

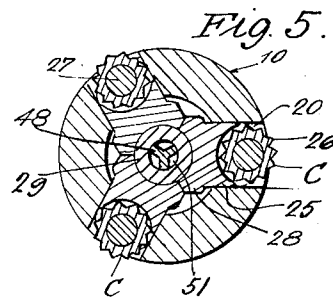
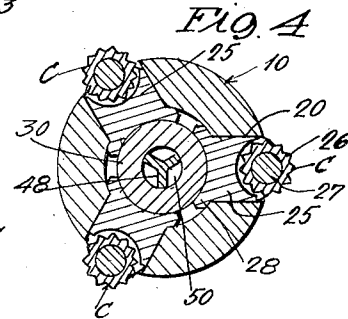
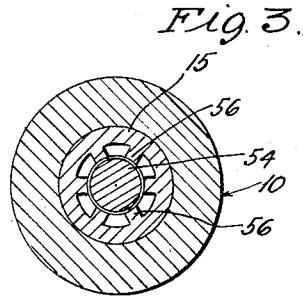
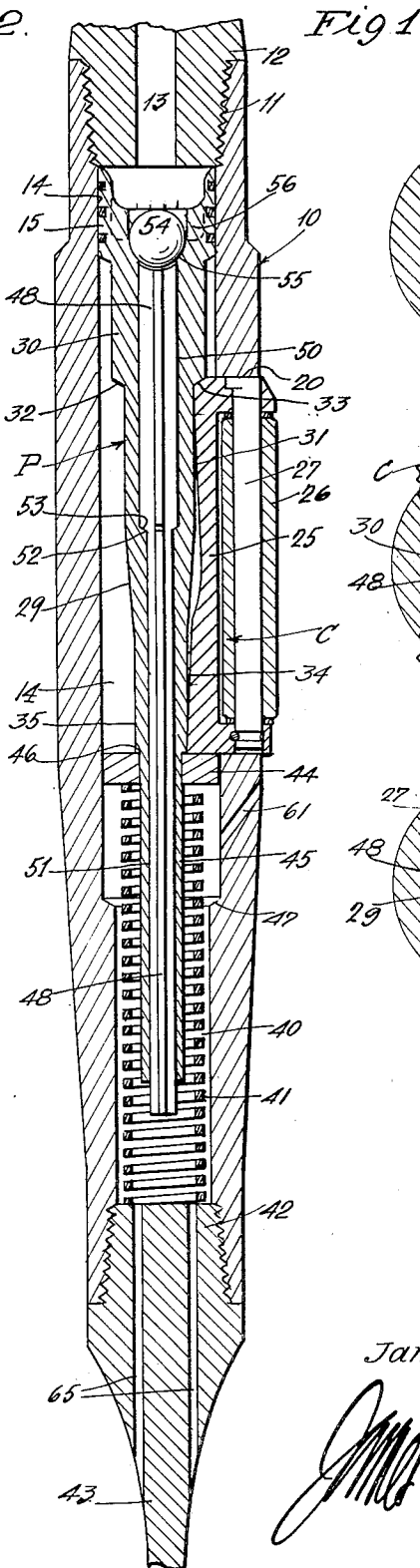
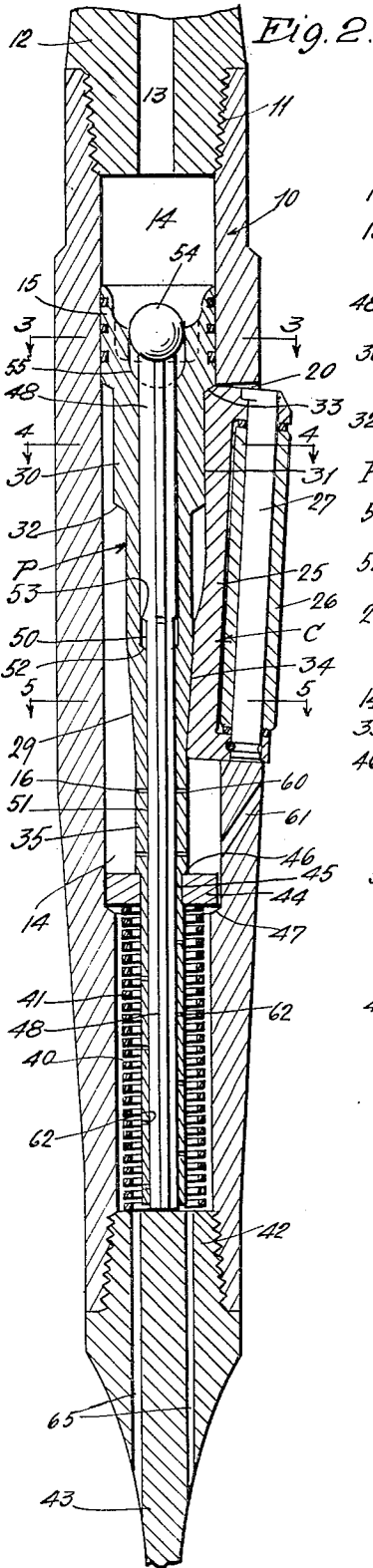
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HYDRAULIC UNDERREAMER

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HYDRAULIC UNDERREAMER

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7 Claims. (Cl. 255—74)

This invention has to do with expansive reaming tools, commonly known as underreamers, of the type actuated by hydraulic pressure.

A general object of the invention is to provide a simple compact and rugged form of expansive reamer or underreamer, actuated to collapsed position by one means, typically a spring, and is actuated to expanded position by hydraulic pressure, and preferably the hydraulic pressure of the circulation fluid which is pumped down through rotary drill pipes to and through a rotary reamer.

In the preferred and illustrative form which I am about to describe in detail, a tubular cutter carrying body is provided, and within the body and between the several cutters I arrange a vertically movable plunger which can be moved upwardly by spring pressure and downwardly by hydraulic pressure. The relative downward movement of the plunger causes outward expansive movement of the cutters; while relative upward movement of the plunger causes or allows contractive movement of the cutters. And a valvular arrangement is provided whereby the full pressure of the circulation fluid is utilized for lowering the plunger and expanding the cutters; the circulation pressure is relieved, and fluid flow permitted onward through and to the various parts of the underreamer, only when the plunger has reached its lowermost point of travel with the cutters locked in expanded position.

For the purpose of a specific and detailed description of an illustrative form and embodiment of the invention, but not for the purpose of limiting the invention to details hereinafter explained I refer to the accompanying drawing in which:

Figure 1 is a longitudinal central section of the typical form of my underreamer, showing the cutters contracted;

Fig. 2 is a similar section showing the cutters expanded; and

Figs. 3, 4 and 5 are cross sections on line 3—3, 4—4 and 5—5, respectively, of Figure 2.

In the drawing, a suitable tubular body is shown at 10, fashioned at its upper end for the usual tool joint connection at 11 with the lower end of a drill pipe or drill stem 12 which has the usual fluid course 13 longitudinally through it. The body has a cylindrical internal bore 14 of suitable size, within this internal bore 14 there is a plunger, generally designated by the letter P. This plunger has at its upper end a piston 15 with a fluid tight fit in cylindrical bore 14, and presents an upwardly facing surface against

which the pressure of the circulating fluid acts to force the plunger down.

The cutters, generally designated by the letter C, are mounted in slots 20 which extend through the body wall; and are movable in and out through those slots. The plunger P, below the piston 15, and the cutters, are so formed and interrelated that downward movement of the plunger wedges the cutters apart and upward movement of the plunger allows the cutters to move inwardly. Seeing that the plunger moves up and down, the cutters are confined longitudinally by fitting fairly closely lengthwise in the body slots.

Although the relative wedging action between the plunger and cutters can, of course, be obtained with a plunger of uniform taper, it is desirable to so form the plunger and cutters that expansive action of the cutters is obtained by a relatively short movement and also that, when the plunger reaches its final position, the cutters are locked in their outward expanded positions, and do not depend upon any wedge or diagonal face to hold them in expanded position. For those reasons, and also because it may be desirable to have cutters which are expanded wholly or mostly at their upper end, I here show a typical inter-formation of plunger and cutters, which I will now describe.

The cutters, as here illustrated, are made up of what I term a cutter carrier 25 and a cutter roller 26 mounted to rotate on an axis pin 27 which is mounted in the carrier. The carrier 25 is the part of the cutter which cooperates directly with the plunger. This carrier fits the body slots fairly tightly in a longitudinal direction, and also fits them snugly in width. The rear edges of the cutter carriers have laterally projecting wings 28 which overhang the inner edges of the body slots and bear outwardly against the body wall when the cutters are expanded. This is seen plainly by reference to Figs. 4 and 5. The plunger, immediately under piston 15, has a comparatively large cylindrical or substantially cylindrical part 30, whose diameter, however, is somewhat smaller than the diameter of body bore 14, so as to leave an annular space between the plunger part 30 and the body wall for entry of cutter wings 28 when the tool is expanded. See Figure 4. The upper part of the cutter carrier has a back surface 31 which bears back against this large part 30 of the plunger when expanded.

Immediately beneath the plunger part 30 there is a rather abrupt diagonal downwardly facing shoulder 32 under which the upper end of the

cutter carrier enters when the plunger is up and the cutters are contracted. See Figure 1. This abrupt diagonal shoulder 32, coacting with a similar diagonal corner surface 33 on the carrier, causes the rather abrupt and quick outward movement of the upper end of the cutter when the plunger moves down. And after this quick expansion of the cutter, then the part 30 of the plunger moves straight down the back surface 31 of the upper part of the cutter, without materially expanding the cutter further outwards; and when the parts have reached the expanded position of Figure 2 the upper expanded end of the cutter is locked in expanded position by bearing squarely back against the surface of plunger part 30.

Further down, the plunger has a slightly tapered portion 29 against which the lower back surface 34 of the cutter carrier bears inwardly when expanded. See Figures 2 and 5. The plunger part 35, below the tapered part 29 is preferably cylindrical; so that when the plunger moves down from the position of Figure 1 to the position in Figure 2, the lower ends of the cutters are expanded comparatively little; in fact the extreme lower ends of the cutters are expanded not at all in the specific design here shown. Thus, as indicated in Figure 5, the extreme lower ends of wings 28 may abut each other circumferentially both when the cutters are contracted and when they are expanded; and thus these extreme lower ends of the cutter wings may simultaneously bear inwardly against the plunger, circumferentially against each other, and outwardly against the body wall.

The lower part of the body has a spring bore 40 accommodating the compression spring 41 which rests at its lower end upon any suitable support, such as the joint pin 42 of drill bit 43 which is usually attached to the lower end of an underreamer. The upper end of this compression spring presses upwardly against a collar 44, which fits around the lower reduced extension portion 45 of the plunger and bears upwardly against the plunger shoulder 43. This collar 44 fits loosely in the large bore 14 of the body; and the body shoulder at 47, between the body bores 14 and 40, may be so located as to form a limiting stop for the downward motion of the plunger. The plunger extension 45 projects on downwardly through the spring bore 40, so that its lower end, when the plunger is down, comes close to the upper end of the joint pin 42.

The joint pin 42 of drill bit 43 may, for all functional purposes of the devices, be looked upon either as a part of the body or as a member supported in or by the body. Its functional purpose, insofar as the operation of the underreamer parts are concerned, is merely to support the spring 41 and to form a stop against which the lower end of valve rod 48 brings up when the plunger is moved down to its lowermost position. This valve rod 48 extends upwardly through a longitudinal bore of the plunger and preferably, although not necessarily, has a limited longitudinal movement with relation to the plunger. Thus the plunger bore is preferably formed with an upper comparatively large bore part 50 and a smaller bore part 51, with a shoulder 52 between the parts. The valve rod 48 has a shoulder 53 which, coming down on plunger shoulder 52, limits the relative downward movement of the valve rod to about the position shown in Figure 1. In the position of Figure 1 the upper end of the valve rod rests just under a

valve 54, here preferably shown as a ball. In the position of Figure 1 this ball valve is resting upon its seat 55 and thus closes the upper end of the plunger bore against liquid flow downwardly. Surrounding the ball valve, above valve seat 55, the interior of plunger 15 is formed with cage ribs 56 which guide the ball to its seat and allow passage of liquid around the ball when it is lifted from its seat. When the ball is lifted off its seat, passage of liquid downwardly through the plunger bore is allowed by reason of the fact that valve rod 48 does not completely fill the bore. It is, for instance, of cruciform or similar section, as is shown in Figure 5.

Compression spring 41 at all times tends to push the plunger upwardly, thereby to allow the cutters to move inwardly to the collapsed position indicated in Figure 1. In this position of the parts there is no force acting upon the cutters tending to move them outwardly; so that the cutters have no tendency to press out against the casing while being lowered through it. And not only is there no force exerted outwardly on the cutters, but the cutters are held in their inner contracted positions by the fact that collar 44 presses upwardly against their lower ends, thus pressing the upper ends of the cutters against the upper ends of slots 20. Compression spring 41 will ordinarily be of some considerable strength; and the cutters are therefore clamped with some considerable pressure longitudinally between the upper ends of the body slots and the collar 44. Held thus in their collapsed positions there is no tendency on the part of the cutter to score or cut into the casing while being lowered. When the tool has been lowered through the casing and into the hole below where it is desired to perform underreaming operations, then the circulation pressure is introduced to the drill pipe from above, and this pressure, acting downwardly on the plunger piston, forces the piston down against the action of compression spring 41. Although the compression spring exerts a rather heavy force upwardly, the total fluid pressure that can be brought to bear on the plunger piston is considerably more than the spring pressure. The plunger is therefore forced down by the heavy pressure. If the tool has been lowered into a part of the hole which has already been enlarged by underreaming, then the plunger moves down immediately to the position of Figure 2 and the cutters immediately are expanded. If, however, the tool has entered into a portion of the hole which has not been previously enlarged, it may be necessary to rotate the tool for a short time without lowering it, and while keeping the fluid pressure on the plunger, in order that the cutters may cut their way outwardly into the hole wall, to allow for their expansion and to allow the plunger to move down to its lowermost position. When the plunger has reached its lowermost position, the cutters are locked in their expanded positions, and then downward reaming operations may be commenced.

As the plunger comes to its lowermost position, the lower end of valve rod 48 strikes the joint pin 42 and is prevented from moving further down. Then as the fluid pressure forces the plunger further down, valve 54 is lifted off its seat; and the circulation passage through the plunger is thus open. The amount of fluid pressure relief incident to the opening of valve 54 is preferably such that the plunger will move on down to, or close to, its lower limiting position

shown in Figure 2. It is, however, not necessary that the plunger fully reach this lower limiting position. Valve 54 is not raised off its seat until the plunger has moved so far downwardly as fully to expand the cutters—the large plunger part 30 has passed downwardly a considerable distance below the upper ends of the cutters before valve 54 is raised. And therein lies another advantage in having a relatively abrupt expansion of the cutters take place on the first downward movement of the plunger, and in thereafter having the plunger part 30 move straight down between the expanded cutters without expanding them further. With this arrangement it makes no great difference just where the plunger thereafter stops—that the relieved fluid pressure is not sufficient to force the plunger much below the point at which valve 54 is raised.

When the parts have reached such an expanded position as shown in Figure 2, then the circulation fluid passes by valve 54 and down through the plunger bore. At points which are then below the lower ends of the cutters, a portion of the circulating liquid passes out through plunger openings 60 into bore 14. Thence this liquid passes outwardly and upwardly through circulation ports 61 which direct the circulation upwardly and outwardly immediately beneath the cutters. It will be noted that this circulation, in reaching the ports 61, passes through the lower part of body bore 14 below the cutters, and thus keeps that part of the bore washed free of any accumulated settlement which might otherwise fill the bore and prevent the upward movement of collar 44 when it is desired to contract the reamer.

Another portion of the circulating liquid is passed through the spring bore 40 below collar 44. The plunger extension 45 has small spaced openings 62 through its wall, and through these openings at least a part of the liquid circulation is delivered into the spring bore and washes that bore free from accumulated settlement. Otherwise accumulation and settlement of solid matter from the circulating liquid mud is very apt to fill up the spring chamber to such an extent that the spring cannot operate.

And finally part of the liquid circulation may pass into the spring bore directly from the lower end of the plunger; but it is preferred that the lower plunger end, when in the expanded position of Figure 2, be either close to or rest upon the joint pin 42; so that liquid circulation will be forced to take place through the various distributive openings leading through the wall of the plunger. It is for this purpose, among others, that it is desirable although not necessary that the relief of pressure by raising of valve 54 be at such a rate that the plunger will be forced downwardly close or quite to its lowermost position as shown in Figure 2. The liquid circulation which passes into and through the spring bore, passes out of that bore through the circulation passages 65 of drill bit below.

I claim:

1. In an hydraulically actuated underreamer, the combination of a tubular body with cutter-receiving slots through its tubular wall, cutters movable inwardly and outwardly in said slots, a plunger having a part fitting the body interior to receive fluid pressure from above, the plunger and cutters being so formed that downward movement of the plunger under fluid pressure causes outward expansive movement of the cutters, means tending to move the plunger up-

wardly, said plunger having a collar located below the lower ends of the cutters and which is moved upwardly along with the plunger and into clamping contact with the lower ends of the cutters.

2. In an hydraulically actuated underreamer, the combination of a tubular body with cutter-receiving slots through its tubular wall, cutters movable inwardly and outwardly in said slots, a plunger having a part fitting the body interior to receive fluid pressure from above, the plunger and cutters being so formed that downward movement of the plunger under fluid pressure causes outward expansive movement of the cutters, means tending to move the plunger upwardly, the plunger having a longitudinal circulation bore therethrough, a downwardly seating valve adapted to close the bore against downward passage of fluid, a relatively movable valve rod within the plunger bore and extending out of the plunger bottom, and a part supported by the body with which the lower end of the valve rod contacts when the plunger is lowered under fluid pressure.

3. In an hydraulically actuated underreamer, the combination of a tubular body with cutter-receiving slots through its tubular wall, cutters movable inwardly and outwardly in said slots, a plunger having a part fitting the body interior to receive fluid pressure from above, the plunger and cutters being so formed that downward movement of the plunger under fluid pressure causes outward expansive movement of the cutters, means tending to move the plunger upwardly, said plunger having a collar located below the lower ends of the cutters and which is moved upwardly along with the plunger and into clamping contact with the lower ends of the cutters, the plunger having a longitudinal circulation bore therethrough, a downwardly seating valve adapted to close the bore against downward passage of fluid, a relatively movable valve rod within the plunger bore and extending out of the plunger bottom, and a part supported by the body with which the lower end of the valve rod contacts when the plunger is lowered under fluid pressure.

4. In an hydraulic underreamer, the combination of a tubular body having longitudinally extending slots through its wall, cutters mounted in the said wall slots and movable in and out there-through, a plunger having a part which fits the body interior to take liquid pressure from above and thereby to cause downward movement of the plunger, a longitudinal liquid passage bore through the plunger, a downwardly seating valve normally closing the plunger bore against downward passage of liquid, the plunger having an upper comparatively large and substantially cylindrical part and having, below said cylindrical part, an abrupt diagonal cutter expanding surface, and having below said expanding surface a relatively smaller part against which the cutters bear inwardly when the plunger is in its upper normal position, means for normally holding the plunger in its upper position, and means acting to lift said valve after the plunger has moved down to a position wherein its relatively large and substantially cylindrical part is between the cutters.

5. In an hydraulic underreamer, the combination of a tubular body having longitudinally extending slots through its wall, cutters mounted in the said wall slots and movable in and out there-through, a plunger having a part which fits the body interior to take liquid pressure from above

and thereby to cause downward movement of the plunger, a longitudinal liquid passage bore through the plunger, a downwardly seating valve normally closing the plunger bore against downward passage of liquid, the plunger having an upper comparatively large and substantially cylindric part and having, below said cylindric part, an abrupt diagonal cutter expanding surface, and having below said expanding surface a relatively smaller part against which the cutters bear inwardly when the plunger is in its upper normal position, a spring pressing the plunger upwardly, a collar connected with the plunger at a point below the cutters and moved upwardly by the spring into clamping engagement with the lower ends of the cutters, and means acting to lift said valve off its seat after the plunger has moved downwardly to a point where its said larger and substantially cylindric part has entered between the cutters.

6. In an expansive reamer, the combination of a cutter holding body, cutters therein movable in

and out for contraction and expansion, a cutter expanding member movable with relation to the cutters to expand them on relative movement in one direction and allow them to contract on relative movement in the opposite direction, means moving the member in said last mentioned direction, and means actuated by said moving means to engage and clamp the cutters in contracted position.

7. In an expansive reamer, the combination of a cutter holding body, cutters therein movable in and out for contraction and expansion, a cutter expanding plunger movable longitudinally with relation to the cutters to expand them on movement in one direction and allow them to contract on movement in the opposite direction, a spring tending to move the plunger in said cutter contracting direction, and means actuated by said moving means to engage and clamp the cutters in contracted position.

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