

[54] **STABILIZED UNDER-DRILLING APPARATUS**

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[51] Int. Cl. **E21b 9/22**

[58] Field of Search **175/406, 399, 53, 325, 175/387, 407, 408**

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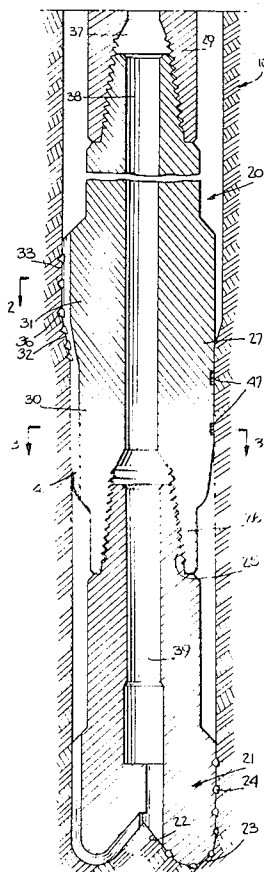
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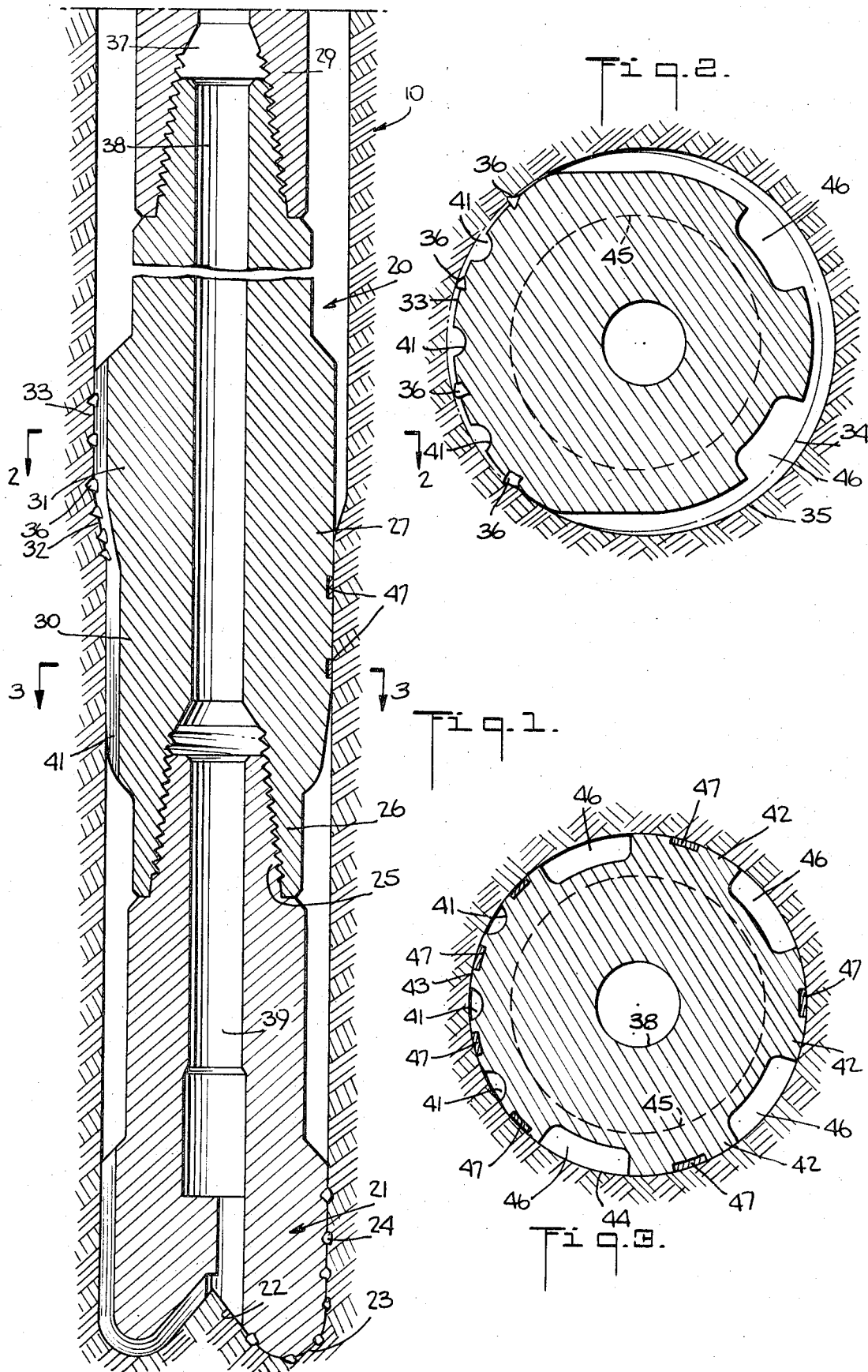
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ABSTRACT

Improved rotary under-drilling apparatus, of the type used for extending and enlarging the bore hole of a well from some point below the surface, includes a pilot drill bit for drilling a small hole in the desired direction of the well, an under-reamer of the offset or asymmetric type, axially spaced from the drill bit, for enlarging the pilot hole to the desired final diameter, and at least one stabilizing means positioned between the reamer and the pilot drill bit. The stabilizing means has an effective diameter of substantially the same size as the hole drilled by the pilot bit but has no cutting surfaces, so that it acts as a journal bearing against the wall of the pilot hole, both to isolate the drill bit from the radial and moment forces generated by the reamer and also to cause the reamer to rotate concentrically with the axis of the pilot hole. Preferably, two stabilizing means are provided, one adjacent to the lower end of the under-reamer and the other spaced between the first guide means and the upper end of the drill bit.

11 Claims, 10 Drawing Figures





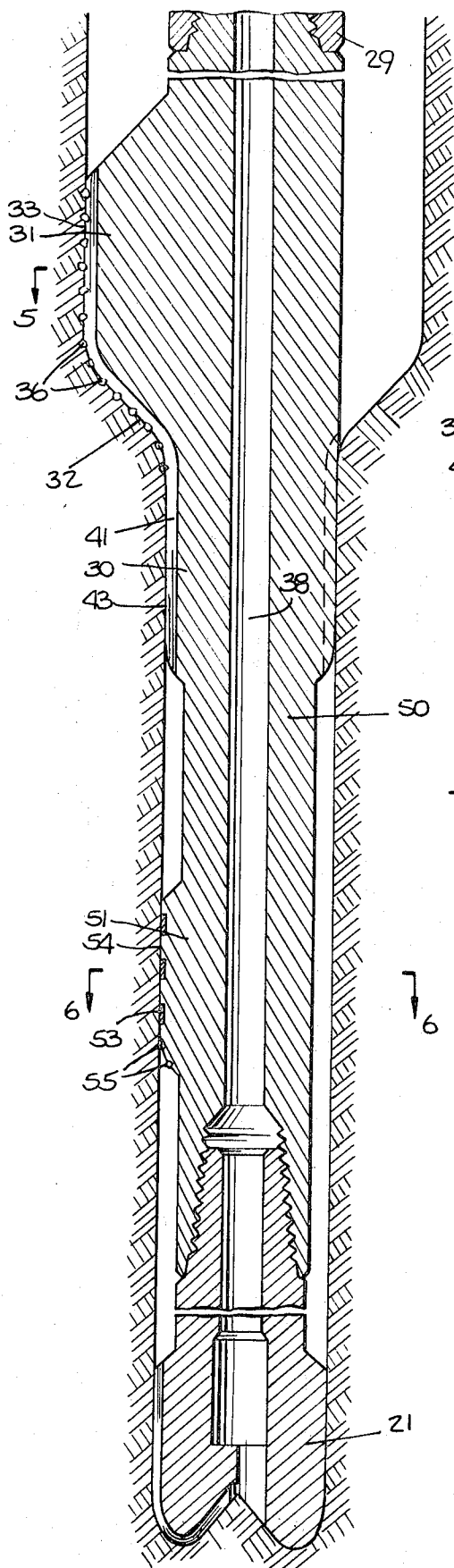
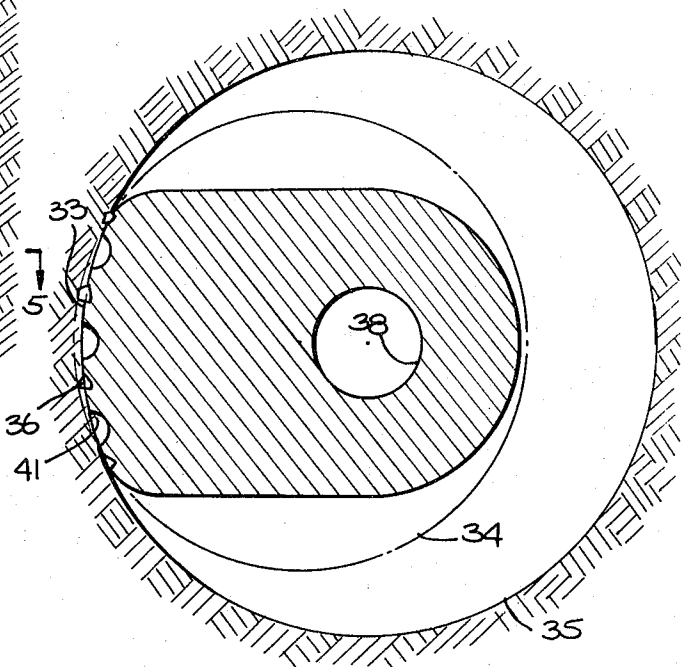


Fig. 5.

Fig. 4.

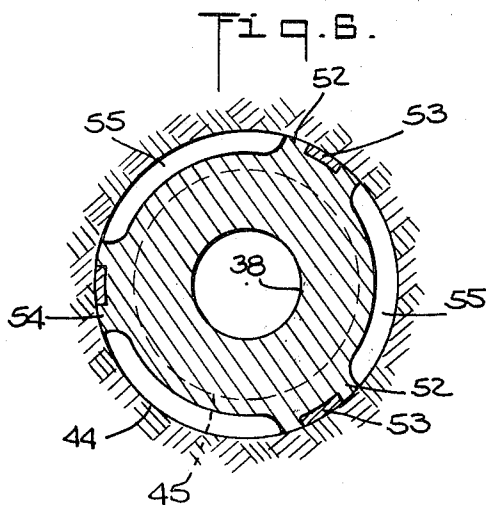


Fig. 6.

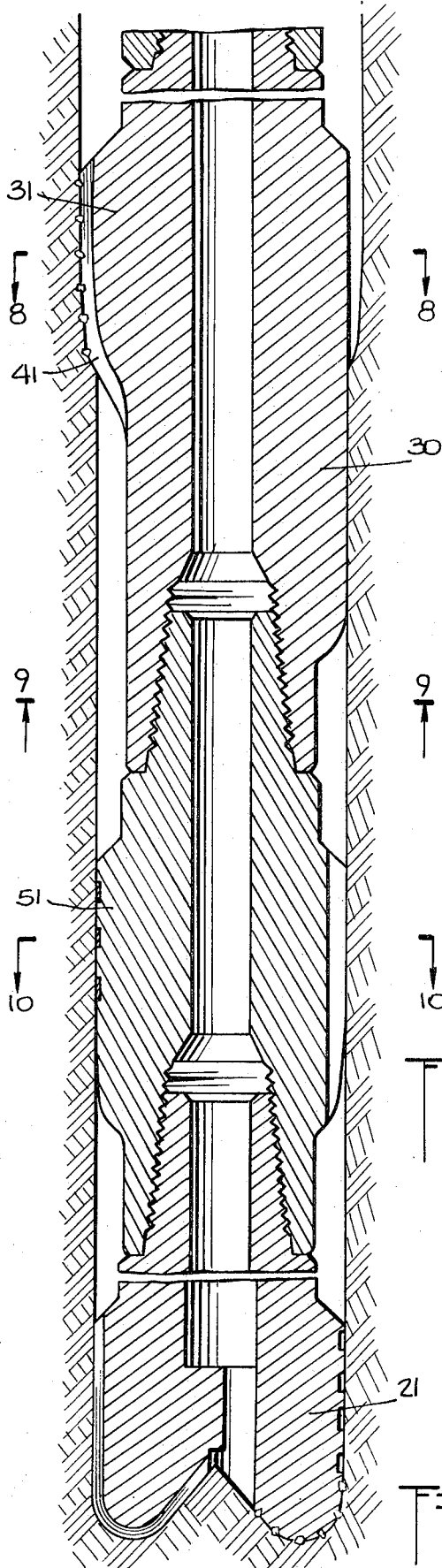
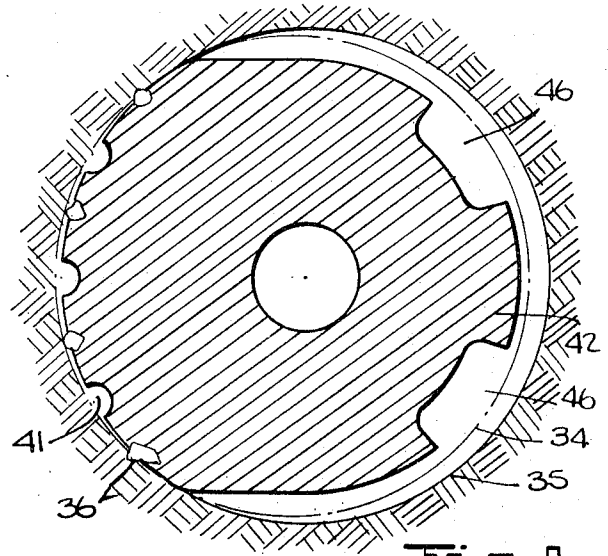
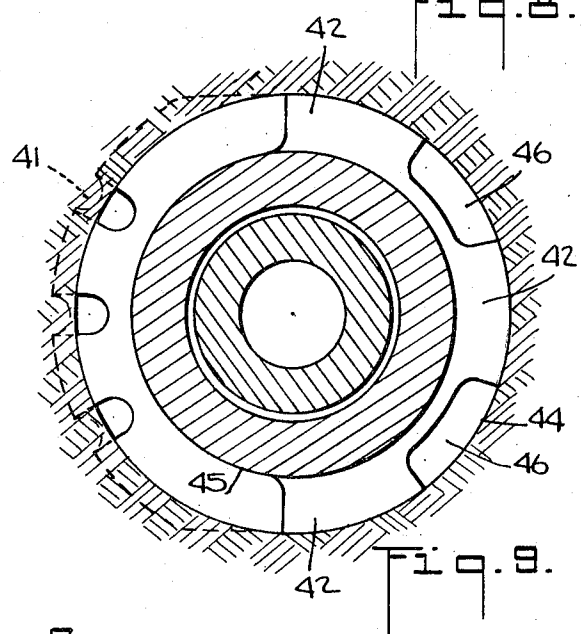
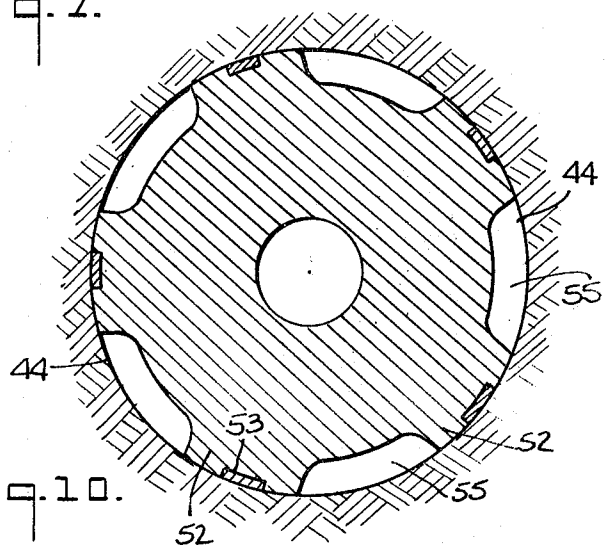


Fig. 7.



STABILIZED UNDER-DRILLING APPARATUS

BACKGROUND

1. Field of the Invention

This invention relates to rotary under-drilling means for extending and enlarging the diameter of a portion of a drilled well hole and, more particularly, to drilling and reaming means in which the reamer is of the offset or asymmetric type.

The terms under-drilling and under-reaming refer to methods for extending and simultaneously enlarging a drilled hole or for enlarging a portion of a previously pilot-drilled hole from a point below the surface. Typically, when deep oil or gas wells are drilled, a depth is reached at which gas pressure, water seepage, or crumbling of the bore hole wall threatens collapse of the hole or flooding if deeper drilling is attempted. At this point the drill string must be withdrawn, a liner or casing inserted, and hydraulic cement pumped down the inside of the casing and up between the outside of the casing and the wall of the bore hole, where it is allowed to set. Drilling may then continue until the extended hole is again deep enough to require lining.

The inside diameter of each lined section will be smaller than that of the section above it because the casing for the lower section must necessarily be able to pass inside the casing of the upper section. In addition, there must be substantial clearance between the outer wall of the casing and the wall of the bore hole to provide a passageway for the hydraulic cement.

If a standard drill just small enough to pass through the upper casing is used to drill the extended hole, the diameter of the new bore hole will be approximately the same size as the inside diameter of the casing, and a lower casing having substantially smaller outside diameter than the inside diameter of the upper casing will be needed to obtain the proper clearance in the extended bore hole.

For example, a well drilled initially to a nominal diameter of 12¼ inches will take a casing having an inside diameter of 9½ inches. If a 9½ inch drill is used for the extended hole, the casing for the lower section will have an inside diameter of only 6 inches. On the other hand, if the extended hole is under-drilled to a nominal 10½ inch diameter, a 7 inch ID lower casing can be used.

2. Description of the Prior Art

Tools for performing the under-reaming function fall into two general classes. The first class includes retractable reamers, which may be either symmetric or asymmetric, and the second class includes fixed reamers, which are necessarily asymmetric in order to pass through a casing smaller than the under-reamed hole. Both types of reamer are usually combined with either a separate or integral pilot drill bit so that the hole can be simultaneously drilled and under-reamed.

The retractable reamers have blades or other cutting means that are normally retracted while the drill string is being lowered through the well casing and are then extended outward to the desired radius of the under-reamed hole after the reamer clears the bottom of the casing. Examples of drill and retractable reamer combinations are given in the following U.S. Pats.: No. 668,340, issued on Feb. 19, 1901 to W. Plotts; No. 1,025,339, issued on May 7, 1912 to F. E. Tucker; No. 1,906,056, issued on Apr. 25, 1933 to F. A. Golish; and

No. 3,051,255, issued on Aug. 28, 1962 to C. L. Deely.

The Tucker and Deely patents provide examples of the symmetric type of retractable reamer. The Tucker apparatus includes a cylindrical carrier having two angled reaming blades pivotally mounted in opposed longitudinal slots for angular movement between a retracted position and an extended position. A fishtail drill bit is threaded onto the lower end of the carrier for cutting a pilot hole somewhat larger than the diameter of the lower end of the carrier. The pilot hole is then enlarged by the reaming blades which, in their extended position, undercut the inside diameter of the well casing.

Deely discloses a four-bladed reamer with a cylindrical body and having a separate drill bit threaded into its lower end, both bit and reamer being of the diamond type. The four blades of the reamer are held in retracted position within spaced longitudinal slots by shear pins as the drill string is being lowered. The retracted blades of both the Tucker and Deely reamers are forced outward by axial movement of a tapered inner plug relative to the reamer body due to the weight of the drill string, once the drill bit engages the bottom of the hole.

The Plotts patent shows an asymmetric type of retractable reamer having a single pivoted blade that swings out from a retracted to an extended position in a manner similar to movement of the twin blades of the Tucker device. Whereas the radial and tangential forces acting on the symmetrically spaced blades of the Tucker and Deely reamers are balanced, so that the reamers are self-stabilized, these same forces acting on the singlebladed, asymmetrically arranged reamer of Plotts are not.

Plotts shows in his drawings an elongated blade type pilot drill threaded onto the lower end of the reamer. Such a drill might provide sufficient bearing surface on the edge of the drill blade diametrically opposed to the reamer blade to counteract the radial force exerted by the wall of the bore hole, but it has no bearing surface at right angles to withstand the tangential forces acting on the reaming cutter. Consequently, the Plotts device will tend to rotate eccentrically and to drill a non-concentric, and possibly crooked, hole.

The Golish patent is for an underreamer that combines a single retractable and a circumferentially spaced pair of nonretractable toothed roller cutters in one unit. When the retractable roller is extended for the under-reaming operation, the reamer provides spaced three-point rolling contact against the sides of the bore hole. Thus, the radial reaction forces of the hole walls against the cutters are inherently balanced, and there are no tangential forces because of the rolling contact.

All of the retractable under-reamers described above have a common drawback, however, in that they have a number of moving parts that can jam or break when the drill is at the bottom of the well. If this happens, the device must be pulled from the hole and quite possibly may get stuck in the process. The above mentioned class of fixed offset under-reamers avoids this problem and provides an inherently simpler and stronger unit.

In reamers of the fixed type, the reaming cutters must necessarily be arranged asymmetrically with respect to the drill string axis in order to pass through the bore hole to the point where the portion to be enlarged com-

mences. As in the case of the retractable reamers, the fixed under-reamers are usually combined with a pilot drill, which may be either integral with the reamer body or a separate unit attachable to the reamer by the conventional threaded coupling.

The radius of the pilot drill and the reamer offset radius are chosen so that the combined tool will pass through the well casing by shifting the drill pipe off center with respect to the hole. Once the drill reaches the bottom of the hole, it tends to pilot itself and rotate concentrically with the hole axis, thereby forcing the offset reaming cutter outward so as to enlarge the pilot hole to the desired final diameter.

Examples of such prior art offset under-reaming devices are shown in the following U.S. Pats: No. 141,344, issued on July 29, 1873 to M. Gillespie; No. 1,065,294, issued on June 17, 1913 to A. G. Collins; No. 1,587,266, issued on June 1, 1926 to J. A. Zublin; No. 2,953,354, issued on Sept. 20, 1960 to E. B. Williams, Jr.; and No. 3,367,430, issued on Feb. 6, 1968 to D. S. Rowley. Another example is shown in Austrian Pat. No. 1430, issued on May 25, 1900 to B. von Vangel. Most of the bit and reamer combinations disclosed in these patents are very similar in principle, differing primarily only in the design of the bit and the reamer. In every case the reaming section extends radially outward on only one side of the drill pipe axis so that the maximum cross sectional dimension is less than the diameter of the hole that the unit will ream when rotating concentrically about that axis.

The Gillespie device is unique in that it has no associated pilot bit; so it can be used only to under-ream a predrilled hole. To insure that the reamer rotates concentrically with the hole axis, Gillespie fills the predrilled hole with sand to the point where the enlargement is to commence and then drops a tubular bearing member into the hole. The offset underreamer has a center pin at its lower end that fits loosely inside the tubular bearing, which thereby centers and guides the rotating reamer without rotating itself. The Gillespie procedure and apparatus is impractical, however, for use in the deep drilled wells for which the present invention is primarily intended.

Collins discloses a twist type pilot drill below a blade type reamer that acts as a boring tool for under-reaming a hole. Zublin shows a fishtail drill bit with an offset underreaming blade formed integrally with and extending laterally from one edge of the fishtail blade. Rowley combines in a single drill bit a lower diamond type pilot bit of conventional design with a stepped, offset, diamond studded reaming section directly above and contiguous with the pilot bit.

The pilot bit in each of these designs has cutting elements or edges on the vertical sides of the drill which tend to gouge or counter-ream the pilot hole in response to unbalanced radial and tangential reaction forces acting on the reamer. As a result, the pilot drill and reamer tend to rotate eccentrically and generate an out-of-round hole. Furthermore, because the reamer is spaced axially above the drill face in the above three examples, it produces a force couple having a moment arm equal to the distance between the reamer and the drill face that tends to turn the pilot drill away from a straight line.

The van Vangel bit, which was a reference in the Rowley patent, has a square-edged castellated pilot drill with fluted straight sides. An eccentric, axially

spaced offset reamer is of similar construction. From the drawing it does not appear that the fluted sides are cutting sides, but the specification states only that the lower "crown" (of the pilot bit) serves to guide the upper eccentric "crown" in operation. The castellated design of the von Vangel bit is not suitable for present day deep well drills, and the square-edged cutting face does not provide the self-piloting action of modern tapered-crown diamond bits. Thus the von Vangel bit will tend to drill away from a straight line, due to the force couple between pilot bit and reamer, as described above.

Finally, the Williams patent discloses a diamond drill bit of conventional design which has been modified to combine the drilling and under-reaming functions by relieving a circumferential portion of the vertical surface of the drill extending over an arc of more than 180°. This reduces the maximum cross-sectional dimension of the drill and at the same time creates in effect an offset reaming section from the portion of the vertical surface of the drill that remains.

The Williams bit tends to rotate about its original center because of the piloting action of its conically concave face against the bottom of the hole. Because this conical face is a cutting face, however, its piloting action is counteracted to some extent by the unbalanced radial and tangential reaction forces acting on the reamer portion, in the manner described above, with a similar effect on the roundness and straightness of the under-drilled hole.

To summarize, therefore, the prior art offset under-drilling devices described above all have a tendency to drill holes that are out-of-round and off-direction because they depend on attached or integral pilot hole drilling bits to absorb the unbalanced radial and tangential forces acting on the assymmetric reaming section.

SUMMARY OF THE INVENTION

The stabilized well under-drilling apparatus of the present invention overcomes the disadvantages of the prior art under-reaming bits by axially separating the drill bit and offset reamer by a substantial distance and positioning at least one stabilizing means or guide member between the bit and the reamer. The guide member has an effective diameter of substantially the same size as the hole drilled by the pilot bit so that it snugly fits into the hole. An important feature of the stabilizing means is that it has no cutting elements on its outside diameter, although it may have flush-mounted inserts of tungsten carbide or similar wear-resistant material to prevent erosion of the bearing surfaces.

The guide member has two functions. First, it stabilizes the pilot drill so that it drills the hole without deviating from a straight line. Secondly, it provides a substantial bearing surface against the wall of the pilot hole to assure that the offset reamer rotates concentrically with the axis of the pilot hole. In this way, the final under-reamed portion of the well hole will be round and coaxial with the previously drilled and cased portion and will continue in a straight line from the end of the casing.

It is recognized that stabilizing devices for controlling drill bit direction are well known, but their use for the functions of the present invention has never been suggested despite the long development history of under-

drilling devices and their attendant drawbacks. A pertinent example is a convertible drilling tool disclosed in U.S. Pat. No. 2,034,075, issued on Mar. 17, 1936 to J. C. Wright. The Wright tool comprises a shank having a drill bit attached at its lower end for making a pilot bore and a stabilizing member mounted on the shank above the bit for guiding the bit during drilling of the pilot hole. The stabilizing member is removable from the shank so that it may be replaced by a bore enlarging cutter, which is then guided by the drill bit, not the stabilizer, to enlarge the predrilled pilot hole.

Specifically then, the apparatus of the present invention comprises a stabilized offset reamer for enlarging a pilot hole of predetermined diameter, the reamer having an elongated cylindrical body, a reaming section extending outward from a portion of the circumference of the upper part of the body subtending an angle of less than 180° , and a first stabilizing section below the reaming section, the stabilizing section having a smooth, non-cutting, bearing surface defined by a cylinder concentric with the axis of the reamer body and having a diameter approximately equal to the diameter of the pilot hole.

Although the stabilized reamer of the present invention can be used alone to ream or under-ream a bore hole after predrilling the pilot hole, the preferred embodiment further comprises a drill bit attached to the lower end of the ream body and having a cutting head, spaced from the lower end of the stabilizing section for simultaneously drilling the pilot hole as the reamer enlarges it.

An alternate embodiment of the invention further comprises a second stabilizing section also having smooth, noncutting, bearing surfaces defined by a cylinder concentric with and of approximately the same diameter as the first cylinder, the upper end of the second stabilizing section being spaced from the lower end of the first stabilizing section. The second stabilizing section can be integral with the reamer body, or it can be a separate unit attachable to the lower end of the reamer body and having provision for attachment of a pilot bit at its lower end.

Accordingly, it is the object of this invention to provide a simple and sturdy device for under-reaming a bore hole so that the under-reamed portion is substantially round and coaxial with a previously drilled hole.

A further object of this invention is to provide means for guiding an offset reamer so that the reaming element rotates concentrically with the center line of a pilot hole.

A still further object of the invention is to provide a stabilized under-drilling device for simultaneously drilling a directionally guided pilot hole and concentrically under-reaming the pilot hole to a substantially round cross section of predetermined final diameter.

These and other objects, advantages, and features of the invention will become more apparent from the following description in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevation view in cross section of a preferred embodiment of the stabilized drilling and under-reaming apparatus of the present invention in operative position in a bore hole.

FIG. 2 is a cross section of the reaming section of the apparatus of FIG. 1.

4-3 is a cross section of the stabilizing section of the apparatus of FIG. 1.

FIG. 4 is an elevation view in cross section of an alternate embodiment of the invention having two stabilizing sections between the drill bit and the reamer.

FIG. 5 is a cross section of the reaming section of the apparatus of FIG. 4.

FIG. 6 is a cross section of the lower stabilizing section of FIG. 4.

FIG. 7 is an elevation view in cross section of another alternate embodiment of the invention.

FIG. 8 is a cross section of the reaming section of the apparatus of FIG. 7.

FIG. 9 is a cross section of the upper stabilizing section of the apparatus of FIG. 7.

FIG. 10 is a cross section of the lower stabilizing section of the apparatus of FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1-3, a rotary drill and reaming assembly 20 is shown in position for drilling and under-reaming a well hole 10. Assembly 20 includes a pilot bit 21 having a cutting head including a conical concave cutting face 22, a convex crown portion 23 and cylindrical gauging sides 24 at the forward end of the drill bit. Drill 21 is preferably a conventional type of diamond drill bit.

The upper end of drill bit 21 has an externally threaded portion 25 which screws into a mating internally threaded portion 26 at the lower end of a stabilized reaming means 27. The upper end 28 of reaming means 27 is also externally threaded to screw into a mating internally threaded end 29 of a conventional drill pipe. Reaming means 27 has a cylindrical tubular body which includes a lower stabilizing section 30 and an upper reaming section 31. Reaming section 31 comprises an integral, radially offset portion having a lower face 32 tapering outward from the upper end of stabilizing section 30 to join an upper cylindrical face 33 that is concentric with the drill pipe axis but has a radius greater than the radii of the pilot drill 21 and of the stabilizing section 30. The offset reamer surfaces 32-33 extend over an arcuate distance substantially less than 180° , as shown in FIG. 2; this permits the reamer to pass through a smaller hole (indicated by brokenline circle 34) than the finished size of the under-reamed hole (shown by full-line circle 35). Since the diameter of circle 34 is a function of the circumferential extent of (or angle subtended by) upper reaming face 33 as well as of the difference between the radius of face 33 and the radius of the pilot bit, it is desirable to make this circumferential extent as small as possible, consistent with permissible loading pressures on the cutting elements, such as diamonds 36, embedded in reaming faces 32 and 33.

In order to lubricate and cool the drill and reamer and to flush away the rock cuttings, drilling fluid is pumped down an inner passageway 37 through center of the drill pipe and connecting passages 38 and 39 through the reamer and drill bodies, respectively, to the face of the drill. The fluid then flows through circumferentially spaced waterways 40 in the face and sides of the drill head, through the annular region between the side of the pilot hole and the bodies of the drill bit and

reaming means, through circumferentially spaced grooves 41 in the reaming surfaces 32 and 33, and finally upward between the wall of the reamed hole and the outside of the drill pipe for discharge at the surface.

Referring to FIG. 3, stabilizing section 30 comprises a number of circumferentially spaced lands 42, together with a downward extension 43 of reaming surface 32. The outer surfaces of lands 42 and extension 43 are defined by a cylinder concentric with the axis of the pilot drill and the reamer body and having a diameter approximately equal to that of the pilot hole (indicated by full-line circle 44) but with sufficient clearance to permit rotation in the hole without binding.

Since the diameter of the reamer body (as shown by dashed-line circle 45) is considerably smaller than the pilot hole diameter, the spaces between lands 42 provide additional passageways 46 for the upward flow of drilling fluid and entrained cuttings.

As mentioned above, the stabilizing section 30 fits snugly within the pilot hole drilled by bit 21 but is capable of free rotation. Although the lands are shown having flushmounted inserts of hardened material 47, these inserts are not necessary if the material of the lands is sufficiently hard and wear-resistant. The important feature is that stabilizer 30 does not perform any drilling or reaming function but is purely a piloting bearing surface. This bearing surface, smoothly lubricated by the upward flow of the drilling fluid through grooves 41 and passageways 46 between its lands, is thus able to withstand severe unbalanced radial forces and moments acting on the offset reaming section 31 without cutting into the wall of the pilot hole. In this way, the stabilizing section insures that the reamed hole will be round and concentric with the pilot hole. At the same time, the section stabilizes pilot drill 21 to prevent any tendency to wander off the axis of the previously bored hole, either because of side forces from the reamer or uneven hardness of the material being drilled.

The embodiment of FIGS. 1-3 has only a single stabilizing means positioned adjacent to the lower end of the reamer. For even better results, it is preferred to add a second stabilizer between the first stabilizer and the pilot drill bit. Two embodiments of such an arrangement are shown in FIGS. 1-6 and 7-10, respectively. Elements of these embodiments which are substantially the same as corresponding elements in the first embodiment are identified by the same reference numerals.

Referring to FIGS. 4-6, the under-drilling assembly includes a pilot drill 21, which may be identical to the drill in the first embodiment and a stabilized under-reaming member 50. Member 50 has an upper offset reaming section 31 and a first stabilizing section 30, adjacent to the lower end of the reaming section, that are similar to the construction in FIG. 1. Below first stabilizing section 30 is a second stabilizing means 51 which is integral with member 50. As in the first embodiment, the drill bit is threadedly connected to the stabilizing and reaming member, and that member, in turn, is threadedly connected to the lower end of a drill pipe 29.

The offset radius of the reaming section in this second embodiment is comparatively larger in relation to the radius of the pilot hole than is the case in the apparatus of the first embodiment. The relation between these radii is a matter of design choice within the limits imposed by the forces on the drill and on the reamer.

Obviously, the smaller the drill diameter, the greater will be the permissible offset radius of the reamer that will still allow the assembly to pass through a given size of well casing and, consequently, provide the largest possible diameter of the under-reamed hole. The pilot drill should not be so small, however, that an undesirably large share of the drilling forces will be carried by the relatively small surface area of the reamer. Within this design limitation, the advantage of having two stabilizer sections is that a larger ratio of reamer radius to drill radius is possible without deflecting the drill or causing the reamer to rotate non-concentrically.

Lower stabilizing means 51 is similar in design to the first stabilizing means, comprising three concentrically spaced lands 52 having inserts of hardened material 53 flush-mounted with the outer surfaces 54 of the lands. Surfaces 54 define a cylinder having substantially the same diameter as the surfaces of the upper stabilizer. Passageways 55 between the lands permit unobstructed flow of the drilling fluid.

Although surfaces 54 are smooth and non-cutting, cutting elements 55 are shown imbedded in the inwardly tapered lower end of stabilizing section 51. These cutting elements merely clean the pilot hole of minor rough areas that would otherwise tend to rapidly wear the bearing surfaces 54.

In the second embodiment, the reamer and upper stabilizing sections are integral with the member carrying the lower stabilizing section. This design can result in a bulky and heavy unit which is both difficult to manufacture and to handle in the field. Furthermore, excessive wear of any one portion, such as the reaming section, requires that the whole unit be sent back to the factory for reworking.

To avoid this problem, the embodiment of FIGS. 8 and 10 shows an assembly in which the pilot bit, the reaming and upper stabilizing sections, and the lower stabilizing means are in three separate units, threaded together. As in the previous embodiments, the drill bit can be a conventional diamond drill 21. Second stabilizing means 51 is similar in construction to the lower stabilizer of FIG. 4 except that it has five lands as shown in FIG. 10 instead of the three lands of the lower stabilizer shown in FIG. 6. The number of lands is merely a matter of design, however, depending on the desired ratio of bearing surface to drilling fluid channel area.

The design of upper stabilizing section 30 differs somewhat, however, from that of the other two embodiments by eliminating the bearing surface portion 43 in the region underlying the offset reaming section 31, as shown in FIG. 9. This provides increased clearance for the flow of lubricating and cooling drilling fluid to the cutting face of the reamer. At the same time the three broad lands 42 opposite the reamer provide adequate bearing surfaces to withstand the unbalanced side loads caused by the reactive radial and tangential forces acting on the reamer.

Although the above embodiments illustrate some variations and modifications possible within the framework of the invention, it will be apparent that other variations may be made without departing from its spirit and scope.

What is claimed is:

1. A rotary under-reaming device for enlarging a pilot hole of predetermined radius drilled in the earth, the device comprising:

an elongated cylindrical body having a radius no greater than the predetermined radius of the pilot hole and a threaded upper end for attachment to a drill pipe;

an asymmetrical reaming section extending outwardly from the upper part of the body about only an arcuate portion of the circumference thereof to a radius greater than the radius of the pilot hole, the arcuate portion subtending an angle of less than 180° and the remainder of said circumference having a non-reaming face, and

a first non-reaming stabilizing section located on the body below the reaming section, the stabilizing section having a smooth, non-cutting, bearing surface defined by a first cylinder concentric with the longitudinal axis of the cylindrical body and having a radius approximately equal to the predetermined radius of the pilot hole but having sufficient clearance to rotate in the pilot hole without binding, whereby the reaming section is caused to rotate concentrically with the axis of the pilot hole.

2. The under-reaming device of claim 1 further comprising:

a drill bit attached to the lower end of the reamer body and having a cutting head axially spaced from the lower end of the first stabilizing section for simultaneously drilling the pilot hole as the reaming section enlarges it.

3. The under-reaming device of claim 1 further comprising:

a second non-reaming stabilizing section located below and axially spaced from the first stabilizing section, the second stabilizing section having smooth, non-cutting bearing surfaces defined by a second cylinder coaxial with and having the same diameter as the first cylinder.

4. The under-reaming device of claim 3 further comprising:

a drill bit located below the second stabilizing section and having a cutting head axially spaced from the lower end of the second stabilizing section for drilling the bottom of the pilot hole as the reaming section enlarges its sides.

5. The under-reaming device of claim 3 wherein:

the first stabilizing section comprises a plurality of axially extending first lands circumferentially spaced about the cylindrical body in the region complementary to the circumferential region subtended by the reaming section, the outer surfaces of the first lands comprising wear-resistant, non-cutting, bearing surfaces defined by the first cylinder; and

the second stabilizing section comprises a plurality of axially extending second lands symmetrically spaced about the cylindrical body, the outer surfaces of the second lands comprising wear-resistant, non-cutting, bearing surfaces defined by the second cylinder, whereby the bearing surfaces of the first and second lands cooperate to subtend

a major portion of the circumference of the pilot hole.

6. The under-reaming device of claim 5 further comprising a central passageway through the cylindrical body for conducting drilling fluid under pressure downward through the bottom of the body and then upward through the spaces between the lands of the second and first stabilizing sections, and wherein the reaming surface contains circumferentially spaced grooves to permit a portion of the fluid flowing upward from the first stabilizing section to lubricate and cool the reaming surface.

7. The under-reaming device of claim 1 wherein the reaming section comprises a cutting surface defined by a circumferential portion of a cylinder concentric with the axis of the reamer body and having a radius larger than the predetermined radius of the pilot hole.

8. The under-reaming device of claim 7 wherein the first stabilizing section comprises a plurality of axially extending lands circumferentially spaced about the cylindrical body in the region complementary to the circumferential region subtended by the reaming section.

9. A rotary under-reaming device for increasing the radius of a pilot hole of predetermined radius drilled in the earth, the device comprising:

an elongated cylindrical body having a threaded upper end adapted for attachment to a drill stem and a threaded lower end adapted for attachment to a stabilizing element and

an asymmetrical reaming section extending outwardly from a first arcuate circumferential portion of the cylindrical body, the reaming section subtending an angle of less than 180° and the remaining circumference of the cylindrical body having a non-reaming surface, the reaming section including

a lower cutting surface extending outwardly from the first portion of the circumference of the cylindrical body to a radius greater than the radius of the pilot hole and

an upper surface defined by a portion of a cylinder having a radius substantially equal to the maximum radius of the cutting surface, the lower cutting and upper reaming surfaces having rows of embedded cutting elements separated by upwardly directed passages for drilling fluid to cool and lubricate the cutting elements.

10. The under-reaming device of claim 9 wherein a second circumferential portion of the reamer body above the lowest extent of the reamer cutting surface in the region not subtended by the reaming section has a radius approximately equal to the radius of the pilot hole.

11. The under-drilling device of claim 10 wherein the second circumferential portion comprises the outer surfaces of a plurality of spaced lands separated by upwardly directed passageways for drilling fluid.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,851,719 Dated December 3, 1974

Inventor(s) Charles T. Thompson and Bobby J. Thompson

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 7, line 45, change "FIGS. 1-6" to --FIGS. 4-6--.

Column 7, line 52, change "reaming" to --reaming--.

Column 10, line 42, change "uper surface" to --upper
reaming surface--.

Signed and sealed this 11th day of February 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks