March 10, 1959 B. L. GADEBERG 2,876,994

RETRACTABLE ROTARY WELL DRILLING BIT

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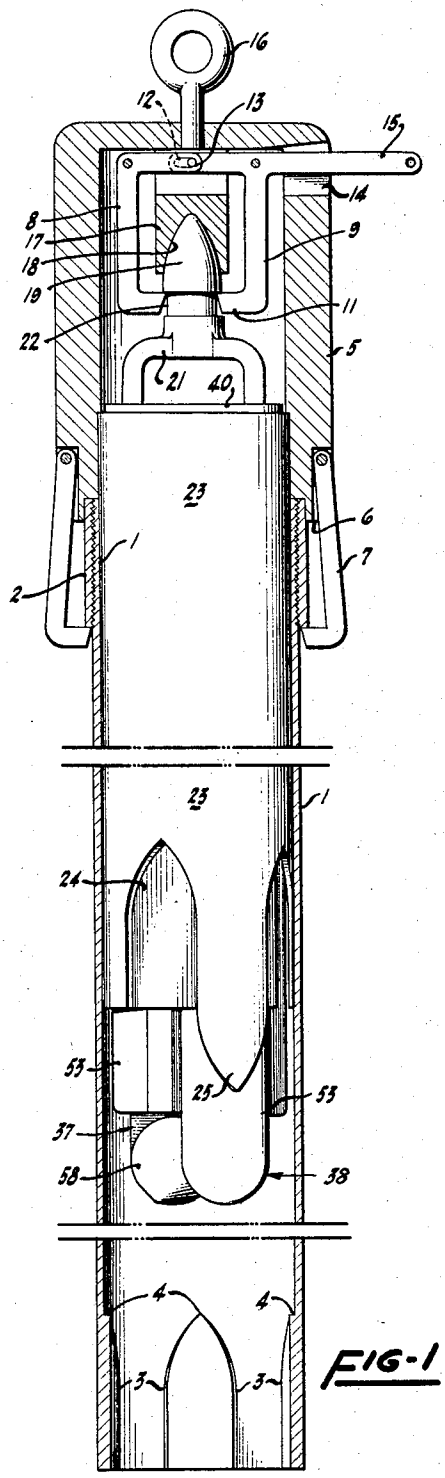


FIG-1

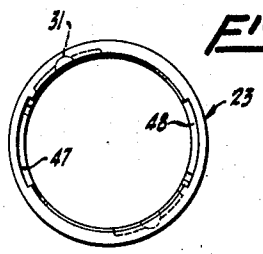


FIG-3

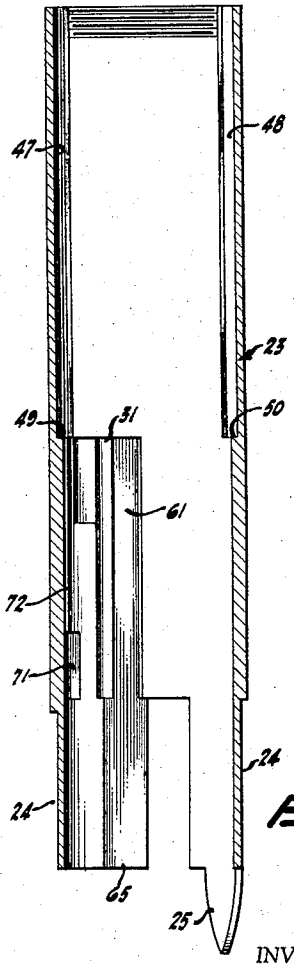


FIG-2

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RETRACTABLE ROTARY WELL DRILLING BIT

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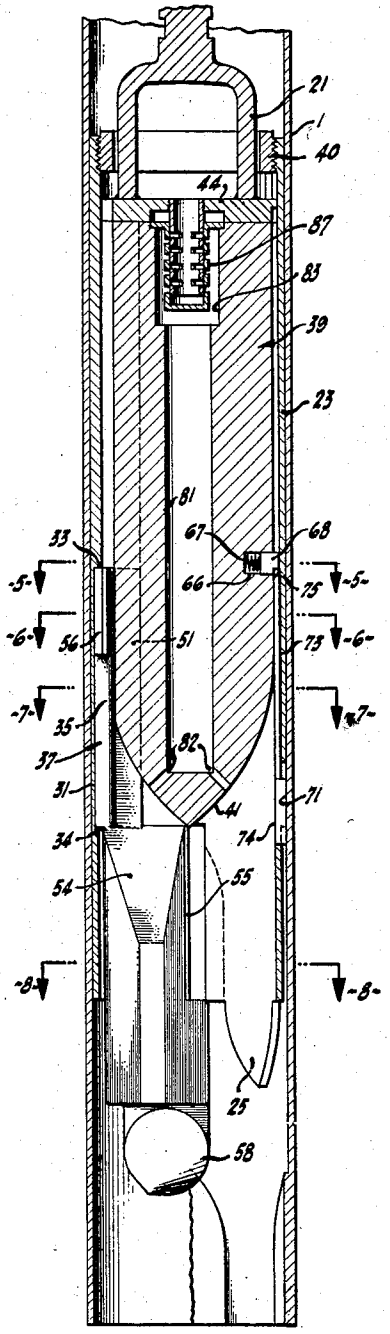


FIG-4

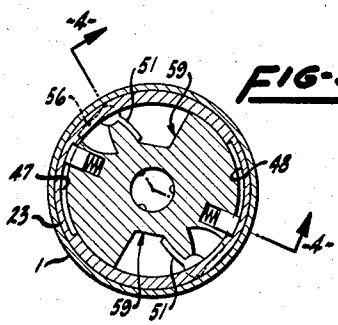


FIG-5

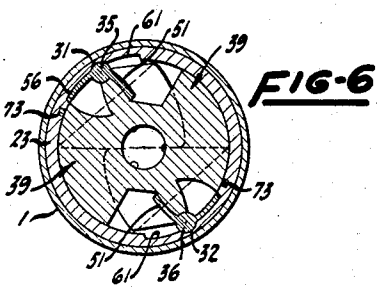


FIG-6

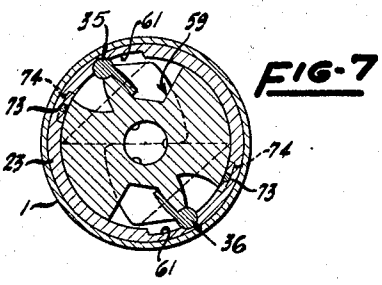


FIG-7

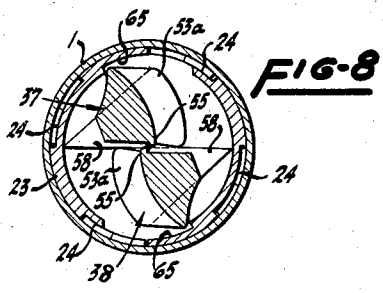


FIG-8

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March 10, 1959 B. L. GADEBERG 2,876,994

RETRACTABLE ROTARY WELL DRILLING BIT

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FIG-9

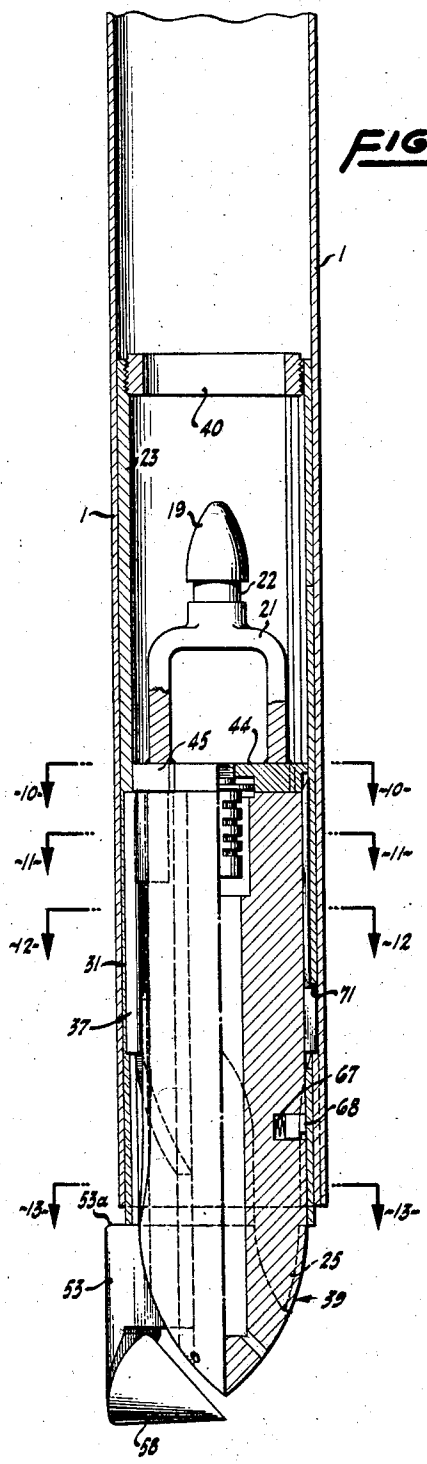


FIG-10

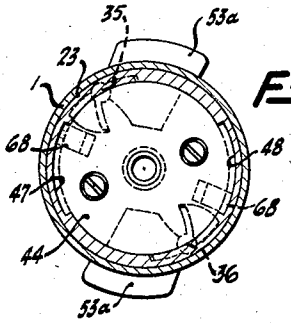


FIG-11

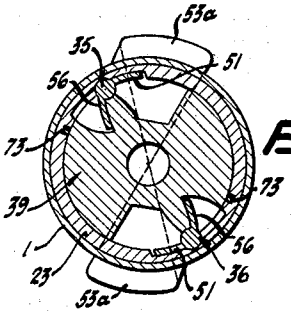


FIG-12

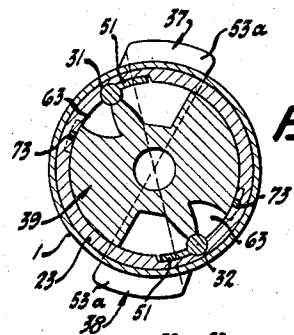
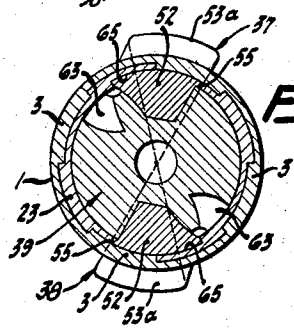


FIG-13



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March 10, 1959 B. L. GADEBERG 2,876,994

RETRACTABLE ROTARY WELL DRILLING BIT

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FIG-15

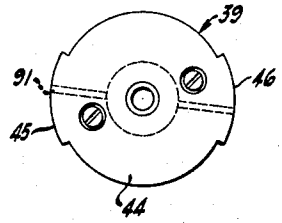
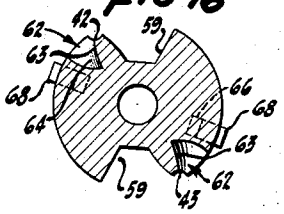


FIG-16



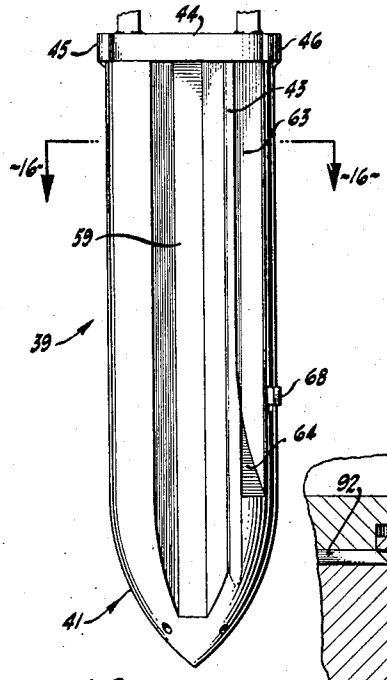


FIG-14

FIG-17

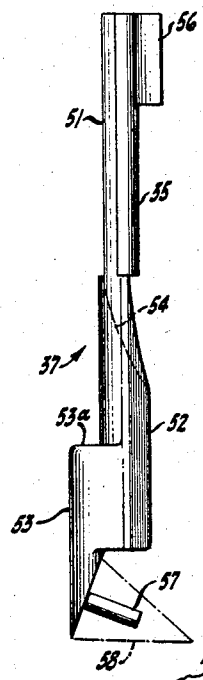
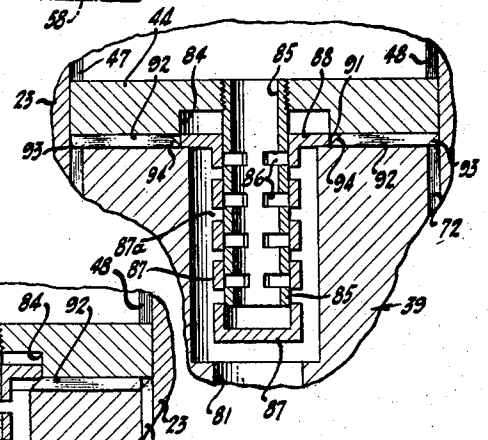


FIG-19



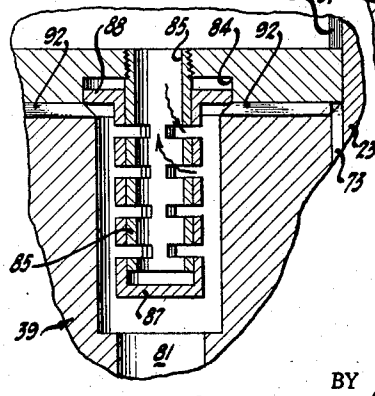


FIG-20

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March 10, 1959 B. L. GADEBERG 2,876,994

RETRACTABLE ROTARY WELL DRILLING BIT

Filed Nov. 26, 1956 5 Sheets-Sheet 5

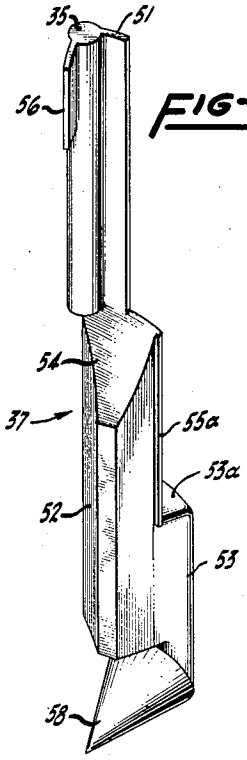


FIG-18

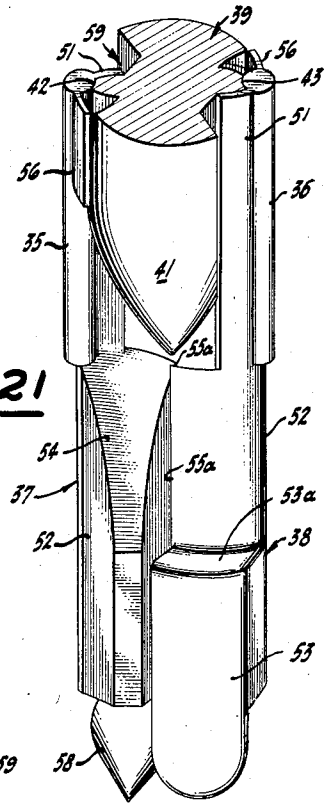


FIG-21

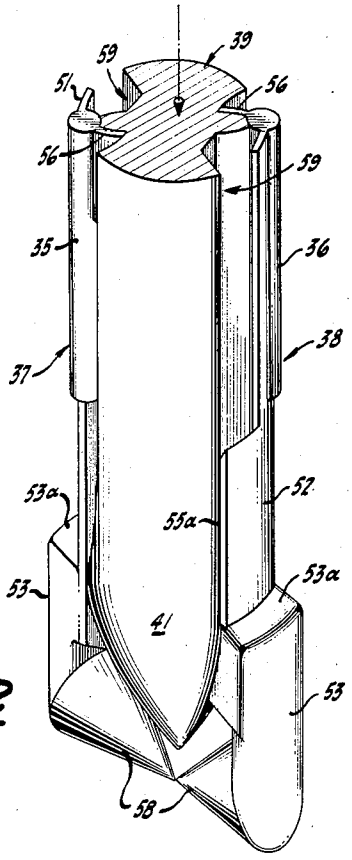


FIG-22

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United States Patent Office 2,876,994 Patented Mar. 10, 1959

2,876,994

RETRACTABLE ROTARY WELL DRILLING BIT

Burnett Laurance Gadeberg, Menlo Park, Calif.

Application November 26, 1956, Serial No. 624,373

15 Claims. (Cl. 255—61)

This invention relates to and in general has for its object the provision of a retractable well drilling tool.

Although various retractable drilling tools have been invented, two principal methods of oil well drilling are now in use. One, the rotary method, uses a cutting bit rotated on the end of a long string of drill pipe; and the other, the cable method, churns the tools on the bottom of the well at the end of a long cable. The advantage of the rotary method is high drilling speed and that of the cable method is ease of replacement of dulled tools. The purpose of this invention is to provide a basic mechanism which will permit of the combination of the essential and beneficial properties of these present methods and thereby permit oil wells to be drilled faster, cheaper, and deeper. This basic mechanism is a retractable rotary bit which may be withdrawn from and replaced in the well through the interior of the drill pipe and without the necessity of pulling the long string of drill pipe out of the well. Thus the high drilling speed of the rotary method is combined with the high replacement speed of the cable method, and either the rotary tools or the cable tools may be used interchangeably in the same well so that the maximum advantages from both systems can be obtained.

The old method of replacing a rotary bit requires that the entire string of drill pipe must be laboriously hauled up, unscrewed, and stacked in the tower. The reverse procedure must then be performed to seat the new bit on the bottom.

The disadvantage of the old system lies in the time and expense consumed in extracting and replacing the drill pipe. In a well of 20,000 feet depth, with a drill pipe extraction and replacement rate of 1,000 feet per hour, 40 hours are required to replace a bit. When this is combined with an average bit time of twelve hours it is apparent that 77 percent of the drilling crew's time is wasted replacing bits. With this new system an extraction and replacement rate of 600 feet per minute or better is possible, thus requiring 67 minutes or less to replace a bit in the same well. Combining this with an average bit time of six hours (due to a smaller bit surface) 15 percent of the drilling crew's time is wasted replacing bits. Hence the new system affords a saving of 62 percent of the drilling crew's time, when drilling a well at 20,000 feet depth. On the basis of 15,000 miles of oil wells drilled per year in the United States, at an average depth of 4,000 feet, and a cost of $10 per foot, and a drilling crew's cost of 20 percent of the total well costs, a yearly saving of $80,000,000 or more is possible in the United States alone.

More specifically, the object of this invention is the provision of a retractable drilling tool comprising: a tool cartridge arranged to be lowered and raised within a drill pipe, and provided with means whereby it can be keyed to the lower end of the drill pipe for rotation therewith; a tool actuator slidable within the tool cartridge and keyed thereto; cutter arms journaled between the tool cartridge and the tool actuator and fixed against axial movement relative to the tool cartridge; and means responsive to

the relative axial movement of the tool actuator and the tool cartridge for rotating said tools from a retracted, inoperative position to an expanded, operative position, or vice versa.

A further object of this invention is the provision of a retractable well drilling tool of the character above described wherein the tool actuator is provided with a spring biased locking pin arranged to seat in the bottom of a keyway formed in the tool cartridge and which serves to restrain the tool actuator from expanding the cutter arms until the tool cartridge has reached a position adjacent the bottom of the drill pipe.

Still another object of this invention is the provision of a retractable well drilling tool of the character above described wherein a locking pin releasing mechanism is carried by the tool cartridge and operative in response to the lower terminal movement of the tool cartridge within the drill pipe for depressing said locking pin, to thereby permit said tool actuator to continue to move downwardly within said tool cartridge and to thereby expand said cutter arms to their operative position.

A still further object of this invention is the provision of a retractable well drilling tool of the character above described wherein the lower ends of the drilling pipe and tool cartridge are provided with a series of complementary lugs or fingers arranged to be interdigitated with each other when the tool cartridge has reached the lower end of the drilling pipe and thus lock or key these two members together so that any rotation to which the drill pipe is subjected may be imparted to the tool cartridge.

Another object of this invention is the provision in a retractable tool of the character above described of cutter arms provided with cam follower ribs or wings disposed within the cam tracks formed in the tool actuator, to thereby cause said cutter arms to rotate in response to the axial movement of the tool actuator relative to the tool cartridge.

The invention possesses other advantageous features, some of which, with the foregoing, will be set forth at length in the following description where that form of the invention which has been selected for illustration in the drawings accompanying and forming a part of the present specification, is outlined in full. In said drawings, one form of the invention is shown, but it is to be understood that it is not limited to such form, since the invention as set forth in the claims may be embodied in other forms.

Referring to the drawings,

Fig. 1 is a front elevation of a drilling tool embodying the objects of my invention, with the drill pipe shown in section and with its tool cartridge shown in its suspended, inoperative position.

Fig. 2 is a vertical midsection of the tool cartridge.

Fig. 3 is a top plan view of Fig. 2.

Fig. 4 is a vertical section taken through the drill pipe, tool cartridge cutter carrier, and actuating torpedo on the section line 4—4 of Fig. 5, showing the relationship of these members at a point where the cutter carrier and its cutters are adjacent, but short of, the lower end of the drill pipe.

Fig. 5 is a horizontal section taken on the section line 5—5 of Fig. 4.

Fig. 6 is a horizontal section similar to the section shown in Fig. 5, but taken on the section line 6—6 of Fig. 4.

Fig. 7 is a horizontal section similar to that of Fig. 5, but taken on the section line 7—7 of Fig. 4.

Fig. 8 is a horizontal section similar to that of Fig. 5, but taken on the section line 8—8 of Fig. 4.

Fig. 9 is a vertical midsection similar to that illustrated in Fig. 4, but showing the tool in its operative position.

Fig. 10 is a horizontal section taken on the section line 10—10 of Fig. 9.

Fig. 11 is a horizontal section taken on the section line 11—11 of Fig. 9.

Fig. 12 is a horizontal section taken on the section line 12—12 of Fig. 9.

Fig. 13 is a horizontal section taken on the section line 13—13 of Fig. 9.

Fig. 14 is a side elevation of the tool actuator.

Fig. 15 is a top plan view of the tool actuator.

Fig. 16 is a horizontal section taken on the section line 16—16 of Fig. 14.

Fig. 17 is a side elevation of one of the cutter arms.

Fig. 18 is an isometric view of one of the cutter arms showing its inner face.

Fig. 19 is a fragmentary vertical section of the upper valved end of the tool actuator showing the valve in its downwardly closed position.

Fig. 20 is a view similar to that illustrated in Fig. 19 but showing the valve in its mid open position.

Fig. 21 is a fragmentary isometric view of the cutter arms and the tool actuator showing the cutter arms in their retracted, inoperative position, and the tool actuator in a position just preceeding or succeeding its actuation of the cutter arms.

Fig. 22 is a view similar to that illustrated in Fig. 21 but showing the cutter arms held in their expanded, operative position by the tool actuator.

The tool as illustrated in these figures includes a drill pipe 1 provided with a collar 2 threaded to its upper end. Formed on the lower end of the drill pipe 1 is a plurality of peripherally spaced, vertically extending keying bosses 3 converging at their upper ends to points 4. The bosses 3 should be equally spaced, and each boss should subtend an angle equal to the angle subtended by the space between adjacent bosses.

Seated on the upper end of the drill pipe 1 is the lower end of a recessed outer cage 5, and pivoted in slots 6 formed therein are hooks 7 arranged to detachably seat over the lower end of the collar 2. Pivoted to, and within the upper end of the cage 5 is a pair of tongs 8 and 9, each provided at its lower end with an inwardly turned hook 11. Formed on the upper inner ends of the tongs 8 and 9 are registering slots 12, and accommodated therein is a pin 13 formed integral with the cage 5. Extending outwardly from the upper end of the tong 9 through a slot 14 formed in the cage 5 is an operating lever 15 serving as a means for simultaneously retracting the hooks 11 of the two tongs. Formed integral with the top of the outer cage 5, coaxially therewith, is a supporting eye 16. Depending from the upper end of the cage 5, coaxially therewith, is a lug 17 formed with a downwardly directed dome-shaped recess 18.

Receivable in the recess 18 is the dome-shaped upper end 19 of an inner cage 21 provided with an annular channel 22 for the detachable reception of the hooks 11 of the outer cage 5. As a result of this construction, it will be seen that the inner cage 21 can be released from the outer cage 5 by the simple expedient of raising the operating lever 15.

Slidable within the drill pipe is a cylindrical tool cartridge 23 provided on the outer face of its lower end with equally spaced, recessed keyways 24 and with at least one intervening, downwardly converging finding finger 25. From an inspection of Fig. 1, it will be noted that the upper ends of the keyways 24 are of a configuration complementary to the upper dome-shaped ends of the keying bosses 3. As a result of this construction, the tapered finding finger 25 cams its way between the tapered keying bosses 3 as the tool cartridge is lowered to the bottom of the drill pipe, thus causing the keying bosses 3 to be keyed within the inwardly recessed keyways 24 of the tool cartridge. In this position of the tool cartridge the rotation of the drill pipe can be imparted to the tool cartridge.

Formed in the tool cartridge, intermediate its ends and at diametrically opposed points thereon, is a pair of inwardly recessed, semicylindrical pintle bearings 31 and 32 provided at their tops and bottoms with end shoulders 33 and 34. Partially journaled and supported within the bearings 31 and 32 are the pintles 35 and 36 of a pair of identical, diametrically opposed cutter arms generally designated by the reference numerals 37 and 38 (Fig. 21).

Longitudinally slidable within the tool cartridge 23 is a generally cylindrical tool actuator designated by the reference numeral 39 (Fig. 14) retained within the tool cartridge 23 by an internal ring 40 threaded thereto and terminating at its lower end in a downwardly converging camming point 41. Formed on diametrically opposed side wall portions of the tool actuator 39 is a pair of indented, semicylindrical bearings 42 and 43 partially surrounding the inner sides of the pintles 35 and 36 and serving to confine said pintles within the complementary bearings 31 and 32 of the tool cartridge. As a result of this construction, the cutter arms 37 and 38 are free to rotate within their respective composite bearings and are restrained against longitudinal or axial movement relative to the tool cartridge 23, but are capable of axial movement relative to the tool actuator 39.

Screwed to the top of the tool actuator 39, coaxially therewith, is a disc 44 (Figs. 14 and 15) provided with diametrically opposed, outwardly extending keywings 45 and 46 receivable respectively in longitudinally extending keyways 47 and 48 formed on the inner walls of the tool cartridge 23 (Figs. 2 and 3). As best shown in Fig. 2, these keyways terminate at their lower ends in shoulders 49 and 50. As a result of this construction, the tool actuator is fixed against rotation relative to the tool cartridge 23, and its downward movement within the tool cartridge is limited by the shoulders 49 and 50. Here it should be noted that the inner cage is welded or otherwise affixed to the disc 44 so as to travel therewith.

Formed integral with each of the cutter arms 37 and 38 and extending radially from each of their pintles 35 and 36 is a rib 51 having a feathered outer edge and formed on a radius substantially equal to the radius of the tool actuator 39 and co-extensive with the pintles 35 and 36. Merging with each of the ribs 51 is a depending cutter arm body portion 52 provided at its lower end with an outwardly stepped cutter bearing bracket or lug 53 having a top face or shoulder 53*a* (Fig. 17). As shown in Fig. 13, the body portion is of generally trapezoidal configuration, although its outer surface is formed on a radius slightly larger than the radius of the tool actuator 39. Here it should be noted that the upper end of the body portion 52 is upwardly and outwardly inclined as at 54 in an arc substantially complementary to the curvature of the lower end or camming point 41 of the tool actuator 39. It should further be noted that the cutter arm body portion 52 is provided along one longitudinal edge of its outer curved side with a cam follower rib 55 having a feathered outer edge 55*a* and extending from the lower level of the cutter arm pintles to the upper end of the radially offset bearing bracket 53.

Extending radially from the upper end of each of the cutter arm pintles 35 and 36 is a relatively short cutter arm retracting cam follower wing 56 formed on a radius substantially equal to the radius of the tool actuator 39.

Supported on the lower undercut end of each of the bearing brackets 53 is a radially and downwardly extending pin 57, and journaled thereon is a conventional conical cutter 58.

Formed in the tool actuator 39 to one side of each of the semicylindrical pintle bearings 42 and 43 is a pair of diametrically opposed, longitudinally extending slots 59 having a cross-sectional configuration substantially identical with the cross-sectional configuration of the body portion 52 of the cutter arms 37 such as, for example, taken on the section line 8—8 of Fig. 4 or the section

line 13—13 of Fig. 9. As a result of this construction, the slots 59 serve to accommodate the ribs 51 when the cutter arms are in their contracted position, and the body portion 52 of the cutter arms when the cutter arms 37 and their conical cutters 58 are in their expanded, operative position as respectively illustrated in Figs. 1, 4–8, and 21, and in Figs. 9–13 and 22.

Formed in the interior side walls of the tool cartridge 23 circumferentially intermediate its actuator keyways 47 and 48 and starting at a point on a level with the lower ends thereof is a pair of diametrically opposed channels 61 of a length equal to the length of the ribs 51 and for the accommodation of said ribs when the cutter arms 37 and their conical cutters 58 are in their expanded and operative position as illustrated in Figs. 9–13 and 22.

Also formed in the side walls of the tool actuator 39 for the accommodation of the cam follower wing 56 is a pair of identical, diametrically opposed, longitudinally extending channels 62, each defined in part by a longitudinal camming side wall. As indicated in Figs. 11, 12, 13, 14, and 16, the side wall 63 is outwardly curved at its lower end as at 64 so as to merge with the outer surface of the body of the tool actuator. As a result of this construction, it will be seen that if the tool actuator is moved upwardly relative to the cutter arms 37, the inclined camming side walls constrain the cam follower wings 56 to rotate outwardly about the axes of the pintles 35 and 36 to thereby force the cutter arms into their retracted, inoperative positions. From an inspection of Figs. 5 to 8, inclusive, it will be noted that when the cutter arms are in their retracted, inoperative position they lie entirely within the confines of the tool cartridge 23, and their conical cutters 58 are disposed side by side. When the device is in its operative position the bearing brackets 53 of the tool arms and their conical cutters are positioned below the lower end of the drill pipe 1, and the conical cutters are positioned apex to apex with their base end extending radially beyond the confines of the drill pipe (Figs. 10–13).

Formed in the inner wall of the lower end of the tool cartridge 23 is a pair of diametrically opposed channels 65 in vertical alignment with the outer surfaces of the cutter arm body portion 52 and arranged to receive the outer curved faces of the ribs 55 when the cutter arms are in their expanded position as shown in Fig. 13 and wherein the cutter bearing brackets 53 are disposed beneath the bottoms of the tool cartridge and the drill pipe.

Provided in the side wall of the tool actuator 39 is a pair of diametrically opposed recesses 66, and seated in each of said recesses under the outwardly biasing action of a coil spring 67 is latch pin 68 extending into the keyways 47 and 48 of the tool cartridge 23 (Figs. 4, 9, 10, 14, and 16). Since, as shown in Fig. 2, the keyways 47 and 48 terminate intermediate the ends of the tool cartridge in shoulders 49 and 50, the pins 68 serve to limit the downward movement of the tool actuator so long as the pins are in their extended position.

Formed in the side wall of the tool cartridge immediately above the level of the upper ends of its keyways 24 is a pair of diametrically opposed, rectangular openings 71, each merging at its upper end with an upwardly extending, narrow, vertical channel 72 formed in the inner wall of the tool cartridge communicating with its keyway 49 and in vertical alignment with the latch pin 68. Receivable within each channel 72 is a latch pin release finger 73 provided at its lower end with a rectangular foot 74 receivable in the rectangular opening 71 and serving to hold the finger 73 against vertical movement. Formed on the upper end of each finger 73 is a wedge-shaped point 75 arranged to engage and retract the latch pin 68 upon the continued downward movement of the tool actuator 39 (Figs. 2 and 4).

The relative positions of the cutter arms 37 and the tool actuator 39 just prior to the retraction of latch pin 68 is illustrated in Figs. 4 and 21, from which it will be seen that the camming point 41 of the actuator is immediately above the feathered outer edges 55*a* of the cam follower ribs 55. Upon any further downward movement of the tool actuator its camming point 41 (Figs. 21 and 22) will engage the edges 55*a* and thus serve to bias the cutter arms outwardly, although of course the cutter arms cannot move outwardly into their expanded position until their cutter brackets 53 have passed below the lower end of the drill pipe 1 (Figs. 9 and 21). In moving from these two positions, the lower end of the tool cartridge becomes keyed to the lower end of the drill pipe 1, as previously explained.

Formed in the tool actuator 39 is an axial bore 81 communicating at its lower end with inclined openings 82, and formed at its upper end with a counterbore 83 in vertical registration with a somewhat larger counterbore 84 formed in the bottom of the disc 44 (Figs. 19 and 20). Threaded into the disc 44 from the lower face thereof is an axial nipple 85 provided with a plurality of equally spaced ports 86. Slidably disposed over the ported nipple 85 is a sleeve 87 closed at its lower end and terminating at its upper end in a radial flange 88 overhanging and supported on the upper end of the bore and vertically movable within the disc counterbore 84. Provided in the sleeve 87 are ports 87*a* formed on centers identical to the centers of the nipple ports 86. This structure therefore constitutes a sleeve valve operating to close the bore 81 under the influence of a fluid pressure imposed on the upper end of the tool actuator or on the lower closed end of the sleeve 87.

Formed in the end of the actuator 39 on a diameter thereof is a channel 91 and slidable therein is a pair of diametrically opposed bars 92 provided with tapered or inclined ends 93 and 94. In the inoperative position of the tool the inclined ends 93 are arranged to extend into the tool cartridge keyways 47 and 48 in vertical alignment with the fingers 73, and the ends 94 are arranged to just clear the peripheral edge of the flange 88, as best shown in Fig. 19. After the fingers 73 have depressed the latch pin 68 as the tool actuator moves downwardly relative to the tool cartridge, the wedge-shaped upper ends 75 of the fingers 73 finally engage the outer inclined ends 93 of the bars 92, thereby forcing the bars 92 inwardly. As a result of this, the inner ends 94 of the bars are forced beneath the flange 88, thus causing the outer valve sleeve 87 to rise a distance sufficient to bring its ports 87*a* into registration with the ports 86 of the inner sleeve 85 as shown in Fig. 20. In this, the operative position of the tool, the slide valve described is in its open position permitting rotary mud to pass downwardly through the tool in accordance with usual practice. However, the sleeve 87 is positively maintained in its open position only so long as the fingers 73 are in engagement with the outer ends of the bars. If the tool actuator 39 is raised relative to the tool cartridge 23 this condition no longer exists, and if rotary mud then be forced downwardly between the drill pipe and the hole being drilled and upwardly through the tool, the pressure of the mud on the inner ends of the bars 92 serves to move them radially outward to their inoperative position and also to elevate the outer valve sleeve 87 to its upper closed position. At this point, all further flow of mud through the tool is blocked, and consequently the mud pressure assists to elevate the tool actuator 39 relative to the tool cartridge 23. In other words, this sleeve valve simply serves to permit rotary mud to flow downwardly through the tool after it has been forced into its operative position at the base of the drill pipe, and at all times prevents rotary mud from flowing upwardly through the tool.

In the operative position of the tool, the conical cutters 58 are in their expanded position, apex to apex, as illustrated in Figs. 9 through 13, and 22; the shoulders 53*a* of the cutter arm brackets are disposed beneath the lower ends of the tool cartridge 23 and the drill pipe 1 and consequently serve to impart to the cutter arms any longi-

tudinal thrust to which the drill pipe is subjected; the tool cartridge is keyed to the drill pipe; and the cutter arm ribs **51** and brackets **55***a* are keyed to the tool cartridge, and consequently any rotary thrust imparted to the tool cartridge by the drill pipe is transmitted to the cutter arms.

When the conical cutters **58** have become dull and have to be renewed, the flow of rotary mud is reversed so as to close the slide valve associated with the upper end of the tool actuator, whereupon the pressure of the rotary mud on the lower face of the actuator disc **44** causes the tool actuator to move upwardly relative to the tool cartridge. During this movement of the tool actuator the camming wings **56** of the cutter arms **37** are constrained to move along the camming side wall **63** of the tool actuator. As a result of this, the cutter arms and their associated conical cutters are forced into their collapsed or inoperative position as shown in Figs. 1, 4 through 8, and 21; and the locking pin **68** serves to hold these members in this position until the tool actuator is again moved downwardly relative to the tool cartridge. However, in cases of emergency the upper end **19** of the inner cage **21** can be engaged by a suitable fishing tool, and the entire tool cartridge and its associated tool actuator and cutter arms raised to the surface for the purpose of changing the conical cutters.

After the cutters have been changed and it is desired to lower the tool cartridge, the latter is mounted within the upper end of the drill pipe as indicated in Fig. 1, the inner cage **21** is released by elevating the lever **15**, and then rotary mud is forced downwardly on the top of the tool cartridge to thus assist in forcing the latter to the bottom of the drill pipe under a hydrostatic head. At this point, the slide valve associated with the upper end of the tool actuator is of course closed.

To assemble the tool above described, the pin release fingers **73** and their rectangular feet **74** are first positioned respectively in the tool cartridge channels **72** and rectangular openings **71**, this being done from the bottom of the tool cartridge; the tool arms **37** and **38** are then mounted within the tool cartridge with their pintles **35** and **36** seated in the pintle bearings **31** and **32**. This having been done, the tool actuator **39** is inserted into the top of the tool cartridge with its keywings **45** and **46** keyed within the tool cartridge keyways **47** and **48**, and the actuator is allowed to drop within the tool cartridge until its latch pins **68** are seated on the lower ends of the tool cartridge keyways **47** and **48**. At this point, the tool arms will of course be in their retracted, inoperative position as illustrated in Figs. 1, 4 through 8, and 21.

As a result of a pull on the inner cage **5**, the tool actuator first moves upwardly relative to the tool cartridge and this results in contracting the tool arms to their closed position in precisely the same manner as produced by the application of hydraulic pressure upwardly against the closed check valve constituted by the valve nipple **85** and sleeve **87**. Regardless of whether the tool is raised hydraulically or by a fishing tool secured to the cage **5**, it is unnecessary to pull the drill pipe. This in itself saves considerable time and expense.

I claim:

1. A retractable well drilling tool arranged to be inserted through a drill pipe comprising: a cylindrical tool cartridge slidable within said drill pipe; means for keying said tool cartridge to the lower end of said drill pipe; a tool actuator slidable within and keyed to said tool cartridge; at least one pair of peripherally spaced cutter arms journaled between said tool cartridge and said tool actuator on axes parallel to the axis of said tool cartridge; means for constraining said cutter arms to move axially with said tool cartridge; a cutter arm expanding camming surface formed on said tool actuator; a cutter arm expanding cam follower formed on each of said cutter arms and arranged to follow said cutter arm expanding camming surface in response to the downward movement of said tool actuator within said tool cartridge; a cutter arm retracting camming surface formed on said tool actuator; and a cutter arm retracting cam follower formed on said cutter arms and arranged to follow said cutter arm retracting camming surface in response to the upward movement of said tool actuator within said tool cartridge.

2. A retractable well drilling tool of the character defined in claim 1, wherein a spring biased latch is provided between said tool actuator and said tool cartridge for limiting the downward movement of said tool actuator within said tool cartridge and wherein a latch release is mounted in said tool cartridge below said latch for tripping said latch in response to the downard movement of said tool within said drill pipe.

3. A retractable well drilling tool of the character defined in claim 1, wherein said tool actuator is keyed to said tool cartridge by means of keyways formed in said tool cartridge and terminating intermediate the ends thereof and by wings formed in said tool actuator and slidably disposed within said keyways.

4. A retractable well drilling tool of the character described in claim 1, wherein said tool cartridge is keyable within the lower end of said drill pipe by means of downwardly extending and converging fingers formed in the lower end of said tool cartridge and upwardly extending and converging lugs formed in the lower end of said drill pipe and arranged to interdigitate with said downwardly extending fingers in response to the downward movement of said tool cartridge within said drill pipe.

5. A retractable well drilling tool of the character described in claim 1, wherein said cutter arms are provided with pintles journaled within closed end bearing recesses formed in said tool cartridge, thereby to constrain said cutter arms to move axially in response to the axial movement of said tool cartridge.

6. A retractable well drilling tool of the character described in claim 1, wherein said tool actuator is formed with longitudinally extending channels for the reception of said cutter arms.

7. A retractable well drilling tool of the character defined in claim 1, wherein the inner surface of said tool cartridge is provided with recesses for the reception of said cam followers.

8. A retractable well drilling tool of the character defined in claim 1, wherein said tool actuator is tubular and is provided with a check valve for permitting fluid to flow through said tool only when said tool is in its operative cutting position.

9. A retractable well drilling tool of the character defined in claim 1, wherein means is provided for closing the upper end of said drill pipe.

10. A retractable well drilling tool of the character defined in claim 2, wherein said tool actuator is keyed to said tool cartridge by means of keyways formed in said tool cartridge and terminating intermediate the ends thereof and by wings formed in said tool actuator and slidably disposed within said keyways.

11. A retractable well drilling tool of the character defined in claim 3, wherein said tool cartridge is keyable within the lower end of said drill pipe by means of downwardly extending and converging fingers formed in the lower end of said tool cartridge and upwardly extending and converging lugs formed in the lower end of said drill pipe and arranged to interdigitate with said downwardly extending fingers in response to the downward movement of said tool cartridge within said drill pipe.

12. A retractable well drilling tool of the character defined in claim 4, wherein said cutter arms are provided with pintles journaled within closed ended bearing recesses formed in said tool cartridge, thereby to constrain

said cutter arms to move axially in response to the axial movement of said tool cartridge.

13. A retractable well drilling tool of the character defined in claim 5, wherein said tool actuator is formed with longitudinally extending channels for the reception of said cutter arms.

14. A retractable well drilling tool of the character defined in claim 6, wherein the inner surface of said tool cartridge is provided with recesses for the reception of said cam followers.

15. A retractable well drilling tool of the character defined in claim 7, wherein said tool actuator is tubular

and is provided with a downwardly closing and upwardly opening check valve for permitting fluid to flow through said tool only when said tool is in its operative cutting position.

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