Sept. 27, 1932. D. H. REAMY ET AL 1,879,490

UNDERREAMER

Filed Aug. 23, 1929 2 Sheets-Sheet 1

Fig. 2.

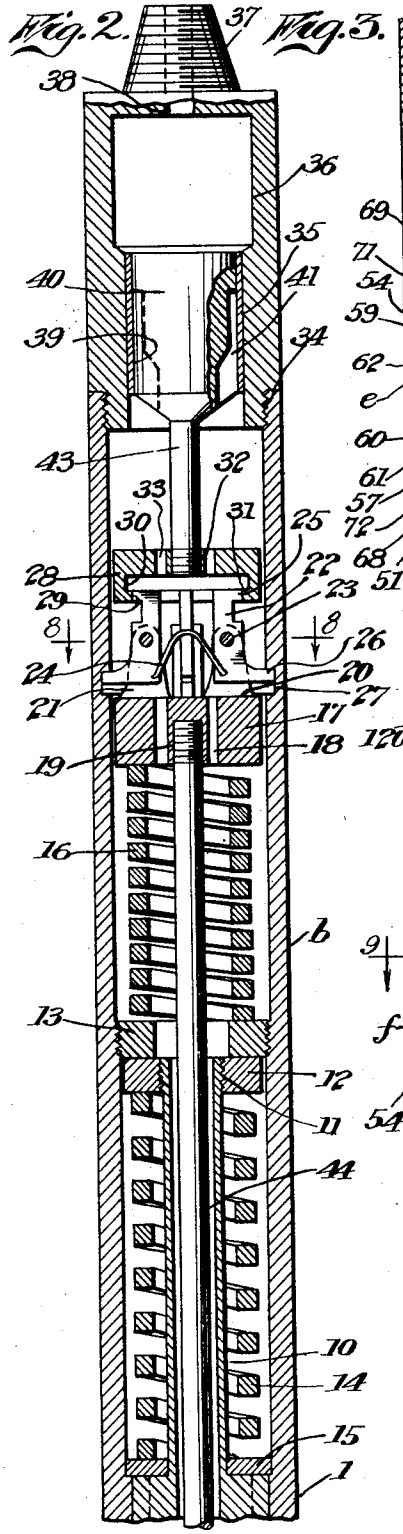


Fig. 3.

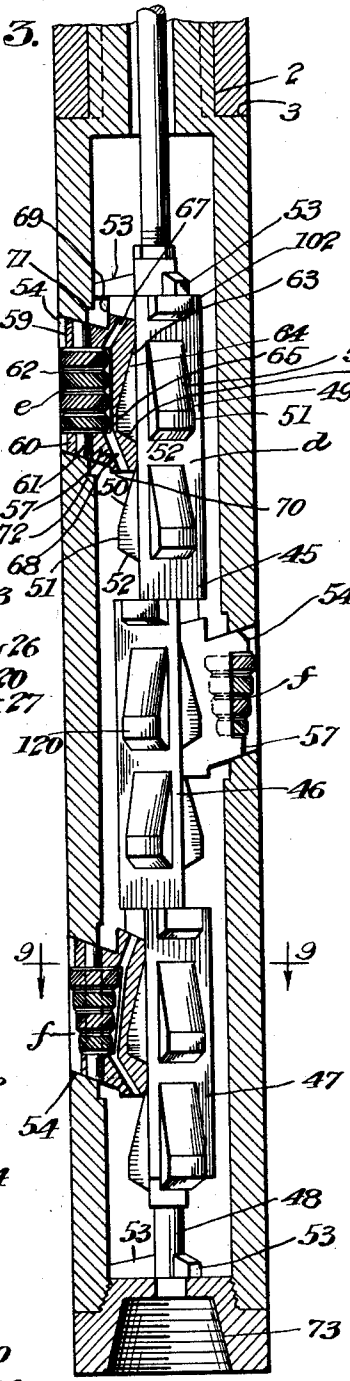
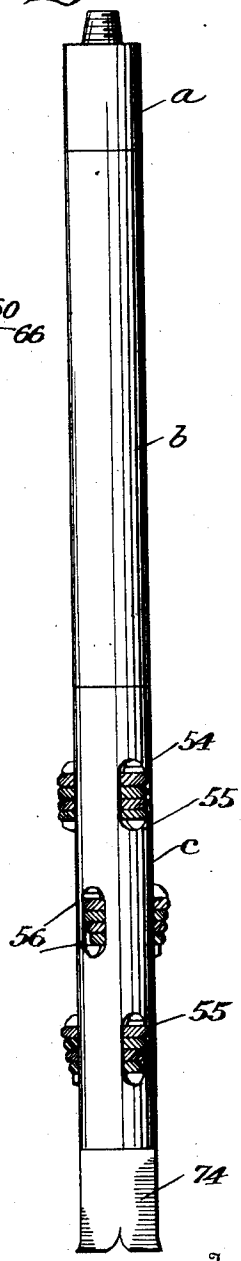


Fig. 1.



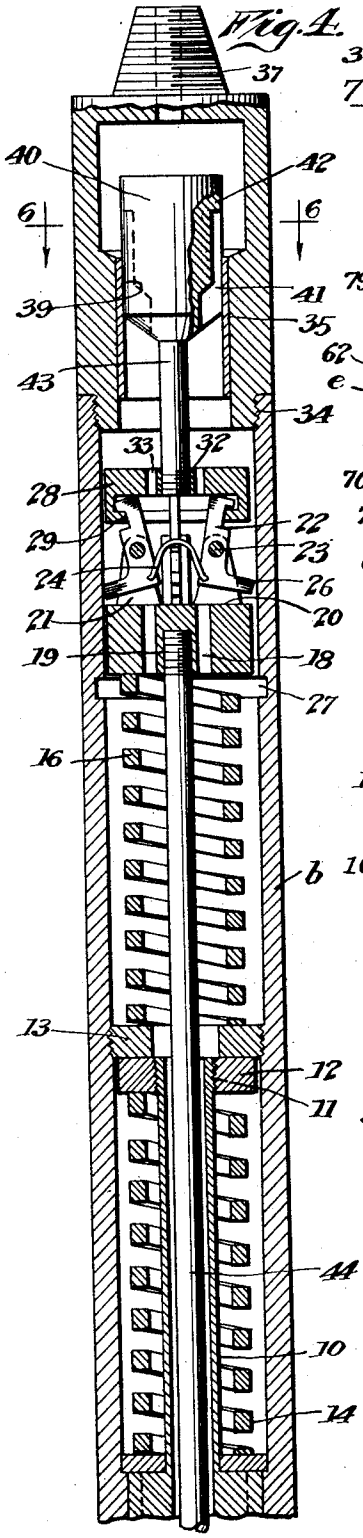
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UNDERREAMER

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Fig. 4.



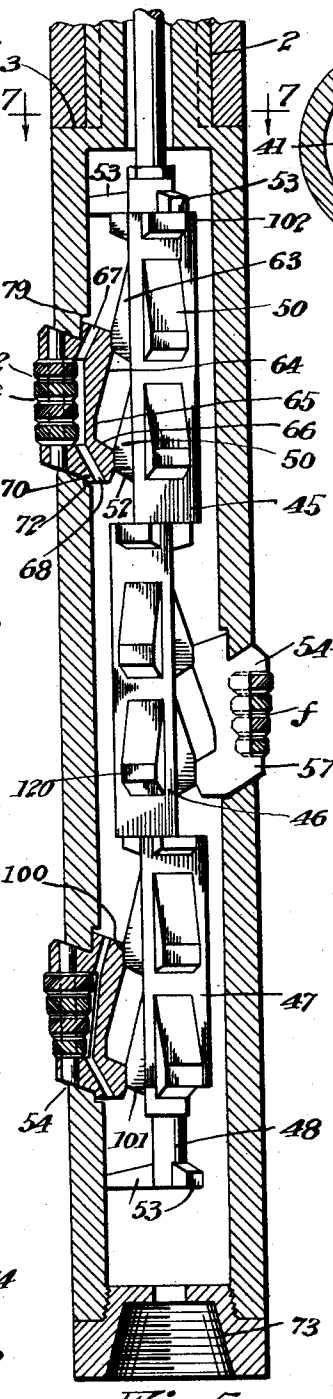


Fig. 5.

Fig. 6.

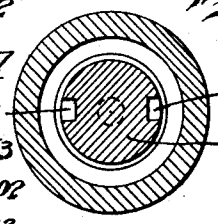


Fig. 7.

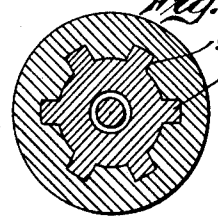


Fig. 8.

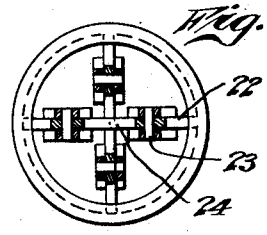
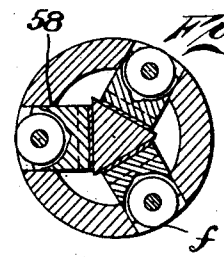


Fig. 9.



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Patented Sept. 27, 1932

1,879,490

UNITED STATES PATENT OFFICE

DANIEL H. REAMY AND ALBERT SWANSON, OF LOS ANGELES, CALIFORNIA

UNDERREAMER

Application filed August 23, 1929. Serial No. 387,889.

This invention relates to underreamers, and has for an object the provision of an underreamer which may be positioned within a well hole and when so positioned may have the cutter members thereof expanded into cutting position, and in such a manner that the cutter members are relieved from stress and strain during operation, and are positively positioned to the end that they will function most efficiently.

Another object is the provision of a underreamer in which the cutter elements thereof are actuated into cutting position at the will of an operator and whereby the attainment of said cutting position, through a novel system, is indicated to the operator.

Another object is the provision of an underreamer having the parts thereof so constructed as to operate automatically to position the cutters into cutter engagement with work at the will of the operator, and which cutters may be readily removed from work-engaging position at any time desired by the operator.

Another object is the provision of an underreamer which may be brought into work-engaging position or released from work-engaging position and again brought into work-engaging position at the will of the operator and while the underreamer is within the well hole.

Another object is the provision of an underreamer wherein the cutter elements thereof may be thoroughly cleaned either before, during, or after a cutting operation.

Another object is the provision of an underreamer wherein the cutters are so arranged that the cutting action is enhanced and the cutter life is increased.

Another object is the provision of an underreamer whereby the cost of replacement of parts is comparatively low.

Another object is the provision of an underreamer in which the cutters are so related as to rough out the hole and likewise finish the hole.

Another object is the provision of a underreamer wherein the operator may readily determine by pressure flow of mud at the pump whether the underreamer is expanding the cutters into position or the cutters have been expanded into working position.

Another object is the provision of an underreamer in which the liability to breakage of parts is reduced to a minimum.

Another object is the provision of an underreamer so constructed that under-gaging of holes in any type of earth formation is practically impossible.

Other objects include an underreamer which is simple of construction, efficient in operation and generally superior in use and serviceability.

With the above and other objects in view: the invention consists in the novel and useful provision, formation, construction and inter-relation of parts, members and features, all as shown in a certain embodiment in the accompanying drawings, described generally, and more particularly pointed out in the claims.

In the drawings:

Fig. 1 is an elevation of the improved underreamer;

Fig. 2 is a fragmentary longitudinal sectional view of the underreamer shown in Fig. 1;

Fig. 3 is a continuation of Fig. 2 being a fragmentary longitudinal sectional view of the underreamer;

Fig. 4 is a fragmentary sectional view of the underreamer, certain parts being in a changed relation from that shown in Fig. 2;

Fig. 5 is a continuation of Fig. 4, being a fragmentary longitudinal sectional view and showing certain parts in a changed relation from Fig. 3;

Fig. 6 is a cross sectional view on the line 6—6 of Fig. 4;

Fig. 7 is a cross sectional view on the line 7—7 of Fig. 5;

Fig. 8 is a cross sectional view on the line 8—8 of Fig. 2; and

Fig. 9 is a cross sectional view on the line 9—9 of Fig. 3.

Referring to the drawings, we have shown in Fig. 1 an elevation of the completed underreamer with the cutter elements thereof extending beyond the periphery of the cutter body. The said underreamer includes

several well defined agroupements of elements located within elements of the cutter body considered as an entirety. *a* is the plunger body which is screw-threaded or otherwise associated with a driving shell *b*. This driving shell in turn is arranged to secure a driven shell *c*. The elements just enumerated when in position of cooperation, as illustrated in Fig. 1, have substantially the same diameter, the peripheral surfaces thereof being in alignment as shown. The shells *b* and *c* are keyed together at 1, the shell *c* to this end being reduced in diameter at 2 to form an annular shoulder 3, and the shell *b* is telescopically received upon this portion 2. The portion of reduced diameter and the shell *b* are in splined relation, see Fig. 7. This spline is of ordinary construction, comprising a plurality of equi-distantly spaced keys 8 extending from the periphery of the part 2 and received within corresponding equi-distantly spaced grooves 9 in the member *b*. The driving shell is further reduced in diameter at 10 and the end thereof is in screw-threaded engagement at 11, with an annular extension head 12. Within the driving shell *b* and screw-threaded or otherwise secured thereto is an annulus 13. This annulus acts to division or substantially division the interior of the driving shell. A coil spring 14 surrounds the part 10 and bears at one end against the extension head 12 and at the opposite end against a washer 15, which washer is seated in the space included between the parts 2 and 10. This washer likewise bears upon the driving shell at this portion due to the splining, see Fig. 7. Normally, this coil spring is expanded against the head 12 so as to hold the driving shell and driven shell in close fitting engagement, as shown in Figs. 2 and 3. Within the driving shell and above the collar 13 is a coil spring 16 similar in construction to the coil spring 14, one end of which spring bears against the collar 13 and the opposite end against a mandrel head 17. This mandrel head is provided with one or more transverse ports 18 and likewise partially bored centrally and screw-threaded as shown at 19. One surface, 20 of said head, is provided with ears or lugs 21 arranged in spaced pairs, as shown in Fig. 8, and between which pairs are latch dogs 22.

It will be noted upon viewing Fig. 8 that four pairs of equi-distantly spaced lugs or ears 21 are provided and which in turn accommodate therebetween four latch dogs. These latch dogs are pivoted by pins or similar means 23 to the ears and diametrically opposite dogs are urged apart into "driving shell" engagment by means 24, constituting, in one embodiment, leaf springs. These locking dogs include elongated arms provided with extended head and foot portions 25 and 26 respectively. The foot portions thereof have a greater extension than the head portions. The driving shell is provided with an annular groove or notch 27, and the foot portions 26 of the latch dogs are adapted to be received within said notch under certain conditions, as hereinafter set forth.

Adapted to be associated with the latch dogs is a latch ring 28. This latch ring is provided with a curved recess 29 and the heads 25 of the latch dogs are adapted to bear against the surface wall bounding said curved recess when the latch dogs are in the position shown in Fig. 2. Said ring is likewise formed with an annular recess 30, which construction provides a shoulder 31 between the recesses 29 and 30. This ring is centrally bored and screw-threaded at 32 and likewise provided with one or more transverse ports 33. The plunger body *a* is reduced in diameter and screw-threaded at 34 for screw-threaded engagement with an end of the driving shell *b*. This plunger body is provided with a plunger-receiving bore 35 and a chamber 36 of greater diameter than the plunger bore. The plunger body is adapted to carry at one end a tool joint 37 provided with a bore 38 communicating with the chamber 36.

Fitted within the plunger-receiving bore 35 is a liner 39, and a plunger 40 is adapted for reciprocal movement within the liner. This plunger includes a cylinder provided with diametrically disposed slots 41. These slots do not extend the entire longitudinal length of the plunger but terminate below the head thereof, as illustrated in Fig. 4 at 42. A stem 43 is screw-threaded to the threads 32 of the latch ring 28. It will be seen that the plunger is of the valve type, the ports thereof being closed when the plunger is within the liner, and the ports open when the plunger is in part received within the chamber 36, as shown in Fig. 4. At that time the ports allow communication between said chamber 36 and the interior of the driving shell.

Secured to the screw threads 19 of the mandrel head is a mandrel stem 44. This mandrel stem is within the confines of the coil spring 16, and is passed through the annular opening of the collar 13 and through the part 10 to where it is received within the portion of enlarged diameter of the driven shell. This mandrel stem is adapted to be secured to a mandrel *d*. This mandrel has angularly-related face portions. In the present instance the mandrel considered as an entirety is made up of a plurality of connected portions 45, 46 and 47 and which portions may be secured together in any approved manner. If these portions are separately formed then each portion may be provided with a longitudinal bore with the said portions received upon a stem and

locked to said stem in a desired position. A stem is shown at 48. More particularly, a cross section of one of the mandrel portions shows that the faces thereof are equilaterally arranged, the angle between each face being 60 degrees, and if a gang of mandrel portions is utilized, as shown in Fig. 3, then the faces of one portion would be in staggered relation to the next adjoining portion. If the mandrel portions were viewed in plan the appearance would be one of star-like formation. Each mandrel portion is provided with one or more cam projections 49. Each cam projection includes an elongated face 50 at an angle to the longitudinal axis of the mandrel, a face portion 51 merging with the face 50 and substantially parallel to the face of the mandrel and a portion 52 between the face of the mandrel and the face 51 and at an angle less than 90 degrees to the face of the mandrel. At both ends of the mandrel are radial arms 53 which contact with the inner wall of the driven shell and act to guide movement of the mandrel within the driven shell.

The driven shell *c* is provided with a plurality of transverse slots 54. It will be noted that the slots 54, shown at 55, are in substantial alignment and that the slots shown at 56 are staggered with relation to the slots at 55 and lie substantially in an intermediate zone between the upper and lower slotted portions 55, (see Fig. 1). To this end it will be noted that the mandrel portions 45 and 47 have the faces thereof in substantial alignment, while the mandrel portion 46 is turned out of alignment therewith or staggered.

Adapted to be projected outwardly from the periphery of the driven shell and through the said slots 54 are cutter means *e* and *f*. The cutter means *e* in the broadest aspect thereof includes a cutter-carrying block 57. This block is formed with a curved recess 58, (see Fig. 9), and a pair of spaced arms 59 and 60. Between these arms extends a shaft or pin 61 upon which is carried one or more cutter discs 62. The peripheries of said cutter discs are provided with spiral fluting and the cutters are arranged in alternate left and right fluted relation, as shown in Figs. 3 and 5 to eliminate "gear" action of a single spiral, and likewise to increase the speed of cutting and life of the cutters. The part 63 of the cutter blocks is recessed so as to receive and confine the cams 49 on the mandrel when the cutter blocks are in one position. Thus the faces 64, 65 and 66 bounding the recess correspond in angularity to the faces 50, 51 and 52 respectively of the cams 49. The cutter block is provided with ports 67 and 68 which lead to the curved recess 58 and to the interior of the driven shell.

The construction of the cutter member *f* so far as the block member is concerned, is identical with the cutter member *e*. The cutter discs, however, are of different diameters. However, the fluting arrangement in alternate relation is the same as before. One or more cutter members *f* may be utilized in carrying out the invention, as shown in the figures. For instance, the mandrel portions 46 and 47 are adapted to cooperate with cutter members of the type *f*, while the mandrel portion 45 is adapted to cooperate with cutter members of the type *e*.

Each cutter block is provided with upper and lower shoulder portions 69 and 70, and which shoulder portions are received against shoulder portions 71 and 72 respectively of the driven shell when the cutters of the cutter blocks extend outwardly from the periphery of the driven shell, as shown in Fig. 5. These shoulders act to stop outward movement of the cutter blocks and may be termed "cutter block stops". The lowermost end of the driven shell is provided with a tapered screw-threaded box 73 which may in one embodiment of the invention receive the pin of a fish-tail bit 74.

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

Underreamers are universally used today in the oil fields when it becomes necessary to lower casings to a new level, and the purpose of the underreamer is to enlarge the diameter of the well hole beneath the casing. The underreamer is passed through the casing within the well hole with the cutters in collapsed condition, as shown in Figs. 2 and 3, and after the underreamer has passed through the shoe attached to the last casing member, the cutters may be expanded into cutter position as illustrated in Figs. 1, 4 and 5. The underreamer action then commences and the hole is enlarged to a greater diameter than the diameter of the last casing member.

With our invention we accomplish various results, which, so far as the inventors are aware, have not been accomplished by prior investigators and operators in the oil well industry.

Assuming the parts of the underreamer in the position shown in Figs. 2 and 3 mud-laden fluid is sent down the tubing and is received within the chamber 36 and will exert a pressure against the plunger 40. Downward pressure on the plunger will force the locking ring downwardly due to the connection between said locking ring and the plunger through the medium of the stem 43. When this locking ring moves down a sufficient distance, the heads 25 of the latch dogs will slip from engagement with the face 29 and be received in the groove 30 and when this occurs the foot portions 26 will be relieved from the annular groove 27 of the driving shell. Upon release of the dogs from the driving

shell the spring 16 which is in compressed condition in Fig. 2, will immediately expand and force the mandrel head upwardly and this upward movement will likewise cause upward movement of the locking ring 28 and move the plunger upwardly to the position shown in Fig. 4, wherein the ports 42 of said plunger will be in communication with the chamber 36 and with the interior of the driving shell. When the mandrel head moves upwardly the mandrel stem attached thereto will likewise move and carry with it the mandrel *d*. The cutter blocks will immediately be moved outwardly by the cams on the mandrel or into the position shown in Fig. 5, wherein it will be seen that the flat faces 100 and 101 of the cutter blocks will be in engagement with the faces 51 of two of the cams. It will be noted that each mandrel portion carries on each of the faces thereof two cams in substantially spaced alignment, and likewise that each mandrel face is provided with a stop lug 102 so as to restrict movement of the cutter blocks in one direction, as shown in Fig. 3. The cutters are limited in their movement outwardly of the slots of the driven shell, by the stops 69 and 70 of said blocks cooperating with the driving shell. When the cutters are in outward position the different cutters will be arranged in alternate staggered relation, as shown in Fig. 1, and the underreamer will be ready for use. The first set of cutters will rough the hole, while the cutters of the cutter member *e* will finish the hole. When it is desired to release the cutters so as to withdraw the underreamer from the hole, the mud pressure to the underreamer is released, whereupon the underreamer is pulled upwardly until the extensions 59 of the uppermost set of cutter blocks contact with the casing shoe. When this occurs, continued upward pull of the driving shell will cause the spring 14 to become compressed, the mandrel, however, being pulled upwardly by movement of the driving shell. Thus, as the mandrel moves, the cutter blocks will pass over the faces 51 of the two cam members and the cutter block will again seat itself upon the succeeding lower cam of the mandrel, at which time the cutter blocks will be retracted within the slotted portions of the driven shell.

A very important feature of the invention resides in the following: When it is desired to expand the cutters through the driving shell, mud may be passed through tubing into the chamber 36, where it will contact with the plunger, and the moment the spring 16 expands from its compressed position, shown in Fig. 2 to that of Fig. 4, there will be a sudden back pressure on the mud line which is sufficient to indicate to the operator at the surface of the well that the locking dogs have operated and the cutters are expanding. A slow flow of mud then passes through the smaller port openings of the plunger and down through the ports 18 to the ports 33 of the locking ring, ports 18 of the mandrel head, and through the collar 13 within the space included between the mandrel stem and the part 10 of the driven shell and within the portion of largest diameter of the driven shell. The restricted action of the pump due to this choked flow of mud through the smaller port openings in the valve continues throughout the expanding period and indicates this expanding period to the operator. When the expansion of the cutter block is completed, plunger 40 moves up while mandrel faces 51 slide over cutter block faces 100 and 101, thereby bringing the large port of the flow valve opening into play, allowing normal flow from the pump and thereby indicating to the operator at the surface of the well that the cutter blocks are fully expanded and the reamer ready to go down. Likewise, clear water or other fluid may be passed downwardly within the underreamer in the same manner for passage through the ports 67 and 68 and contact with the cutters 62 to clean the same.

It is obvious that various changes and modifications and variations may be made in practicing the invention in departure from the particular showing of the drawings without departing from the true spirit of the invention.

We claim:

1. In an underreamer: a plunger, a latch ring carried thereby, a mandrel and a latch dog between the mandrel and the latch ring, a cam carried by said mandrel, a cutter block provided with a cutter for engagement with said cam, resilient means normally urging said mandrel in one direction to cam the cutter block and bring the cutter into work engagement, said latch being released upon movement in one direction of said plunger to permit said movement of the mandrel.

2. In an underreamer: a plunger body, a driving shell secured to the plunger body, a driven shell keyed to the driving shell, a coil spring within the driving shell and in part surrounding the driven shell for holding the two in working relation; a mandrel extending through the driven shell and received within the driving shell and a coil spring normally urging the mandrel in one direction; a plunger within said plunger body and latch means between the plunger and said mandrel, a cutter adapted to be actuated into work engagement upon movement of the mandrel, said plunger when moved in one direction unlatching said latch means to allow expansion of one of said springs to move the mandrel.

3. In an underreamer: a shell, a mandrel therein provided with a plurality of cams arranged in staggered relation, said shell be-

ing provided with transverse slots in the plane of said cams; cutter blocks provided with disc cutters in part received within said slots and for engagement with said cams and whereby when said mandrel is moved in one direction said cutter blocks are engaged by the cams to move the cutters outwardly from said shell.

4. In an underreamer: a plunger body, a plunger, provided with port openings, within said plunger body and whereby when the plunger is moved in one direction fluid may be directed through said ports; latch means secured to said plunger, a mandrel associated with the latch means and cutter elements adapted to be actuated into working engagement upon movement of said mandrel; the ports of said plunger being normally closed and when fluid under pressure is directed against said plunger, said latch means is tripped to permit said plunger to expose said ports and likewise to move the mandrel to actuate the cutters, the fluid passing around the mandrel.

5. In an underreamer: a casing, a plunger provided with port openings confined in part within said casing, latch means secured to the plunger, a mandrel within the casing, and means normally urging the mandrel in one direction, said latch means cooperating with the casing to hold the mandrel against movement, and means whereby fluid may be admitted within the casing for impingement upon the plunger to release the latch means and permit movement of the mandrel.

6. In an underreamer: a casing, a plunger formed with valve ports within said casing, a latch ring secured to the plunger, a mandrel head and swinging latch dogs carried by the mandrel head and in engagement with the latch ring, the casing being formed to have latching engagement with said latch dogs, and resilient means normally urging said mandrel head in one direction; fluid pressure against said plunger moving said latch ring in one direction to release the latch dogs from engagement with the casing and permit expansion of said spring to in turn move the plunger to expose the said ports and permit passage of fluid through the casing.

7. In an underreamer: a casing, a plunger formed with valve ports within said casing, a latch ring secured to the plunger, a mandrel head, and swinging latch dogs carried by the mandrel head and in engagement with the latch ring, the casing being formed to have latching enagement with said latch dogs, and resilient means normally urging said mandrel head in one direction; fluid pressure against said plunger moving said latch ring in one direction to release the latch dogs from engagement with the casing and permit expansion of said spring to in turn move the plunger to expose the said ports and permit passage of fluid through the casing; in combination with cam means carried by said mandrel and a cutter block provided with cutters adapted to be brought into working engagement by said cam means when the mandrel is moved.

8. In an underreamer: a casing, a plunger formed with valve ports within said casing, a latch ring secured to the plunger, a mandrel head and swinging latch dogs carried by the mandrel head and in engagement with the latch spring, the casing being formed to have latching engagement with said latch dogs, and resilient means normally urging said mandrel head in one direction; fluid pressure against said plunger moving said latch spring in one direction to release the latch dogs from engagement with the casing and permit expansion of said spring to in turn move the plunger to expose the said ports and permit passage of fluid through the casing; in combination with cam means carried by said mandrel and a cutter block provided with cutters adapted to be brought into working engagement by said cam means when the mandrel is moved; said cutter block being formed with circulation openings leading to and from the cutter and whereby when fluid is passed through the casing said fluid is directed against said cutter.

In testimony whereof, we have signed our names to this specification at Whittier, California, this 13th day of August, 1929.

DANIEL H. REAMY.
ALBERT SWANSON.