

Oct. 5, 1937.

H. C. SMITH

2,094,855

UNDERREAMER

Filed July 12, 1935

2 Sheets-Sheet 1

Fig. 1

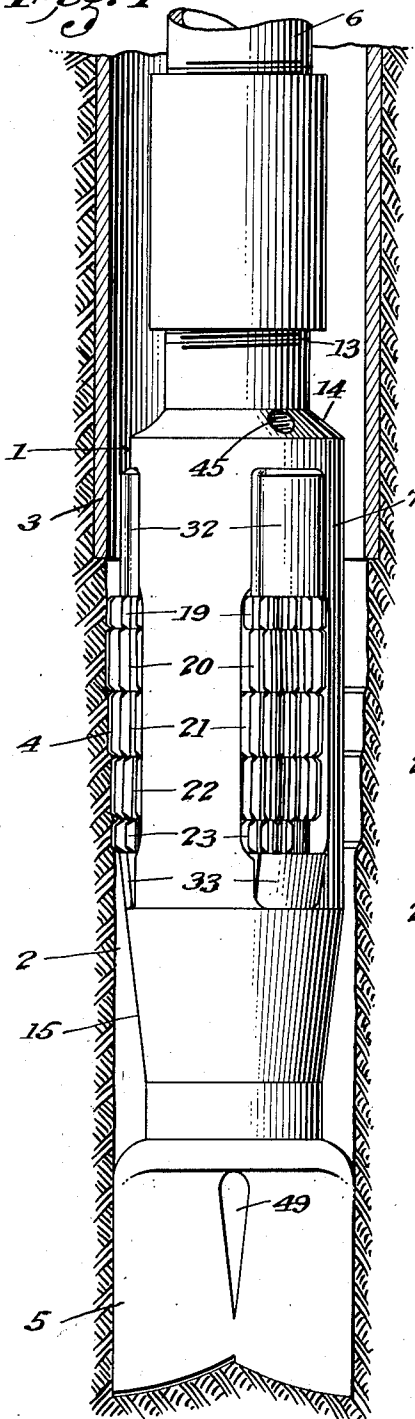
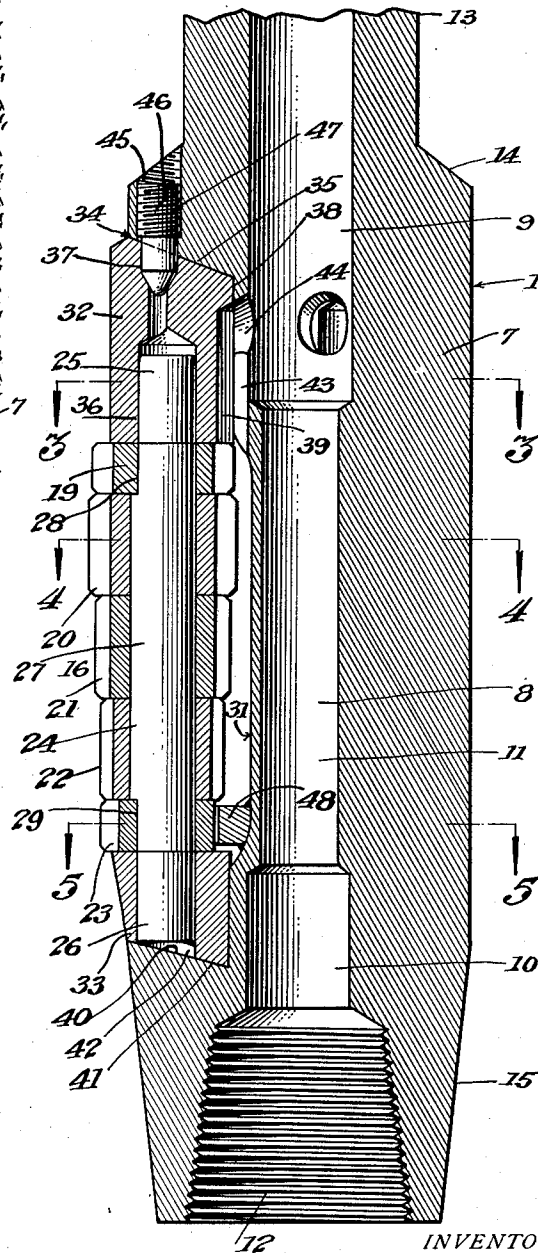


Fig. 2



INVENTOR:
Herman C. Smith,
BY *Galvin Brown*
ATTORNEY

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Fig. 3

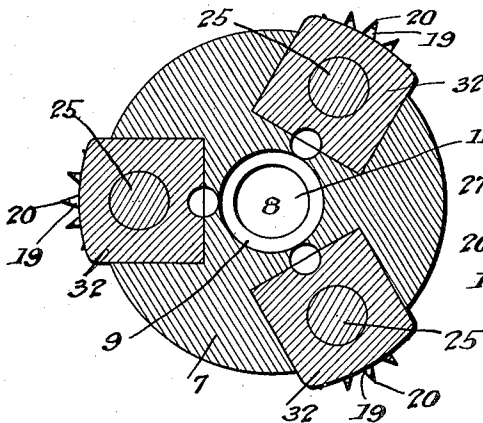


Fig. 4

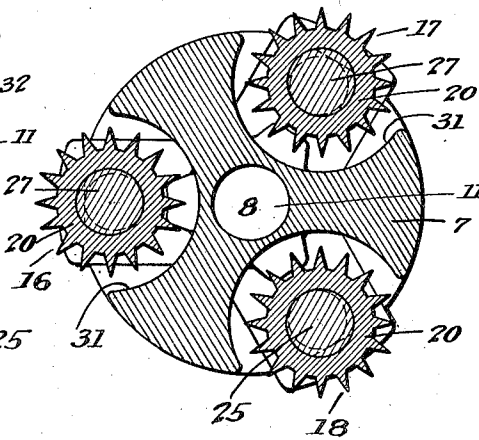


Fig. 5

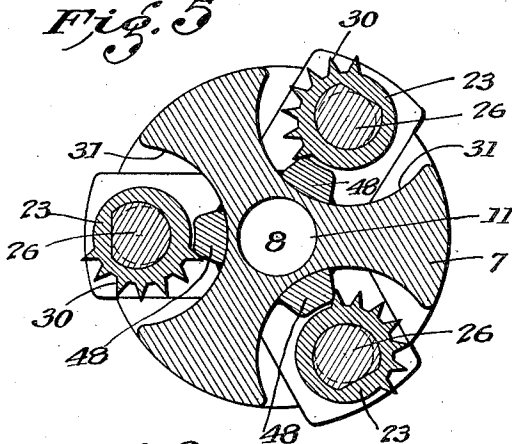
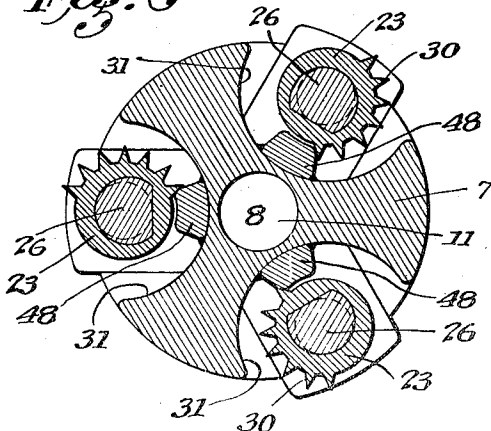


Fig. 6



BY

INVENTOR:
Herman C. Smith,
Calvin Brown
ATTORNEY

UNITED STATES PATENT OFFICE

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UNDERREAMER

Herman C. Smith, Whittier, Calif.

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11 Claims. (Cl. 255—74)

This invention relates to underreamers, and particularly to that form of underreamer which may be used with rotary well apparatus.

The invention contemplates an underreamer so constructed and arranged that cutter elements thereof may be brought into or out of work engagement at the will of the operator.

An object of the invention is the provision of a rotary underreamer utilizing rotary cutters, said cutters being positively actuated into work engagement at any given location within a well hole and under known working conditions to the well operator.

As is well known, underreamers are utilized for the purpose of enlarging a well hole. Cable tool underreamers are well known in the art, but the present invention may comprise a bit secured in advance of the underreamer. As the bit drills a hole of a given size, the underreamer will follow and ream the hole to a larger size or diameter and beneath the lower end of the casing within the well hole. In fact, it is possible with the present tool to follow the underreamer with casing, where ordinary care is used that the underreamer does not contact the casing shoe.

The cutters of the present underreamer are toothed and are so arranged with relation to the longitudinal axis of the underreamer body that the said cutters may be collapsed within the said body or eccentrically disposed relative to the periphery of the body and its axis to bring the cutters into formation engagement.

It is an object of the present invention to provide an underreamer wherein the cutter elements are so associated and interrelated that likelihood of damage thereto is in a large measure obviated.

It is a further object, in this connection, to provide an underreamer of few working parts, thus lessening the likelihood of damage or non-functioning of the various elements of the underreamer.

A further object is the provision of an underreamer of the rotary type which provides for a proper cleaning of the cutters during an underreaming operation, to the end that the cutters will not become clogged or otherwise rendered inefficient. Thus, by properly cleaning the cutters, it is evident that the cutters will actually ream the formation at all times. Hence, a more rapid underreaming than is usual may be obtained.

Another object is the provision in an underreamer of novel means whereby the cutter ele-

ments of said underreamer may be readily disassembled from the body or reassembled within the minimum of time through the simple expediency of the removal of a single keeper member.

Other objects of the invention, include simplicity of structure, inexpensiveness in cost of manufacture, and general efficiency of the device.

With the above mentioned and other objects in view, the invention consists in the novel and useful provision, formation, construction, association and interrelation of parts, members and features, all as shown in a certain embodiment in the accompanying drawings, described generally, and more specifically pointed out in the claims.

In the drawings:

Figure 1 is an elevation of the improved underreamer shown partly in cross section, with the underreamer positioned within a well hole prior to underreaming the formation below a well casing, shown in section,

Figure 2 is a fragmentary vertical sectional view of the underreamer construction and on an enlarged scale from the showing of Figure 1,

Figures 3, 4 and 5 are transverse sectional views taken on correspondingly numbered sectional lines of Figure 2, and

Figure 6 is a transverse sectional view, certain elements of the invention being in a changed relationship from that of Figure 5.

Referring now with particularity to the drawings, the underreamer is designated as an entirety by the numeral 1, and the said underreamer in Figure 1 is positioned within a well hole 2. The lowermost end of casing 3 is positioned above cutter elements designated generally as 4. The present underreamer 1 carries a fish tail bit 5 at one end thereof. The opposite end of the underreamer may be secured in any approved manner to the drill string 6. Referring to Figure 2, the underreamer 1 includes an elongated body 7 provided with a central bore, designated generally as 8, and which may vary as to diameter. For instance, the bores 9 and 10 may be of greater diameter than the bore 11. This bore is, of course, for circulation purposes. One end of the body is provided with a tapered threaded box 12 concentric with the bore 8, while the opposite end of the body may be provided with a threaded pin 13. The diameter of the pin is less than the diameter of the body, this construction affording an annular shoulder 14. The opposite end of the body in the zone of the box may be externally tapered, as shown at 15. The body is formed to

best carry the cutter elements 4. These cutter elements may be arranged in groups and in the present instance, three groups of cutter elements are provided, as designated generally and shown in Figure 4, as groups 16, 17 and 18. As all of the groups are identical in construction but a single group will be described, like numerals applying to the other groups.

The group 16 is shown in Figure 2, and comprises four toothed cutter rollers 19, 20, 21, 22, and 23.

For the purpose of holding the cutter rollers in assemblage as a group, I have provided a shaft 24. This shaft is provided with eccentric end portions 25 and 26, and the main body 27 of the shaft, interposed between the eccentric end portions, is provided with plane faces 28 and 29. The cutter roller 19 is adapted to fit around the shaft at the plane face portion 28 thereof. The bore of the roller 19 is provided with a flattened portion for engagement with the plane face 28, to the end that any rotation of said roller produces rotation of the shaft 24, considered as an entirety. The cutter rollers 20, 21 and 22 are free to rotate about the main body 27 of the shaft. The roller 23 has its central bore provided with a flattened portion adapted to closely engage the plane face 29 of the shaft. As will be seen by viewing Figures 5 and 6, this cutter roller is provided with segmental teeth 30. The rollers 19 and 23 may be considered as actuating members for the shaft. In order to hold the shaft with its cutter rollers mounted thereon in position to the body of the underreamer, I have provided in the underreamer an elongated channel inwardly extending from the periphery thereof, as indicated at 31. This elongated channel is concave in cross section, as best shown in Figures 4 to 6, in that zone occupied by the cutter rollers. Portions at each end of the concaved channels are so formed in the body as to best accommodate bearing blocks 32 and 33 for holding the shaft 24 and the assembled cutter rollers thereon to the body. In this respect, it will be seen that the upper bearing block 32 has its upper end face 34 inclined or at an angle to the side faces thereof, and that the body 7 of the underreamer is likewise provided with an inclined face 35 for matching engagement with the face 34. A transverse section of the block 32 is illustrated in Figure 3, and the said block is provided with a journal portion 36 adapted to receive the shaft portion 25. A bore 37 extends inwardly from the inclined face 34 and the rear face 38 of the block is formed in part with a half circle bore 39. The bearing block 33 is provided with an inclined or tapered end face 40 adapted to be received upon an inwardly tapered face 41 of the body 7, and this said block is formed with a bore 42 to receive the shaft portion 26.

The body 7 in the zone of the half-bore 39 of the block is correspondingly half-bored at 43 so as to provide a substantially complete circular bore, and a transverse bore 44 communicates with the two cooperating half bores and with the bore portion 9 of the bore 8. The shoulder 14 is provided with a threaded bore 45 adapted to receive a centering and locking pin 46, threaded in part as shown at 47. It will be seen that the assemblage of a cutter set within the body is simple of accomplishment, in that the shaft carrying the bearing blocks with the cutter rollers and actuating rollers interposed therebetween may be readily positioned within a channel of the body of the underreamer, through the simple

expediency of placing the blocks in position and then causing the centering and locking pin 46 to be received within the bore 37 of the block 32, as illustrated in Figure 2.

A stud 48 is positioned adjacent the periphery of the actuator roller 23, this stud being secured within the channel 31 of the underreamer body. The actuator roller 23 is stopped in its movement by a toothed portion engaging one of the two sides of the said stud, as best illustrated in Figures 5 and 6.

The operation, uses and advantages of the invention just described are as follows:

We may assume that, in the present embodiment, three complete sets of cutter rollers, as illustrated at 16, 17 and 18, are provided, with the said underreamer secured to a drilling string 5. The fish tail bit 5 is secured to the underreamer and in advance thereof, to the end that the fish tail bit may, when the drill string is rotated, cut the formation while the underreamer follows and enlarges the cut hole. During well drilling, it is customary to circulate a fluid through the drill string, to the end that the fish tail bit does not "freeze" and this circulation through the drill string passes in turn through the bore 8 of the underreamer and outwardly through openings in the fish tail bit, as illustrated at 49. A portion of the circulation fluid passes through the openings 43 and within the concaved channels surrounding the cutter rollers of the underreamer. In Figure 1, it will be observed that the casing 3 is located at a given position within the well hole and when it is desired to lower the casing to a greater depth within the well hole, it is customary to enlarge the well hole through the medium of an underreamer. This underreamer must pass through the casing and quite obviously the cutters should not contact the inner surface of the casing and cause damage to both the casing and the underreamer cutters. Hence, after the underreamer has passed from beneath the lower end of the casing and drilling commences, the cutter members of the underreamer may be brought into formation engagement by rotating the drill string. This rotation, which would be clockwise or to the right, viewing Figure 1, will cause the slightly projecting teeth of the actuating roller 23 to engage the formation and rotate the roller from the position shown in Figure 6 to that shown in Figure 5. This rotation will rotate the shaft 24 to project the cutter roller teeth beyond the periphery of the underreamer body, as shown in Figure 4. As rotation of the underreamer continues, it is evident that the cutter rollers are maintained in their outward cutting position by a tooth of the actuator roller 23 engaging the stop 48, see Figure 5. Hence, as long as rotation continues and the drilling operation proceeds, the cutters will rotate about the shaft and ream the hole. The cutter teeth are at all times maintained in substantially a clean condition and free from cuttings by the flow of fluid around said cutters, a feature of importance. When it is desired to release the cutter rollers from formation engagement, the tool may be rotated to the left, and the uppermost actuator roller will engage the formation as will likewise the lowermost actuator roller 23 and rotate the shaft or shafts from the position of Figure 5 back to the position shown in Figure 6, to move the cutter rollers substantially fully within the concaved channels or grooves to the end that the teeth do not project substantially beyond the periphery of the body of the underreamer.

When it is desired to replace worn cutter rollers, or actuators, it is only necessary to remove the pin 46 and the bearing blocks, together with the assembled rollers on the shaft between the bearing blocks, from the body of the underreamer. Removing one or the other of the bearing blocks will allow the cutters and cutter actuators to be removed from the shaft. Very little time is necessary for this operation.

It is usual practice to use a casing shoe at the lower end of the casing, and if the underreamer cutters are not collapsed inwardly of the body upon counterrotation, due in part to the fact that the well hole has not been underreamed to such an extent that the actuator rollers are not capable of acting, the uppermost actuator roller will strike the casing shoe and the engagement therebetween will cause a collapsing of each group, to the end that the underreamer may be withdrawn through the casing. It is also possible to use the underreamer without any following casing, as would be self-evident.

It is to be particularly noted that the underreamer cutters vary as to diameter from the lowermost actuator cutter 23 to the uppermost actuator cutter 19, with the result that each cutter performs its full degree of work. No one cutter performs work to the exclusion of a contiguous cutter.

A feature of importance in the present invention resides in the method of positioning the bearing blocks within the body. It is to be noted that the relation of the bearing blocks to the keeper pin is such that stress forces the bearing blocks inwardly of the body, with the result that if the pin should become dislodged there is still little likelihood of the bearing blocks or the cutters becoming disengaged from the body, which would result in a fishing job.

Another feature resides in the arrangement of the water passage through the body 7 with relation to the port openings 44. Obviously, the fluid passed through the bore 9 will not have as high a velocity as a fluid passed through bore 11 due to the difference in diameter. There will also be a tendency toward back pressure of the fluid with resultant forcing of the fluid through the port openings 44 and into the half bores 39 and 43 at a high velocity, which velocity, in actual practice, has been found sufficient to thoroughly clean the cutter teeth and keep off debris during a cutting operation. This construction is equivalent to nozzle action.

I claim:

1. An underreamer including a body in longitudinal alignment with the drilling string by which it is to be rotated, a shaft carried by the body and rotatable relative thereto, a cutter roller carried on said shaft, and an actuator roller secured to said shaft, said shaft having its axis of rotation eccentric to the axis of rotation of the cutter roller.

2. An underreamer comprising a body in longitudinal alignment with the drilling string by which it is to be rotated, said body provided with an elongated channel, a shaft, bearing blocks for ends of said shaft and fitted within said channel, a cutter roller on said shaft and in part received within said channel, and a toothed actuator fixedly secured to said shaft, the center of rotation of which shaft is eccentric to the axis of said cutter roller, the relationship being such that movement of the actuator rotates the shaft to move the said cutter roller into the said channel or outwardly therefrom.

3. An underreamer including a body formed with a longitudinal peripheral channel, a shaft, bearing blocks for ends of said shaft, said bearing blocks and shaft adapted for placement within said channel, a cutter roller free to rotate on said shaft, an actuator roller secured to the shaft, and means adapted to limit the rotation of said actuator roller in two directions, movement of said actuator roller in one direction projecting said cutter roller beyond the periphery of the underreamer body and movement of the cutter roller in a second direction moving said cutter roller within the channel.

4. An underreamer comprising a body adapted to be rotated, a shaft having end portions thereof rotatably secured in said body, and an intermediate portion the axis of which is eccentric to the axis of said end portions, a cutter roller rotatably carried on the intermediate portion of the shaft, and a further cutter roller secured to one of the said end portions.

5. An underreamer comprising a body in longitudinal alignment with the drill string by which it is to be rotated, said body provided with a longitudinally extending channel opening inwardly from the periphery thereof, a shaft, bearing blocks for ends of said shaft, said bearing blocks adapted to be received within said channel, a cutter roller, and an actuator roller on said shaft, said actuator roller secured to said shaft and the cutter roller free to rotate on said shaft, the axis of rotation of said shaft relative to the bearing blocks being eccentric to the axis of rotation of said cutter roller.

6. An underreamer comprising a body in longitudinal alignment with the drill string by which it is to be rotated, said body provided with a longitudinally extending channel opening inwardly from the periphery thereof, a shaft, bearing blocks for ends of said shaft, said bearing blocks adapted to be received within said channel, a cutter roller, an actuator roller on said shaft, said actuator roller secured to said shaft and the cutter roller free to rotate on said shaft, the axis of rotation of said shaft relative to the bearing blocks being eccentric to the axis of rotation of said cutter roller, and said cutter roller.

7. An underreamer including a body provided with a central bore, said body formed with a longitudinal channel eccentric to the axis of said bore, a shaft, and end bearing blocks for said shaft, said bearing blocks both provided with inclined end portions and said body having complementary inclined portions in the zone of said channel, and means for securing one of said bearing blocks to the body when both said bearing blocks are within said channel.

8. An underreamer including a body, a pair of spaced apart bearing blocks, a shaft received within said bearing blocks, and a cutter roller on said shaft and between said bearing blocks, the end faces of said bearing blocks being angularly related other than 90° to the axis of said shaft, said body provided with a channel, the end walls bounding which are angled complementary to the ends of the bearing blocks, and means for securing one of said bearing blocks to said body whereby the bearing blocks, shaft, and cutter roller are maintained secured to said body.

9. An underreamer comprising a body arranged in longitudinal alignment with the drilling string by which it is to be rotated, said body formed with an axial fluid passageway communicating with the drilling string, a shaft, a cutter roller free to rotate on said shaft, said shaft having

end portions, the axis of which is eccentric to that portion of the shaft around which said cutter roller rotates, bearing blocks for each end of said shaft, said body provided with an eccentric channel formed to receive the bearing blocks, shaft and said roller, means for locking said bearing blocks to said body when received within said channel, an actuator roller keyed to said shaft at an eccentric end portion thereof, and means between said body and said actuator roller for limiting the rotation thereof and whereby when the underreamer is rotated in one direction, and said actuator roller held, the said shaft will move said cutter roller outwardly of the said channel to engage formation, and counterrotation of said underreamer body, said actuator roller being held, will retract the said cutter roller within said channel.

10. An underreamer comprising a body arranged in longitudinal alignment with the drilling string by which it is to be rotated, said body formed with an axial fluid passageway communicating with the drilling string, a shaft, cutter rollers free to rotate on said shaft, said shaft having end portions, the axis of which is eccentric to that portion of the shaft around which said cutter rollers rotate, bearing blocks for each end of said shaft, said body provided with an eccentric channel formed to receive the bearing blocks, shaft and said rollers, means for locking said bearing blocks to said body when received within said channel, an actuator roller keyed to said

shaft at an eccentric end portion thereof, means between said body and said actuator roller for limiting the rotation thereof and whereby when the underreamer is rotated in one direction, and said actuator roller held, the said shaft will move said cutter rollers outwardly of the said channel to engage formation, and counterrotation of said underreamer body, said actuator roller being held, will retract the said cutter rollers within said channel, and means for by-passing any fluid passed through the drill string and the said underreamer body into the zone of said cutter rollers to maintain said cutter rollers free of cuttings.

11. An underreamer including a body, a pair of spaced apart bearing blocks, a shaft received between said bearing blocks, and a cutter roller on said shaft; the end face of one of said bearing blocks being at an angle other than 90° to the axis of said shaft, said body provided with a channel, one end wall bounding said channel being at an angle complementary to the angled face of a bearing block, said body provided with a threaded bore opening externally the body, and a threaded pin for reception within said threaded bore for engagement with the other of said bearing blocks, whereby when said complementary body end wall and bearing block face co-engage and the pin engages the other bearing block, said bearing blocks, shaft and cutters are maintained secured to said body.

HERMAN C. SMITH.