

July 24, 1928.

1,678,075

J. T. PHIPPS

EXPANSIBLE ROTARY UNDERREAMER

Filed Dec. 14, 1925

2 Sheets-Sheet 1

Fig. 1

Fig. 2

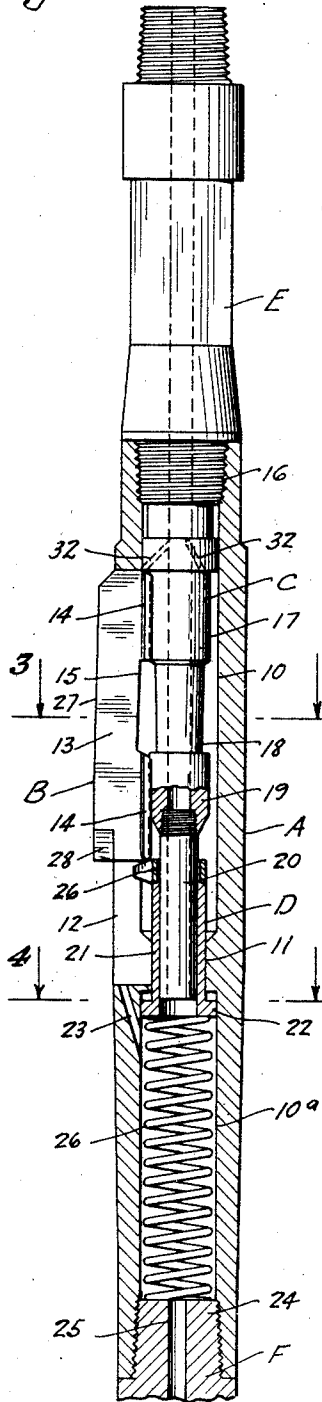
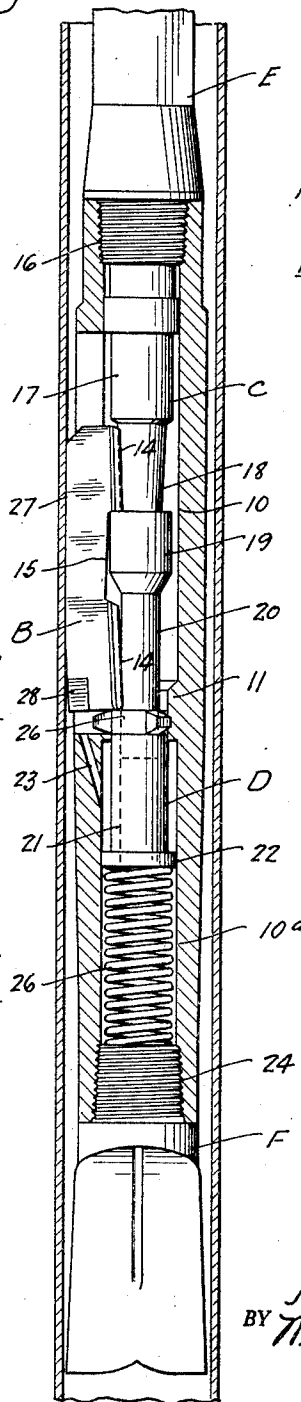


Fig. 3

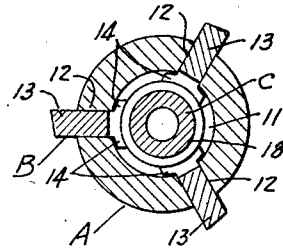
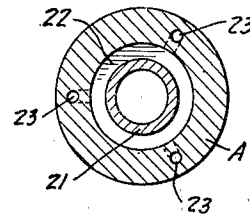


Fig. 4



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2 Sheets-Sheet 2

Fig. 5

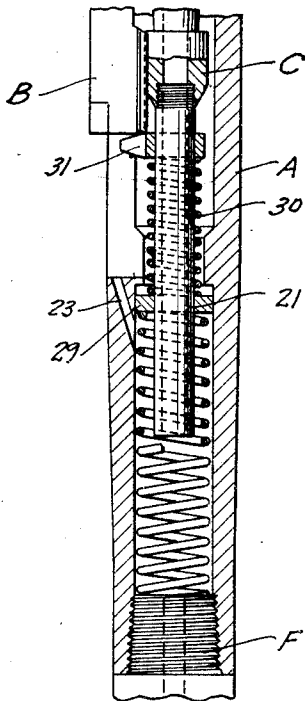
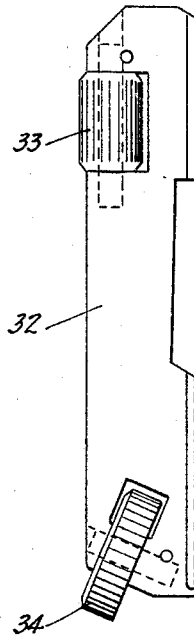
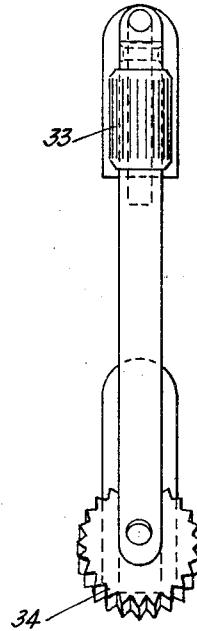


Fig. 6 *Fig. 7*



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UNITED STATES PATENT OFFICE.

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EXPANSIBLE ROTARY UNDERREAMER.

Application filed December 14, 1925. Serial No. 75,275.

This invention relates to a rotary underreamer for enlarging well holes. It pertains more particularly to an underreamer for use in hydraulic drilling wherein wash water is circulated to carry away cuttings and detritus. More specifically, the present invention relates to an underreamer of the character described which has expandible cutters.

It is the primary object of this invention to provide an underreamer having the following features of construction: cutters loosely mounted within a body, but anchored against separation therefrom and projectable laterally into expanded position; a mandrel stationary within said body against which the cutters may rest, the structure being such that the relative longitudinal position of said cutters and mandrel determines the projection of the cutters; means to normally maintain said cutters in position so that the cutters are projected. Other objects of this invention are to provide wash water chambers and passages together with parts actuated thereby, such that the wash water is directed upwardly upon said cutters in the general direction of wash water flow; to provide a structure such that the wash water pressure aids in the expansion of the cutters further; to provide a structure such that the expansion or contraction of the cutters is signalled through the wash water circulation system. A further object of this invention is to provide cutters which may include roller bits.

These objects together with other objects and corresponding accomplishments are obtained by means of the embodiment of my invention illustrated in the accompanying drawing, in which:

Fig. 1 is an axial sectional view partly in elevation, the cutters being shown in expanded position; Fig. 2 is a view similar to Fig. 1 showing the cutters in retracted position; Fig. 3 is a section as seen on the line 3—3 of Fig. 1; Fig. 4 is a section as seen on the line 4—4 of Fig. 1; Fig. 5 is an axial sectional view through the lower fragment of an underreamer having another form of cutter push spider; Fig. 6 is a face view of a cutter employing rollers; and Fig. 7 is an end view of the structure shown in Fig. 6.

Referring more particularly to Figs. 1 to

4, inclusive, A indicates an elongated tubular body within which are mounted cutters B. These cutters extend through slots in the body and are anchored therein against loss. A mandrel C determines the lateral projection of the cutters. A cutter actuator is indicated generally by D.

Referring more particularly to the body, it comprises a tubular member internally threaded at the upper end to receive the pin of a joint or sub member E. A bore 10 extending through the tubular member is substantially of uniform diameter except for a constricted portion 11 forming a shoulder bevelled at the upper side. The lower end of the bore is internally threaded so that it may receive the pin of a tool or element, such as a bit F. The body as shown herein is provided with three elongated peripheral slots 12 for the purpose of accommodating the cutters B.

The cutters comprise elongated bodies 13 having outer cutting edges and anchor ribs 14 on the inner edge to form in effect a T-head. These ribs are of greater span than the width of the slots 12 so that the cutters may not be separated from the body by being pushed outwardly. Thus, the cutters float within the body and are imprisoned therein. The cutters may be projected outwardly until the ribs engage the inner wall of the bore 10 of the body. This position is shown in Figs. 1 and 3. Each cutter has a chamfered upper outer corner. The outer and lower faces are tapered to produce working or cutting edges. A notch 15 is provided on the inner face intermediate the ends.

The joint E has a threaded pin 16 whereby the body A may be attached thereto. Depending from the pin is a cylindrical stem portion 17 having a tapered portion 18 of reduced diameter converging toward the lower end. At the lower end the stem is of full diameter as indicated by 19. A bore extends through the joint and stem, the lower end of the bore being enlarged and threaded to receive a tail pipe 20 forming a portion of the mandrel. The configuration of the mandrel is such that when the cutter is in uppermost position as shown in Fig. 1, the ribs 14 rest against the portions 17 and 19 of the stem, thereby holding the cutters in projected position. When in

lowermost position, the notches in the cutters will receive the portion 19 of the stem, the ribs resting against the reduced portions 18 and 20 of the mandrel. The cutters are thus collapsed. This position of the cutters is shown in Fig. 2. Due to the fact that the lower reduced portion 20 of the mandrel is of smaller diameter than the upper reduced portion 18, the cutter when moved to its collapsed position has its lower end moved inwardly further than its upper end. Thus, while in the expanded position the outer edge 27 of the cutter may be in the relative position shown in Figure 1; the larger inward movement of the lower end of the cutter puts the collapsed cutter in the relatively tilted position shown in Figure 2, so that its lower edge is not in engagement with the casing, as is clearly shown in that figure. When the cutters are moved upwardly to expanded position, they should rise outwardly without hindrance, and to this end I have bevelled the lower shoulder of the portion 19 and the upper inner corner of each of the cutters.

Slidably mounted about the tail 20 of the mandrel is a hollow rod 21. This rod is arranged to telescopically connect with the tail 20, and on the lower end thereof is a hydraulic impeller or piston 22. This piston slidably and snugly fits within the lower portion of bore 10. This places the portion 10^a in communication with the bore through the mandrel and provides for the entrance of circulation water therinto. Water courses 23 extend from the bore upwardly directing wash water against the cutters from the lower sides. The bore in the bottom of the body is closed by a pin 24 of some tool such as a fish tail bit F. There is a water passage 25 extending through the bit. However, the water passage 25 is of less cross-sectional area than the bore through the joint and mandrel. Thus, if circulation water is supplied through the tool, pressure will be built up in the bore 10^a. This pressure will be greater if the piston 22 is below the port openings for water courses 23 as shown in Fig. 2. The hydraulic pressure in bore 10^a tends to hold the piston and hollow rod 21 in their upper positions. A compression spring 26 is imprisoned between the pin 24 and the plunger, also tending to hold the piston 22 and rod 21 in their upper positions. This spring is conveniently disposed within the bore 10^a after assembly of all the parts and before attachment of the boring tool F. Attaching the boring tool to the body compresses the spring and holds the latter in position. When the tool F is removed, the spring is freed and no pressure is exerted upon the piston 22 and its rod 21 making disassembly of the parts easy. Secured to the upper part of the rod 21 is a cutter push member or spider 26 having ra-

dial arms, with one disposed under each cutter. These arms operate in the slots 12 and engage the lower faces of the cutters.

Normally the parts of the tool are in the position shown in Fig. 1, the spring 26 holding the piston 22 and rod 21 in upper position. This causes the spider 26 to maintain the cutters B in their upper positions with ribs 14 against the section 17 and 19 of the mandrel.

To collapse the cutter, pressure is exerted downwardly upon the upper faces of the cutters. The cutters are moved thereby longitudinally in their slots 12 downwardly against the action of spring 26. On reaching their lowest position, the cutters move inwardly, portions 19 being disposed within notches 15. Collapsion may be produced by the underreamer being disposed within a casing with the cutters below the shoe and then pulling upwardly upon the string to raise the underreamer. The upper faces of the cutters engage the shoe and cause the cutters to be moved downwardly and the body of the underreamer to be raised. When the cutters have reached their lowest position, they are retracted as shown in Fig. 2, and the cutters may enter the casing being maintained in collapsed position. Circulation water tends to cause the spider to be moved upwardly through the intermediate piston rod 21 and piston 22 due to the pressure in the bore 10^a. As the underreamer is lowered in the casing for expansion, and the cutters pass below the shoe, spring 26 together with the wash water causes the piston 22 and rod 21 to be moved upwardly forcing the cutters upwardly by means of the spider 26. The ribs 14 of the cutters ride onto the full diameter portion of the mandrel into expanded position. As the piston 22 overrides the port for water passage 23, pressure is relieved in the bore 10^a. This relieves the pressure upon the circulation pump or other means supplying circulation fluid and signals that the cutters are in open position and ready for working. Until this pressure has been relieved, there is no indication that the cutters are open. Wash water is immediately projected against the cutters from their lower ends and in the direction of the upward outflowing circulation fluid so as to effectively clean the cutters. If for any reason during operation of the underreamer the driller wishes to collapse the same without complete withdrawal, he may elevate the string, the pressure in the circulation system indicating when the tool is collapsed. Water courses 32 at the top of the mandrel direct wash water outwardly through the slots of the body over the cutters and clean the cutters and slots of any mud which might pack and interfere with the collapsion of the cutters. In the same manner upon lowering expan-

sion is signalled by means of the circulation fluid pressure.

In Fig. 5 I have indicated a body A of the same construction, cutters B and a mandrel C. Disposed about the tail 21 is a slidable ring piston or impeller 29. This ring is not provided with a hollow rod. Resting thereon and encompassing the tail-piece is a compression spring 30, supporting at its upper end a spider 31. This provides for a double compression spring action, and the springs are easily removable upon removal of the tool F.

In Figs. 6 and 7 I have shown a cutter having a body 32 acting as a carrier in which are mounted roller cutters 33 and 34. The carrier on its inner edge is substantially of the same construction as the cutters before described.

What I claim is:

1. An expansible underreamer comprising a body, cutters mounted therein to play lengthwise, means urging said cutters lengthwise into expanded condition; and hydraulic indicator means for signalling when the cutters are in expanded condition comprising a cutter impeller, there being a water course for directing water against said cutters controlled by said impeller so as to permit the passage of water therethrough when said cutters are expanded.

2. An expansible underreamer comprising a body, cutters mounted therein to play lengthwise thereof, a stationary mandrel therein serving as an abutment for said cutters in expanding and contracting, said mandrel having a circulation passage extending lengthwise thereof; and hydraulic indicator means for signalling when the cutters are in expanded condition, comprising a cutter impeller having a chamber in communication with said circulation passage, there being a water course connected to said chamber for directing water against said cutters controlled by said impeller to permit the passage of water therethrough when said cutters are expanded.

3. An expansible underreamer comprising a slotted body, cutters mounted in the slots of said body to play lengthwise thereof, a stationary mandrel therein serving as an abutment for said cutters in expanding and contracting, said mandrel having a circulation passage extending lengthwise thereof; and hydraulic indicator means for signalling when the cutters are expanded including a cylinder communicating with said circulation passage, a piston mounted in said cylinder, there being a port in said cylinder traversed by said piston and opening the cylinder working space at the expansion of said cutters, there being a water course directing water against said cutters, said course communicating with said port.

4. An expansible underreamer comprising

a slotted body portion, cutters mounted to play lengthwise in the slots and to be moved laterally, said cutters being anchored against separation from said body, there being means in said body against which said cutters ride arranged so that when the latter are at one end of their lengthwise travel they will be maintained in projected position and at the other end may be in collapsed position, a circulation fluid bore extending through said resilient means operating upon said cutters urging them lengthwise to expanded position and means operated hydraulically by said fluid in said body acting upon said cutters tending to urge them lengthwise to expanded position.

5. An expansible underreamer comprising a slotted body portion, cutters mounted to play lengthwise in the slots and to be moved laterally, said cutters being anchored against separation from said body, there being means in said body against which said cutters ride arranged so that when the latter are at one end of their lengthwise travel they will be maintained in projected position and at the other end may be in collapsed position, a circulation fluid bore extending through said body, water courses in communication with said bore directing wash fluid upwardly in said slots against said cutters.

6. An expansible underreamer comprising a body, cutters mounted to play lengthwise thereof and to be expanded laterally at the upper ends of their travel, a circulation fluid passage extending through said body and ending in a chamber at the lower end, an impeller member mounted in said chamber for action thereon by the circulation fluid, resilient means acting upon said impeller urging said cutters lengthwise into expanded condition and means actuated by said impeller for moving said cutters lengthwise into expanded position.

7. An expansible underreamer comprising a hollow slotted body, cutters mounted to play in the slots lengthwise thereof and to be expanded laterally, a circulation fluid passage extending through said body and ending below said cutters, water courses communicating with said passage directing circulation fluid to the outside of said body into said slots and upwardly against the bottom of said cutters.

8. An expansible underreamer comprising a body, cutters mounted to play lengthwise thereof and to be expanded laterally at the ends of their travel, a circulation fluid passage extending through said body and ending in a chamber at the lower end, an impeller member mounted in said chamber for action thereon by the circulation fluid, means actuated by said impeller for moving said cutters lengthwise into expanded position, water courses in said body communicating with said chamber for directing circulation

fluid to the outside of said body and upwardly against said cutters, the communication of said chamber and water courses being controlled by said impeller so that when
 5 said impeller is in position collapsing said cutters, the passage of circulation water therethrough is shut off.

9. An expansible underreamer comprising a body, cutters mounted to play lengthwise thereof and to be expanded laterally
 10 at the ends of their travel, a circulation fluid passage extending through said body and ending in a bore at the lower end, a piston slidably mounted in said bore for action
 15 thereon by the circulation fluid so that pressure of the latter will tend to move said piston upwardly, a cutter push member movable by and with said piston, said push member engaging said cutters to support and
 20 move the latter, water courses in said body for directing circulation fluid against said cutters, said courses having ports in the wall of said bore disposed to be passed over by
 25 said piston at the upper end of its travel and thereby to place said bore in communication with said courses.

10. An expansible underreamer comprising a slotted body, cutters mounted to play
 30 lengthwise thereof and to be expanded laterally, said cutters being anchored against separation from said body, a hollow mandrel extending axially through said body and against which said cutters ride, said mandrel
 35 having a configuration such as to project and retract said cutters as they ride therealong and ending at the lower portion in a tail tube, said body having a cylindrical
 40 piston at its lower end, a piston slidable in said bore, a hollow piston rod telescoping said tail tube and placing said bore and
 45 mandrel in communication for the passage of circulation fluid, a cutter push member at the end of said rod engaging said cutters to move the latter lengthwise, water courses in
 50 said body for discharge of circulation fluid, said courses having ports communicating with said bore and disposed so as to be passed over by said piston at the upper end of its travel and to place said bore in communication with said courses.

11. An expansible underreamer comprising a slotted body, cutters mounted to play
 55 lengthwise thereof and to be expanded laterally, said cutters being anchored against separation from said body, a hollow mandrel extending axially through said body and against which said cutters ride, said mandrel
 60 having a configuration such as to project and retract said cutters as they ride therealong and ending at the lower portion in a tail tube, said body having a cylindrical piston bore at its lower end; detachable means
 65 closing the lower end of said bore, a piston slidable in said bore, a hollow piston rod telescoping said tail tube and placing said

bore and mandrel in communication for the passage of circulation water, a compression spring mounted between said detachable means and said piston, and a cutter push member at the end of said rod engaging said
 70 cutters to move the latter lengthwise.

12. An expansible reamer comprising a cutter holding body, cutters mounted therein to move laterally to and from an expanded position, a longitudinally extending
 75 mandrel in the body between the cutters, the mandrel and cutters being formed to cause lateral expansive movement of the cutters by relative longitudinal movement between the cutters and the mandrel in one direction, resilient means operating to cause said longitudinal movement, a fluid circulation passage in the mandrel, and means operated
 80 hydraulically by fluid from said passage also causing said longitudinal movement to move the cutters to expanded position.

13. An expansible underreamer comprising a cutter holding body, a cutter mounted therein to move to and from an expanded position, resilient means operating on the
 85 cutter to urge it to expanded position, a fluid circulation passage in the body, and means operated hydraulically by fluid from said passage urging the cutter to expanded position, said means embodying a cylinder and
 90 piston, said cylinder having a fluid outlet port uncovered by the piston when the cutter is in its expanded position.

14. In an expansive reamer, the combination of a hollow body having an interior cutter chamber and a separate spring chamber,
 100 cutters movable in the cutter chamber, a cutter actuating spring in the spring chamber, a mandrel in the cutter chamber and extending into the spring chamber and having
 105 a water course to deliver water through its end into the spring chamber, the spring chamber having other water courses to deliver water therefrom so that water flows through the spring chamber to keep it washed clean, and
 110 cutter actuating means including a sleeve fitting around the mandrel, having its opposite ends lying in the spring chamber and cutter chamber, respectively, and fitting the body interior fluid-tightly between the two
 115 chambers to exclude foreign matter from the spring chamber.

15. An expansible reamer comprising a cutter holding body, cutters mounted therein to move laterally to and from an expanded position, a longitudinally extending mandrel
 120 in the body between the cutters, the mandrel and cutters being formed to cause lateral expansive movement of the cutters by relative longitudinal movement between the cutters and mandrel in one direction, resilient means
 125 operating to cause said longitudinal movement, a fluid circulation passage in the mandrel, and means operated by fluid pressure from said passage and acting in cooperation
 130

with the resilient means to cause said longitudinal movement and thus to cause movement of the cutters to expanded position.

16. An expansible underreamer comprising a cutter holding body, a cutter mounted therein to move to and from an expanded position, resilient means operating on the cutter to urge it to expanded position, a fluid circulation passage in the body, and means operated by fluid pressure from said passage and acting in co-operation with the resilient means to cause movement of the cutter to expanded position, said fluid pressure operated means including a pressure release port which is opened when the means is actuated to move the cutter to expanded position.

17. In an expansible reamer, the combination of a mandrel with two vertically spaced

reduced portions, a cutter having two vertically spaced lateral projections and adapted to be moved vertically relatively to the mandrel, said lateral projections, in one position of the cutter, being adapted to rest in the reduced portions of the mandrel, and in another position to rest against the mandrel beyond opposite ends of a reduced portion; the lower one of the reduced portions having greater depth relative to the unreduced portion of the mandrel than has the upper reduced portion, so that the cutter is tilted in moving from one position to the other, for the purpose described.

In witness that I claim the foregoing I have hereunto subscribed by name this 28th day of November, 1925.

JOHN T. PHIPPS.