Feb. 4, 1969 B. H. FUCHS 3,425,500

EXPANDABLE UNDERREAMER

Filed Nov. 25, 1966 Sheet 1 of 2

FIG. 1.

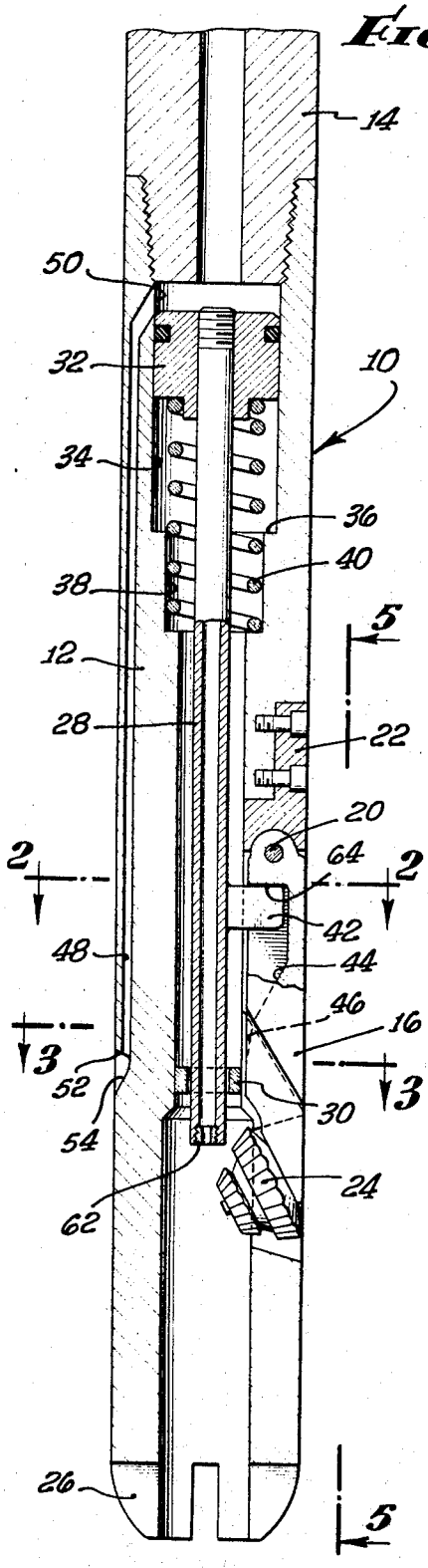


FIG. 2

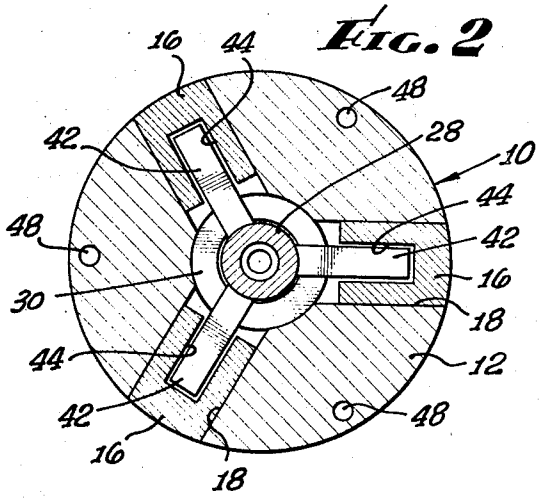
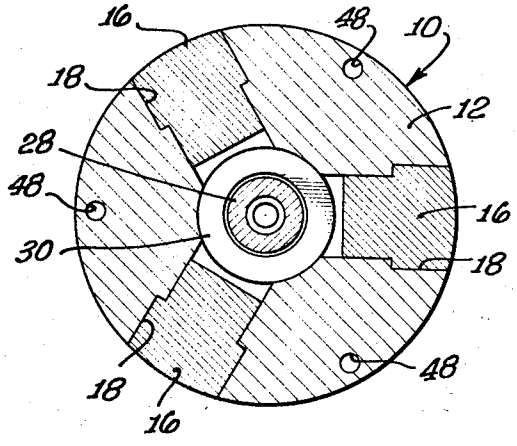


FIG. 3.



INVENTOR.
BENJAMIN H. FUCHS
By Huebner & Worrel
ATTORNEYS.

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FIG. 4.

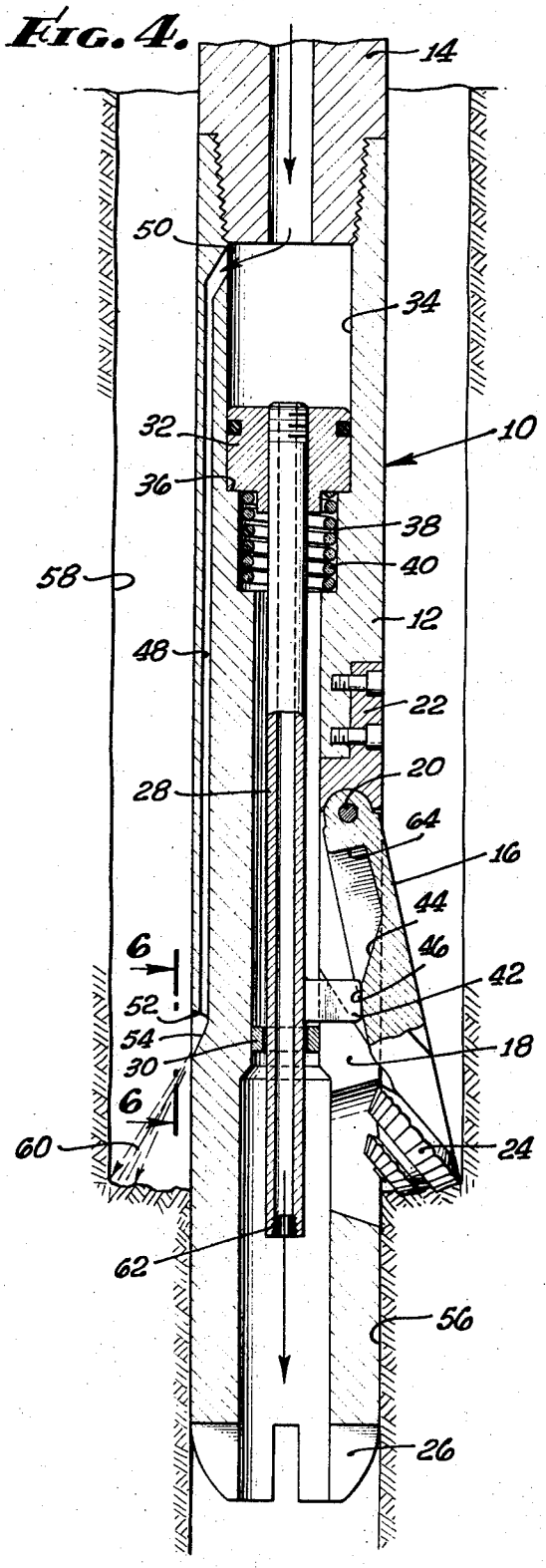


FIG. 5.

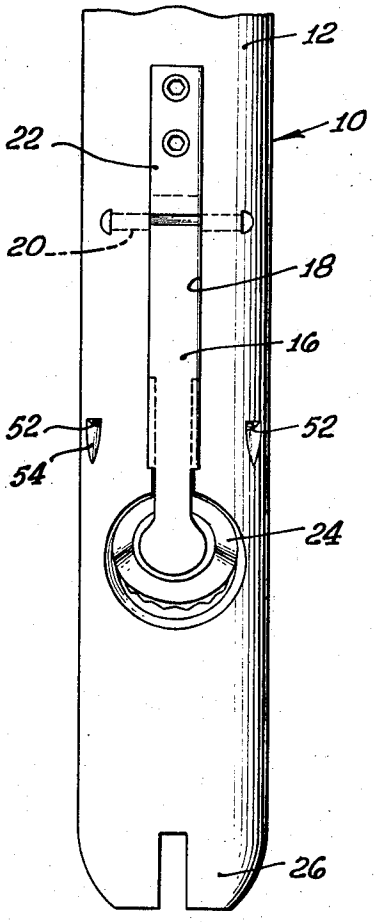
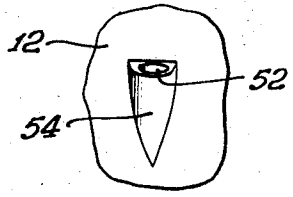


FIG. 6.



INVENTOR.
BENJAMIN H. FUCHS
BY
Huebner & Worrel
ATTORNEYS.

United States Patent Office

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3,425,500

EXPANDABLE UNDERREAMER

Benjamin H. Fuchs, 3842 Rose Ave.,
Long Beach, Calif. 90807

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U.S. Cl. 175—269 1 Claim
Int. Cl. E21b 9/26

ABSTRACT OF THE DISCLOSURE

An expandable underreamer having pivoted, longitudinally arranged cutter arms which swing out from elongated slots in the body of the tool, the arms being actuated by a hydraulic cylinder and piston arrangement in the body above the arms, and jet streams of drilling fluid originating in the cylinder and passing through longitudinal passages in the body intermediate the cutter arm slots and being ejected from the body above the cutters outwardly and downwardly toward the cutting plane.

The present invention relates generally to the well drilling art, and it relates more particularly to underreamers for enlarging well holes and to novel wash means embodied therein for keeping the underreamer cutters clean during the operation.

Underreamers are employed extensively for enlarging portions of the well bore in oil and gas wells for various purposes, as for example to provide clearance for running casing, to obtain adequate annular space in the hole for cementing, to enlarge zones for gravel pack completion, and for other purposes. Conventional practice for removing the cuttings and washing the underreamer cutter cones is merely to pump the drilling fluid down through the underreamer into the region of the hole below the underreamer, the fluid washing upwardly past the cutters. However, the cutters are in effect operating on a ledge, and the drilling fluid which is thus released into the hole below the cutters tends to flow upwardly past this ledge without applying any concentrated washing flow at the critical area of cutting on the ledge, the fluid which does flow into the cutting area merely being a backwash which is not sufficiently concentrated or under sufficient pressure to properly clean the cones. Accordingly, with such conventional washing the sand and cuttings tend to ball up on the cutting ledge, requiring that portions of the formation be recut over and over again, thus greatly impairing the cutting efficiency of the tool and resulting in a reduction in the rate at which a hole can be enlarged and more frequent replacement of the cutter cones.

While there have been prior art attempts to solve this problem, they have also been generally unsatisfactory. For example, one means which has been employed in an attempt to obtain improved washing of underreamer cutters is to employ upwardly directed spray jets on the tool at a point below the cutters, with a jet of drilling fluid being directed upwardly along the outside of the tool toward each of the cutters. However, these upwardly directed spray jets are released in the relatively small part of the hole below the cutting ledge, so that the primary force of these jets is not directed against the cutters where they are performing their work on the ledge.

In view of these and other problems in the art, it is an object of the present invention to provide a novel

underreamer wash system wherein drilling fluid is jetted under pressure directly into the region of the cutting plane of the cutters so that the washing action of the drilling fluid is fully effective on the ledge where the cutters are performing their work.

Another object of the invention is to provide a novel underreamer wash system of the character described wherein fluid jet outlets are disposed on the underreamer immediately above the cutters and are arranged to direct pressurized jet streams of drilling fluid directly to the cutting plane of the cutters proximate the diameter of cutter operation.

A further object of the present invention is to provide an underreamer wash system of the character described wherein the jet orifices are positioned on the underreamer body intermediate the cutter arms and immediately above the cutter cones, the orifices directing pressurized jet streams of drilling fluid in a downwardly and outwardly diverging direction against the ledge where the cutters are operating, whereby the drilling fluid is placed without interference from the cutter arms or other structure in the optimum position for effectively washing the cutters.

Further objects and advantages of this invention will appear during the course of the following part of this specification, wherein the details of construction and mode of operation of a preferred embodiment are described with reference to the accompanying drawings, in which:

FIGURE 1 is a vertical, axial section, with portions in elevation, illustrating an underreamer embodying the present invention, with the cutter arms disposed in their collapsed or withdrawn positions.

FIGURE 2 is a horizontal section taken on the line 2—2 in FIGURE 1.

FIGURE 3 is a horizontal section taken on the line 3—3 in FIGURE 1.

FIGURE 4 is a vertical, axial section, with portions in elevation, similar to FIGURE 1, but illustrating the underreamer of FIGURE 1, 2 and 3 in operation enlarging a bore, with the cutter arms in their extended, operative positions.

FIGURE 5 is a fragmentary elevational view showing the lower portion of the underreamer that is shown in FIGURES 1 to 4.

FIGURE 6 is an enlarged, fragmentary elevational view, taken on the line 6—6 in FIGURE 4, illustrating one of the jets.

Referring to the drawings, an expandable underreamer **10** according to the present invention includes a generally tubular, elongated body **12** which is threadedly connected to a suitable tubular top sub **14**.

Three cutter arms **16** are longitudinally arranged at regularly spaced intervals about the tubular body **12** in the lower portion thereof, the arms **16** being supported in respective elongated slots **18** in the body **12**. The cutter arms **16** are pivotally supported proximate their upper ends on respective horizontal support pins **20** which are mounted in the body **12**, and arcuate upper ends of the cutter arms **16** are seated in complementary recesses in respective arm retainers **22** which are bolted or otherwise secured to the body **12** and serve as thrust bearing means for applying drill string weight to the cutters. Conventional cutter cones **24** are rotatably mounted at the lower ends of the respective cutter arms **16**.

Axially centered within the tubular body **12** is a wash barrel **28** which is slidably supported near its lower end in a bushing **30**, and which has a piston **32** secured to its upper end portion, the piston **32** being slidable within an enlarged cylinder **34** in the tubular body **12**. In the inoperative position of the underreamer as shown in FIGURE 1, the wash barrel **28** and piston **32** are in an uppermost position, and in the fully operative position of the tool as illustrated in FIGURE 4 the wash barrel **28** and piston **32** are in a lowermost position which is defined by engagement of the piston **32** against an upwardly facing shoulder **36** at the bottom of the enlarged cylinder **34**. An intermediate enlargement **38** in the bore of body **12** provides seating for a helical spring **40** which biases the piston and wash barrel toward their uppermost positions as illustrated in FIGURE 1. The piston **32** and wash barrel **28** are normally in the uppermost position of FIGURE 1, but may be selectively moved downwardly to the position of FIGURE 4 by the introduction of drilling fluid under pressure through the sub **14** and into the cylinder **34**.

Three cams **42** project radially outwardly from the wash barrel **28**, the cams **42** being integrally connected to the wash barrel **28** as by welding and being regularly spaced thereabout so that each of the cams **42** is in alignment with a respective one of the cutter arms **16**. The arms **16** have generally radially inwardly facing cam follower surfaces **44** thereon which are engaged by the respective cams **42** upon downward movement of the cams **42** to move the cutter arms **16** from their retracted positions as illustrated in FIGURE 1 outwardly to their extended, operative positions as illustrated in FIGURE 4. The cam follower surfaces **44** terminate at their lower ends in respective cam ledges **46** against which the cams **42** abut for holding the cutter arms **16** in the fully extended or full swing position illustrated in FIGURE 4.

Three fluid passages **48** extend longitudinally through the body **12** from respective entrances **50** located in the upper part of the enlarged cylinder **34** to respective jet orifices or outlets **52** that are located as close as is practical above the cutter cones **24**. Each of the jet orifices **52** opens into a recess in the outer surface of body **12** that is formed by a downwardly and outwardly curving guide surface **54**. These jet guide surfaces **54** have been found to be a convenient means for directing the jet flow of pressurized fluid in a downwardly and outwardly diverging stream. Accordingly, each of the jet guide surfaces **54** may be considered as actually forming a part of its respective jet orifice **52** for the purpose of the present invention.

Preferably, the fluid passages **48** are circumferentially disposed in the body **12** intermediate the cutter arms **16** as best illustrated in FIGURES 2 and 3. Similarly, the jet orifices **52** are circumferentially arranged about the body **12** intermediate the cutter arms **16** and immediately above the cutter cones **24**. Thus, when the tool is rotating during a cutting operation to ream a portion of a hole **56** out to an enlarged portion **58** as in FIGURE 4, each of the cutting cones **24** is led by a jet stream **60** which is directed generally into the region of the cutting plane, and in this manner the jet stream **60** will provide a full high-velocity washing flow directly in the region of the cutting ledge where it is most effective, the flow being unimpaired by any stricture on the underreamer or by the ledge itself.

In the inoperative position of the underreamer **10** as it is being lowered through the hole to a desired region of operation, drilling fluid will not be pumped through the sub **14** into the cylinder **34**, and hence the biasing force of spring **40** will hold the piston **32**, wash barrel **28** and cams **42** in their uppermost positions as illustrated in FIGURE 1, these positions being defined by engagement of the cams **42** against shoulders **64** in the cutter arms **16**. In this inoperative condition of the underreamer the cutter arms **16** are held in their collapsed positions as shown in FIGURE 1 by gravity, and also by the spring

biased engagement of the cams **42** against the shoulders **64** in the cutter arms.

When the tool is at the desired position in the hole to commence reaming, the tool is rotated and drilling fluid is introduced under pressure through the sub **14** into the cylinder **34**. Some of this drilling fluid will pass on downwardly through the wash barrel **28** and thence through the hollow lower portion of the body **12** into the hole below the underreamer, and the flow of this fluid back upwardly around the tool will wash away the cuttings which are relatively free and which are freed by the jet streams provided according to the present invention. Preferably, there is a constriction **62** in the wash pipe which serves to build up fluid pressure in the cylinder **34** so as to more effectively actuate the cutters and provide high pressure and velocity to the jet streams **60** of the invention.

The fluid pressure in cylinder **34** will force piston **32** downwardly from the position of FIGURE 1 to the position of FIGURE 4, which will in turn move wash barrel **28** and cams **42** downwardly so as to swing the cutter arms **16** outwardly to their operative positions. The pressurized fluid in cylinder **34** will also cause fluid to be forced through the fluid passages **48** from entrances **50**, and thence out through the jet orifices or outlets **52** which direct the jet streams **60** divergently downwardly and radially outwardly to the general region of the cutting plane of the cutters **24**.

When the reaming operation is completed the fluid pressure is relieved, and this stops the jet streams **60** and also permits the spring to return the piston **32**, wash barrel **28** and cams **42** back to their positions of repose as illustrated in FIGURE 1, collapsing the cutter arms **16** back into the confines of the respective slots **18** in the body of the underreamer.

While the instant invention has been shown and described herein in what is conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of the invention, which is therefore not to be limited to the details disclosed herein, but is to be accorded the full scope of the claim so as to embrace any and all equivalent devices.

I claim:

1. An expandable underreamer adapted to be suspended from a drill string, said underreamer comprising an elongated, generally cylindrical body having three cutter members regularly peripherally spaced about said body at substantially the same axial position, said cutter members each including a cutter arm extending downwardly from a pivotal connection with the body and terminating at its lower end in a roller cutter, the cutter arms being recessed within respective elongated slots in the body in their inoperative positions and swinging outwardly to their operative positions, hydraulic actuating means responsive to drilling fluid pressure from the drill string for moving said cutter members from their inoperative positions to their operative positions comprising a hydraulic cylinder in the body spaced above said cutter members and receiving drilling fluid under pressure from the drill string, a piston in said cylinder movable in response to drilling fluid pressure, cam means connected to said piston and cooperating cam follower means connected to said cutter members, and means for washing the region proximate said roller cutters during operation thereof comprising three regularly spaced fluid ports in the body of the tool communicating with said hydraulic cylinder above said piston, three fluid passages extending longitudinally through the body of the tool from the respective said fluid ports at their upper ends to three respective jet orifices at the lower ends thereof, said three fluid passages and said jet orifices being regularly circumferentially spaced about the body of the tool intermediate said three cutter members, with said jet orifices being disposed intermediate the cutter arms substantially

immediately above the roller cutters, the application of drilling fluid pressure from the drill string substantially simultaneously initiating jet streams from said jet orifies and moving said piston downwardly in said cylinder so as to cause said cutter members to be moved from their inoperative positions to their operative positions.

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CHARLES E. O'CONNELL, *Primary Examiner.*

R. E. FAVREAU, *Assistant Examiner.*