with greater facility, and in which the tendency of the cutting elements to become wedged or frozen to the underreamer body is largely, if not entirely, eliminated.

Another object of the invention is to provide an underreamer whose cutter blades are expanded outwardly, and in which the expansion of the blades themselves removes or eliminates any substances, such as drilling mud, which may have become wedged between the blades and the underreamer body.

One form which the invention may assume is exemplified in the following description and illustrated by way of example in the accompanying drawings, in which:

Fig. 1 is a longitudinal section through an underreamer, with its cutter blades shown in elevation and in retracted position.

Fig. 2 is a partial side elevation of the underreamer disclosed in Fig. 1.

Fig. 3 is a cross-section taken along the line 3—3 in Fig. 2, with the cutter blades in retracted position.

Fig. 4 is a view similar to Fig. 3, disclosing the cutter blades in expanded position.

Underreamers of the type disclosed in the drawings are described in detail in United States Patent No. 1,857,616. They include an elongate main supporting body 10 provided with an upper threaded box 11 attachable to the lower end of a string of drill pipe 12 or the like, by means of which the underreamer is lowered in the well bore and rotated in the performance

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of its underreaming operations. The body has a central longitudinal passage 13 therethrough merging into a lower elongate slot 14 opening outwardly of the body. A pair of cutter blades 15 of the drag type are movable within the slot 14 being mounted upon a hinge pin 16 extending through the body and across its slot 14.

The cutters 15 have an initial downward position substantially completely retracted within the confines of the body 10 and are swingable outwardly in opposite directions to extend beyond the periphery of the body, occupying a generally horizontal position with their upper sides 15a engaging the upper shoulders 17 of the longitudinal slot 14. A second set of longitudinal slots 18 extend upwardly to one side of and above the stop shoulders 17 at the ends of the main slot 14 to provide passages through which drilling fluid may pass for discharge onto the cutter blades 15.

The blades are swingable inwardly and outwardly of the body slots 14 in response to upward and downward movement of an operating plunger 19 slidable within the central passage 13 of the main body. This plunger includes a tubular plunger body 20 having a transverse hole through depending legs 21 in its lower end for receiving a pivot pin 22 in which the upper ends of a pair of links 23 are pivotally mounted between the legs. The lower end of each link is pivotally attached to a cutter blade 15 by means of a pin 24. It is to be noted that the links 23 are pivoted to the blades on opposite sides of the hinge pin 16 in order that downward movement of the plunger 19 pivots the blades 15 oppositely in upward and outward directions. Such outward movement may continue, as aforementioned, until the blades occupy horizontal positions in contact with the body shoulders 17.

The upper end of the body passage 13 is enlarged in diameter to form a cylinder 25 slidably receiving the upper piston portion 26 of the plunger, which is also enlarged to a diameter greater than the lower body portion 20. A plurality of piston rings 27, of rubber or similar material, are mounted on the piston for slidable sealing engagement with the wall of the cylinder 25 to prevent leakage in both directions around the piston. A spring 28 encircles the smaller diameter plunger body portion 20, one end engaging the lower end 29 of the cylinder, and its other end engaging the piston 26. This spring is under compression and tends to elevate the plunger 19 and retract and

maintain the blades 15 in their inward position within the confines of the body 10 against longitudinally extending stops 14c welded to the sides of the slot 14 adjacent its outer ends.

The plunger 19 is movable downwardly and the blades expanded outwardly by the pressure of fluid, like drilling mud, pumped downwardly through the string of drill pipe 12 and acting upon the piston 26. Since it is desired to discharge the drilling fluid onto the cutters 15 to maintain them free of detritus, the fluid continues downwardly through a central passage 30 in the plunger 19 for discharge in opposite directions through elongate slots 31 in the lower portion of the plunger body and through the upper body slots 18 onto the forward cutting faces 15b of the cutter blades 15. In view of this discharge of fluid, an orifice or restriction 33 is provided in the plunger passage 30 to enable a back pressure to be built up on the high pressure side of the piston 26 sufficient in value to overcome the compressive force of the spring 28, shift the plunger 19 downwardly, and swing the blades 15 outwardly through the agency of the pin and link connections 22, 23, 25 between the plunger 19 and blades 15. A slotted screen 41 may also be provided above the orifice 33 to prevent plugging of the latter.

Heretofore the sides of the slot 14 have been made parallel to one another and to the sides of the flat cutter blades 15 throughout their length, and have had substantial sliding engagement with the blades upon outward expansion of the latter in order that the back or trailing faces 15c of the blades would be engaged directly by the main body of the underreamer during rotation of the tool in the performance of the underreaming operation. Such support would prevent bending or breaking of the blades under high torque operating conditions. Despite the desirability for having such firm backing on the blades by the body, the trailing faces 15c of the blades were in comparatively snug engagement with the sides of the slot 14. Under some hole conditions, drilling mud would pack between the blades 15 and the sides of the slot 14 while the blades were in retracted position, and during their lowering through the drilling mud in the well bore to the location at which underreaming was to be performed. The extent of such packing or wedging of the drilling mud is oftentimes such as to prevent outward expansion of the blades 15 from their retracted positions upon the subjection of high pressures to the piston 26 of the plunger 19, the blades remaining in their retracted positions and unavailable for the performance of the underreaming function. As a result, removal of the underreamer from the well bore was required for the purpose of freeing the blades, at a substantial economic loss, and without assurance that they would be expandible upon rerunning in the well.

By virtue of the present invention, it is proposed to effect relief between the blades 15 and the sides of the slot 14, to eliminate the wedging tendency of the drilling mud on the blades and to enable their expansion whenever sufficient hydraulic pressure is imposed on the plunger piston 26. However, the blades 15 would still have sufficient backing upon their outward expansion to the horizontal position.

As disclosed in the drawings, the lower portion of the side of the slot 14 adjacent the back face 15c of each blade is relieved to provide an elongate laterally tapered surface 14a inclined in

cross-section away from the back face 15c of the blade in the direction in which the blades are expanded outwardly. In effect, such relief is V-shaped or wedge shaped in cross-section. The relief, however, does not extend along the upper portion 14b of the slot sides, which are parallel to the trailing faces 15c of the blades 15 and adapted to engage such blades along a substantial area of contact.

The underreamer is run in the well bore with the blades 15 in retracted positions and with their lower sides 15d disposed longitudinally and in engagement with the longitudinal ribs or stops 14c. During the running of the tool in the well bore to the desired location, drilling mud and other substances may pack around the blades 15 within the body slot 14 and may completely fill the wedge shaped relief portions of the slot between the trailing faces 15c and the inclined surfaces 14a, being packed firmly between such faces and tapered relieving surfaces. Upon reaching the location in the well bore at which the underreaming operation is to commence, the pumps are started at the surface of the well bore and fluid pressure imposed on the piston 26, forcing it downwardly against the action of the retractor spring 28 and tending to swing the cutter blades 15 in opposite directions upwardly and outwardly of the body slot 14. It is to be noted that the initial portion of the outward swinging of the blades will move the packed mud out of the wedge shaped relief portion of the body slot 14, since the slightest movement will move the V-shaped mud pack toward a larger space between the back face 15c of each blade and the tapered side 14a of the relieved area. Following this initial movement, the blades 15 may be swung outwardly to their fullest extent and horizontal position, without interference from the drilling mud that may have been originally packed therearound.

It is to be noted that upon swinging outwardly to horizontal position, the upper sides 15a of the blades are in engagement with the shoulders 17, with their trailing faces 15c in snug engagement with the unrelieved upper sides 14b of the slot 14, such sides 14b providing a firm backing to the blades during their rotation and operation upon the formation material in the well bore.

It is, accordingly, apparent that an underreamer has been provided in which wedging of the blades by the drilling mud and other substances in the well bore is largely, if not entirely, eliminated, thereby insuring the expansion of the blades to the fullest extent when and where desired. Despite the relief of the sides of the slot 14 to accomplish the aforementioned purpose, the blades have full backing by the body for the purpose of transmitting the drilling torque directly from the body to the blades themselves.

While I have shown the preferred form of my invention, it is to be understood that various changes may be made in its construction by those skilled in the art without departing from the spirit of the invention as defined in the appended claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. An underreamer, including a body adapted for attachment to a drill string, said body having a transverse slot, initially retracted cutter means within said slot, means connected to said cutter means for moving said cutter means in a single central plane within said slot laterally outward of said body, said cutter means having a mar-

ginal portion providing a cutting edge and an opposite marginal portion facing outwardly of said body, in the direction in which said cutter means is moved, when said cutter means is disposed in retracted position within said slot, said cutter means and side of said slot having a relieved portion whose surface is inclined in cross-section to the plane of movement of said cutter means within said slot for facilitating such lateral outward movement of said cutter means.

2. An underreamer, including a body adapted for attachment to a drill string, said body having a transverse slot, an initially retracted flat cutter blade mounted within said slot, means connected to said cutter blade for moving said blade in a single central plane within said slot laterally outward of said body, said cutter blade having a marginal portion providing a cutting edge and an opposite marginal portion facing outwardly of said body, in the direction in which said blade is moved, when said blade is disposed in retracted position within said slot said cutter blade and side of said slot having a relieved portion whose surface is inclined in cross-section to the plane of movement of said cutter blade within said slot for facilitating such lateral outward movement of said blade.

3. An underreamer, including a body adapted for attachment to a drill string, said body having a transverse slot, an initially retracted flat cutter blade pivotally carried by said body within said slot, means connected to said cutter blade for swinging said blade in a single central plane within said slot laterally outward of said body, the side of said slot adjacent said cutter blade having a relieved portion whose surface is inclined in cross-section to the adjacent side of said cutter blade for facilitating lateral movement of said blade outwardly of said body.

4. An underreamer, including a body adapted for attachment to a drill string, said body having a transverse slot, a cutter blade pivotally carried by said body within said slot, means connected to said blade for swinging it outwardly of said body to expanded position, the lower portion of the side of said slot adjacent the trailing face of said blade being relieved to facilitate outward swinging of said blade, the upper portion of the side of said slot being unrelieved to contact said trailing face and transmit rotary motion of said body directly to said blade following outward expansion of said blade.

5. An underreamer, including a body adapted for attachment to a drill string, said body having a transverse slot, a cutter blade pivotally carried by said body within said slot, means connected to said blade for swinging it outwardly of said body to expanded position, the side of said slot adjacent the trailing face of said blade having a lower relieved portion whose surface is inclined in cross-section to the adjacent trailing face of said cutter blade, said inclined surface diverging from said trailing face in the direction of outward swinging of said blade, the upper portion of the side of said slot being unrelieved and parallel to said trailing face to contact said trailing face and transmit rotary motion of said body directly to said blade following outward expansion of said blade.

6. An underreamer, including a body adapted for attachment to a drill string, said body having a transverse slot, a pair of cutter blades pivotally carried by said body within said slot, means connected to said blades for swinging them in opposite directions outwardly of said body to expanded positions, the lower portions of the sides of said slot adjacent the trailing faces of said blades being relieved to facilitate outward swinging of said blades, the upper portions of the sides of said slot being unrelieved to contact said trailing faces and transmit rotary motion of said body directly to said blades following their outward expansion.

7. An underreamer, including a body adapted for attachment to a drill string, said body having a transverse slot, a pair of cutter blades pivotally carried by said body within said slot, means connected to said blades for swinging them in opposite directions outwardly of said body to expanded positions, the lower portions of the sides of said slot adjacent the trailing faces of said blades being each inclined in cross-section to the adjacent trailing face of a cutter blade, said inclined portion diverging from said trailing face in the direction of outward swinging of said blade, the upper portions of the sides of said slot being unrelieved and parallel to said trailing faces to contact said trailing faces and transmit rotary motion of said body directly to said blades following their outward expansion.

8. An underreamer, including a body adapted for attachment to a drill string, said body having a transverse slot whose upper portion constitutes a shoulder, a pair of cutter blades pivotally carried by said body and adapted for disposition vertically within said slot, means connected to said blades for swinging them in opposite directions outwardly of said body to horizontal positions in engagement with said shoulder, the lower portion of the sides of said slot adjacent the trailing faces of said blades being each inclined in cross-section to the adjacent trailing face of a cutter blade, said inclined portion diverging from said trailing face in the direction of outward swinging of said blade, the upper portions of the sides of said slot being unrelieved and parallel to said trailing faces to contact said trailing faces and transmit rotary motion of said body directly to said blades following their outward expansion into engagement with said shoulder.

9. An underreamer, including a body adapted for attachment to a drill string, said body having a transverse slot, an initially retracted flat cutter blade pivotally carried by said body within said slot, means connected to said cutter blade for swinging said blade in a single central plane within said slot laterally outward of said body, said cutter blade having a marginal portion providing a cutting edge and an opposite marginal portion facing outwardly of said body, in the direction in which said body is swung, when said blade is disposed in retracted position within said slot, the side of said slot adjacent said blade having a relieved portion whose surface is inclined in cross-section to the adjacent side of said cutter blade for facilitating lateral movement of said blade outwardly of said body.

10. An underreamer, including a body adapted for attachment to a drill string, said body having a transverse slot, a cutter blade pivotally carried by said body within said slot, means connected to said blade for swinging it outwardly of said body to expanded position, said cutter blade having a marginal portion providing a cutting edge and an opposite marginal portion facing outwardly of said body, in the direction in which said blade is swung, prior to swinging of said blade outwardly of said body, the lower portion of the side of said slot adjacent the trailing face

of said blade being relieved to facilitate outward swinging of said blade, the upper portion of the side of said slot being unrelieved to contact said trailing face and transmit rotary motion of said body directly to said blade following outward expansion of said blade.

11. An underreamer, including a body adapted for attachment to a drill string, said body having a transverse slot, a cutter blade pivotally carried by said body within said slot, means connected to said blade for swinging it outwardly of said body to expanded position, said cutter blade having a marginal portion providing a cutting edge and an opposite marginal portion facing outwardly of said body, in the direction in which said blade is swung, prior to swinging of said blade outwardly of said body, the side of said slot adjacent the trailing face of said blade having a lower relieved portion whose surface is inclined in cross-section to the adjacent trailing face of said cutter blade, said inclined surface diverging from said trailing face in the direction of outward swinging of said blade, the upper portion of the side of said slot being unrelieved and parallel to said trailing face to contact said trailing face and transmit rotary motion of said body directly to said blade following outward expansion of said blade.

12. An underreamer, including a body adapted for attachment to a drill string, said body having a transverse slot, a pair of cutter blades pivotally carried by said body within said slot, means connected to said blades for swinging them in opposite directions outwardly of said body to expanded positions, each cutter blade having a marginal portion providing a cutting edge and an opposite marginal portion facing outwardly of said body, in the direction in which said blade is swung, prior to swinging of said blade outwardly of said body, the lower portions of the sides of said slot adjacent the trailing faces of said blades being relieved to facilitate outward swinging of said blades, the upper portions of the sides of said slot being unrelieved to contact said trailing faces and transmit rotary motion of said body directly to said blades following their outward expansion.

13. An underreamer, including a body adapted for attachment to a drill string, said body having a transverse slot, a pair of cutter blades pivotally carried by said body within said slot, means connected to said blades for swinging them in opposite directions outwardly of said body to expanded positions, each cutter blade having a marginal portion providing a cutting edge and an

opposite marginal portion facing outwardly of said body, in the direction in which said blade is swung, prior to swinging of said blade outwardly of said body, the lower portions of the sides of said slot adjacent the trailing faces of said blades being each inclined in cross-section to the adjacent trailing face of a cutter blade, said inclined portion diverging from said trailing face in the direction of outward swinging of said blade, the upper portions of the sides of said slot being unrelieved and parallel to said trailing faces to contact said trailing faces and transmit rotary motion of said body directly to said blades following their outward expansion.

14. An underreamer, including a body adapted for attachment to a drill string, said body having a transverse slot whose upper portion constitutes a shoulder, a pair of cutter blades pivotally carried by said body and adapted for disposition vertically within said slot, means connected to said blades for swinging them in opposite directions outwardly of said body to horizontal positions in engagement with said shoulder, each cutter blade having a marginal portion providing a cutting edge and an opposite marginal portion facing outwardly of said body, in the direction in which said blade is swung, when said blade is disposed vertically within said slot, said opposite marginal portion engaging said shoulder, the lower portions of the sides of said slot adjacent the trailing faces of said blades being each inclined in cross-section to the adjacent trailing face of a cutter blade, said inclined portion diverging from said trailing face in the direction of outward swinging of said blade, the upper portions of the sides of said slot being unrelieved and parallel to said trailing faces to contact said trailing faces and transmit rotary motion of said body directly to said blades following their outward expansion into engagement with said shoulder.

REUBEN C. BAKER.

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