METHOD OF AND BIT FOR CUTTING A HOLE LARGER THAN THE BIT

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This invention pertains to the rotary system of drilling wells and it is embodied in a rotary bit for use therein. This application is in part a continuation of applicant's copending application Serial No. 54,875.

The ordinary rotary equipment employs a drill pipe having a bit attached to the end thereof, which drill pipe extends into the well being bored and is rotated by means of a rotary machine located on the floor of a derrick at the surface of the ground. The upper end of the drill pipe is provided with a swivel head to which is connected a traveling block by means of which the drill pipe is supported and fed into the well as the drilling operation proceeds. A flexible hose is connected to the swivel head and to the stand pipe of a high pressure pump, by means of which mud water under high pressure is pumped downwardly through the drill pipe into the lower end of the well at the bit for the purpose of removing the cuttings from the bit, for supporting the walls of the well column and for the purpose of mixing the cuttings thoroughly with the mud water so that they will float therewith to the surface of the ground.

It is an important object of this invention to provide a rotary bit which bores the well by reciprocating motion of the cutter and removes the bottom of the well by an impacting or percussion action.

The bit of my invention has a cup-shaped cutter which fits on a pin extending from the bottom of the body. This pin extends into a cavity of the cutter which must be rotatable therein in order that the cutter will function properly. It is imperative that no cuttings or other foreign matter enter between the bearing surfaces of the pin and cutter, since they are liable to clog therein and retard or prevent the rotation of the cutter relatively to the body of the bit.

It is a salient object of this invention to provide a bit of the character just described in which the bearings of the pin and cutter are kept free of cuttings or other foreign matter by means of a strong flow of fluid between the bearing surfaces at all times when the bit is in the well.

It is common practice to drill an oil well in sections which are each of smaller diameter than the section directly above it. For example, the first section of the well may be drilled to fifteen inches and a well casing set therein. This casing is set in the well for the purpose of supporting the walls thereof during further drilling operations. The next section of the well is drilled with the largest size of bit which will pass through the casing which has already been set. The next section of the well is then drilled to a size which is substantially the same diameter as the internal diameter of the set casing. With the ordinary drill the second section of the well will be of proper size at the upper end thereof, but as drilling proceeds the bit wears and the hole will gradually taper. It is necessary for this reason to elevate the bit and to lower a reamer into the well which will ream the second section of the well to the proper size throughout its entire length, which is of course the internal diameter of the set section of casing. A second casing is thereafter set in the second section of the well and a third section of the well is drilled with a bit which is extended through and will cut a hole the same size as the internal diameter of the second section of casing, it being necessary to ream the third section of the well in the same manner as in the case of the second section of the well.

It is a very important object of this invention to provide a rotary bit which will cut a hole of larger diameter than the maximum diameter of the cutter thereof, and will cut a hole of larger diameter than the internal diameter of the casing through which the bit is passed. The bit of my invention will, therefore, cut a hole which is larger than the casing through which it is extended. Therefore, as the bit wears the hole will not be smaller than the internal diameter of the casing through which it was extended, and there will be no necessity of reaming.

Other objects and the marked advantages of this invention will be explained hereinafter.

Referring to the drawings in which my invention is illustrated,

Fig. 1 is a diagrammatic view illustrating the utility of my invention.
Fig. 2 is an elevational view partly sectioned of a rotary bit incorporating the features of my invention.

Fig. 3 is a view of the lower part of Fig. 2, taken as indicated by the arrow 3 of Fig. 2.

Fig. 4 is a cross section taken on the line 4—4 of Fig. 2.

Fig. 5 is a bottom plan view of the body of the bit shown in the drawings with the cutter removed therefrom.

Fig. 6 is a diagrammatic view illustrating the motion of the drill pipe during the operation of the bit.

Fig. 7 is an elevational diagrammatic view illustrating the reciprocating action of the cutter of the bit.

Figs. 8 to 12 inclusive, are very diagrammatic views illustrating the gyrating reciprocating motion of the bit.

Referring to Fig. 1, 20 represents a rotary bit embodying the features of this invention which is secured to the lower end of a drill column or drill pipe 21. The drill pipe 21 extends upwardly through a well casing 22 and passes through a rotary table 23 of a rotary machine situated on the floor 24 of a derrick. The drill pipe 21 is rotated by the rotary table 23. A swivel head 25 is attached to the upper end of the drill pipe 21, and connected to the swivel head 25 is a traveling block 26 by means of which the drill pipe 21 is supported and fed downwardly into the well as the bit 20 digs away the bottom thereof. Connected between the swivel head 25 and a stand pipe 28 of a high pressure pump 29 is a flexible hose 30. The high pressure pump 29 draws rotary fluid from a sump 31 through an intake pipe 32 and forces it under high pressure through the drill pipe 21 and the bit 20 into the lower end of the well.

Referring to Figs. 2 to 5 inclusive, the bit 20 of this invention has a body 34 which is formed concentric of an axis A—A which is the axis of the drill pipe 21. The upper end of the body 34 has a threaded pin 35 by means of which the bit 20 is secured to a tool joint 36 which is provided at the lower end of the drill pipe 21. The lower end of the body 34 has an eccentric formation 37 from which an inclined pin 38 extends. The inclined pin 38 is formed concentric of an axis C—C as illustrated in Figs. 2 and 7. The inclined pin 38 is formed in two parts, an upper part 39 which is preferably formed integral with the eccentric formation 37 and a lower part 40 in the form of a bearing member 40. The bearing member 40 has a threaded projection 41 which screws into a threaded recess 42 of the upper part 39. The bearing member 40 provides an annular thrust bearing face 44 which surrounds the upper end of a cylindrical projection 45 and a radial bearing face 46 which is provided by the cylindrical projection 45.

This cylindrical projection 45 is formed at the extreme lower end of the bearing member 40. The body 34 is provided with a mud water passage 48, the lower end of which connects to the top of the threaded cavity 43. The bearing member 40 has a mud water opening 49 formed concentric throughout which connects to the passage 48 in the body 34 and to the exterior of the bit through the lower end of the bearing member 40. The opening 49 is constricted at 50 and flared at 51 at the extreme lower end thereof. A branch opening 53 connects between the upper part of the opening 49 and the inner part of the thrust bearing face 44. The thrust bearing face 44 is provided with an annular channel 54 which is formed at the innermost part of the thrust bearing face 44 in communication with the branch opening 53. A channel 56 is formed in the thrust bearing face 44 connecting to the branch opening 58 and extends upwardly along an upper side face of the bearing member 40, as illustrated best in Fig. 2.

The pin 38 is adapted to rotatably carry a cutter 59. The cutter 59 includes a cup-shaped portion 60 having a cavity 61 into which the pin 38 extends. In the cavity 61 the cup-shaped portion 60 is provided with a thrust journal face 63 which is adapted to engage the thrust bearing face 44 of the bearing member 40. The cup-shaped portion 60 also provides a cylindrical radial journal face 64 which is adapted to engage the radial bearing face 46 of the cylindrical projection 45. The thrust bearing face 44 is arranged to take the thrust of the cutter 59 and the radial bearing face 46 is arranged to centralize the lower end of the cutter 59.

The upper end of the cutter 59 is centralized by an upper radial bearing which is illustrated clearly in Fig. 2. The upper part 39 of the pin 38 is provided with an external annular semi-cylindrical bearing race 66 and the upper part of the cup portion 60 is provided with an internal semi-annular bearing race 67 which is wider than the bearing race 66. Adapted to operate in the races 66 and 67 are ball bearings 69. At the upper part of the right side of the portion 39 of the pin 38 is formed a recess 70, the lower end of which connects to the race 66. This recess 70 is filled by a lock plug 71 which is secured in place by a machine screw 72. Formed in the upper part of the cup portion 60 of the cutter 59 is a channel 73 which connects between the race 67 and the upper part of the portion 60. When the lock plug 71 is removed from the recess 72 and the channel 73 is aligned therewith, a passage is provided whereby the ball bearings 69 may be inserted into and removed from between the races 66 and 67. The ball bearings, just described, in addition to serving as a centralizing means for the upper end of the cutter 59, serve as a means for locking the cutter onto the pin 38.
From an inspection of Fig. 2 it will be apparent that the cutter 59 cannot be removed while the ball bearings 89 are between the races 66 and 67.

Extending from the lower end of the cup portion 60 is a plurality of pilot blades 80 which are of radial extension and are four in number. The peculiar construction of these blades is very important to the invention. Outer faces 81 at the lower ends of the pilot blades 80 are formed concentric to a point indicated at D in Figs. 2, 6 and 7. This point D is on an axis B—B which is the center line of the hole which the bit 20 will dig. The point D also is situated at the intersection of the axes B—B and C—C. It is extremely important to the invention that the point D, which is the center on which the faces 81 of the pilot blades 80 are formed, be eccentric to the axis A—A of the body of the bit and of the drill pipe 21. Another important part of the construction of the pilot blades 80 is that the lower ends 88 thereof are somewhat lower than the point D.

Formed on the cup portion 60 above the pilot blades 80 is a row of lower reaming blades 84 having spaces 85 therebetween and a row of upper reaming blades 86 having spaces 87 therebetween. The blades 86 are offset from the blades 84 and they are in alignment with the spaces 85 between the blades 84, whereas the blades 84 are in alignment with the spaces 87 between the blades 86. Communicating with the interior of the cup portion 60 and the exterior thereof in the spaces 85 are lower ducts 88, and communicating with the interior of the cup portion 60 and the exterior thereof in the spaces 87 are upper ducts 89.

The operation of my bit is extremely difficult to describe because the cutter 59 has a three dimensional movement which is radically peculiar and there is no terminology which fittingly explains its motion.

In the first place, the bottom of the well 22 is formed by the cutters so as to have a concentric pilot bore 95 which is somewhat smaller than the gauge of the well. This pilot bore is in a general way concave but has three pronounced depressions indicated in Figs. 8 to 12 inclusive by the letters a, y and z which surround a central core 96 (Figs. 2 and 7). The pilot bore 95 (Fig. 7) is dug by the pilot blades 80. It is generally acknowledged that a cutter tends to cut along the line of least resistance and consequently the smallest possible hole. This holds true for the pilot blades 80 which cut the pilot bore 95 the smallest possible diameter.

The smallest size of bore which the pilot blades 80 will make is one whose radius is the same as the radii of the faces 81 of the pilot blades 80. The center of the semi-spherical bore 95 is therefore at D which is the center of the curved outer faces 81 of the pilot blades 80. In fact, as shown in Fig. 6, when the bit 20 operates, the entire motion thereof centralizes around the point D which is the only point in the entire bit which is stationary. The point D is, as stated before, at the intersection of the axes B—B and C—C so it will be at once obvious that the bit does not rotate on its own axis A—A which is also the axis of the drill pipe 21, but rotates on the axis B—B which is drawn vertically through the point D.

The body of the bit gyrates around the axis B—B, and a point E of the body which is at the intersection of the axes A—A and C—C moves through an orbit 97 (Fig. 6) which orbit is concentric to the axis B—B.

The motion of the body 34 of the bit is easy to understand, since it is purely a gyrating movement.

The motion of the cutter 59 is somewhat difficult to explain and to understand, since it is a combination of a gyrating and reciprocating motion and hammering action. The reciprocating motion of the cutter is illustrated in Fig. 7. As the body 34 rotates, the cutter successively reciprocates from the position shown in full lines in this figure into the position shown by dotted lines 99. Each blade therefore reciprocates between a raised position and a lower position, as illustrated by the full and dotted lines of Fig. 7. In Fig. 7 the reciprocating motion is illustrated as being wholly in the plane of the drawing, but this is not the case since the cutter 59 gyrates as it reciprocates so that each blade as it moves up and down also moves in a plane at right angles to the plane of the drawing.

The gyrating motion of the cutter as it reciprocates is illustrated in Figs. 8 to 12 inclusive. The gyrating motion of the cutter may be best understood by following the action of the points 83 of the pilot blades 80 which are four in number and are indicated by the small circles a, b, c and d respectively in Figs. 8 to 12 inclusive. The large circles f and g respectively, represent the core 96 and the outline of the semi-spherical pilot bore 95. The dots a, y and z, as mentioned before, represent the bottoms of the depressions formed in the pilot bore 95 by the points 83 of the pilot blades 80. Referring now to Fig. 8 the blades 80 are shown in the positions they occupy in Figs. 1 and 7 of the drawings. The blade a, which is on the right, is in its lowest position in the bottom of the depression a. The blades b and c are in positions half way between lowered and raised positions, and the blade c is in raised position which is its highest position. The point H, indicated in Figs. 7 to 12 inclusive, is a point on the body 34 which is at all times adjacent to the lowest blade of the cutter. The body of the bit rotates in a direction indicated by arrows 98 of Figs. 7 to 12 inclusive. As the
body rotates from the position shown in Fig. 8 into the position shown in Fig. 9, the point H moves one-third of a revolution as indicated by the line 89 of Fig. 9. The blade $b$, which is in mid-position moves into lower position into the depression $y$. It should be noted that the point of the blade $b$ moves inwardly, downwardly and forwardly when it moves from the position shown in Fig. 8 into the position shown in Fig. 9. The point $c$ moves from raised position into mid-position, starting on its downward stroke, and the point $d$ rises from mid-position into raised position, finishing its upward stroke.

The point $a$ moves from lower position into mid-position and starts on its upward stroke. When the point $H$ moves two-thirds of a revolution, as indicated by the line 100 in Fig. 10, the point $c$ is moved from mid-position into lower position and into the depression $x$. The point $d$ moves from raised position into mid-position, starting on the first half of its down stroke. The point $a$ moves from mid-position into raised position and finishes the last half of its up stroke. The point $b$ moves from lowered position into mid-position and completes the first half of its up stroke.

When the point $H$ has completed one revolution, as indicated by the line 102 of Fig. 11, the point $d$ moves from mid-position into lowered position and into the depression $x$. The point $a$ moves from raised position into mid-position. The point $b$ moves from mid-position into raised position. The point $c$ moves from lowered position into mid-position, as shown in Fig. 11. When the point $H$ has revolved a revolution and a third, as indicated by the line 103, the point $a$ is moved from mid-position into lowered position and completes one entire reciprocation which consists of an up stroke and a down stroke. The point $b$ moves from raised position into mid-position. The point $c$ moves from mid-position into raised position and the point $d$ moves from lowered position into mid-position.

From the foregoing description of the operation of the cutter, it will be seen that when the point of each blade $a, b, c$ or $d$ has moved through one complete reciprocation, the point $H$ has moved through one and one-third revolutions and the points $a, b, c$ and $d$ have moved one-third of a revolution, that is to say, the blade $a$ when the body $34$ has revolved one and one-third revolutions moves one-third of a revolution from the depression $x$ to the depression $y$.

Although the theoretical paths of the points of the different blades $a, b, c$ and $d$ of the cutter 59 are impossible to accurately delineate on a plane surface, it is believed that the actual action of the cutter itself may be understood from the foregoing explanation. I prefer to use four blades 80 although three, five, six, or even more, could be used but with a considerably lessened efficiency. With four blades, as illustrated, the bit digs a semi-spherical pilot bore 95 having the three pronounced depressions $x, y$ and $z$ in the bottom thereof. These depressions are well defined and the cutter 59 acts as if it were geared to the bottom of the pilot bore, each blade 80 passing downwardly into each depression in succession and acting as a sort of gear tooth to swing the cutter into position for the engagement of a successive blade. While this gearing relation between the pilot blades 80 and the depressions $x, y$ and $z$ is maintained during the drilling in all formations, it is thought that in going through the harder formations, the point 83 of each of the blades 80 does not make quite one-third of a revolution about the core $f$ for one and one-third revolutions of the drill body 34. Thus the radial location of one of the depressions $x, y$ and $z$ would be moved slightly in a counterclockwise direction with each descent of a blade 80 to its lowermost position. This constant counterclockwise shifting of the points of impact of the points 83 of the blades 80 will cause the blades 80 to continually shave away the formation which would otherwise tend to remain in the pilot bore $g$ between the positions of the depressions $x, y$ and $z$ as shown in Figs. 8 to 12 inclusive. Thus these depressions $x, y$ and $z$ never become deep enough below the rest of the surface of the formation within the pilot bore $g$ to place too great strains upon the blades 80 as they are tilted in approaching and leaving their lowermost positions.

In the form of the bit shown, the point D is well above the point 83 of the lowest blade 80, as shown in Figs. 2 and 7, which point 83 moves substantially towards and away from the axis $B-B$ in a plane to which the axis $C-C$ is perpendicular. The blades 80, therefore, not only serve as gear teeth to determine their own motion and that of the bit, but they act as digging members to break away the bottom of the hole. In so doing they work toward and away from the central core 96. Resistance or counter pressure for the blade during the cutting at any time is provided by the engagement of the outer face 81 of the opposite blade. Since the point D falls well above the cutting blades 80, all points on the outside of the cutter and particularly the blades 80 have a positive swinging or chopping action and no point on the exterior of the bit remains stationary. The action of the bit is, therefore, purely a digging action. Each blade, as it is forced down, digs away chunks of material from the walls of the pilot bore.

Each blade in turn is called upon to support the entire weight exerted by the drill pipe which is a hammering force on the bottom of the well, this weight being in turn rapidly shifted from one blade in one de-
pression to an adjacent blade in a different depression. This rapid shifting of pressure tends to break the rock along its cleavage lines. The elasticity of the drill pipe which may be several thousand feet in length also assist the action of my bit. As each blade of my bit approaches its lowermost position, the load upon it increases as does the torque necessary to drive it. The drill pipe hanging free in the hole, the block 26 is stretched due to the drill pipe's weight and as a portion of this weight is exerted on the descending prong, the blade 80 moves slightly upwardly. At the same time the increased torque twists the drill pipe slightly and puts it into torsion. As the blade passes its lower position and the torsion and weight are relieved, the elasticity of the pipe causes the next engaging blade to be chipped downwardly. This downward hammering forms an ideal motion for breaking loose and large pieces are chipped away with little wear on the blades. The blades in this particular, work by a digging and wedging action, not by abrasion.

The main reason that the bit 20 cuts a hole larger than the maximum diameter of the cutter is that the pilot blades 80 are formed so that the whole bit rotates about the point D which is eccentric to the axis A-A of the bit. The pilot bore 95 is a positive guide for the bit, and the pilot blades and pilot bore work as a ball and socket joint. The action of the reaming blades 84 and 86 is purely a reaming action and serves to trim the well to proper size. The reaming blades 84 and 86 swing on the point D, as indicated by broken lines 105 and 106 respectively of Fig. 7. The reaming blades are able to cut the well to gauge because a counter pressure is provided by the back face 81 of an opposite pilot blade 80.

During the operation of the bit mud water is forced under high pressure, as previously described, through the drill pipe 20 by means of the high pressure pump 26. This mud water is forced through the passage 72 and through the opening 49 of the pin 38. A portion of this mud water passes entirely through the opening 49 and into the semi-spherical pilot bore 95 where it is mixed with the cuttings due to the peculiar gyrating and reciprocating motion of the blades 80 and will efficiently remove them from the pilot bore so that the blades 80 will cut effectively. The lower end of the opening 49 is flared, as indicated at 61, so that any cuttings which may be jammed therein while the bit is being lowered or at other times may be readily forced therefrom by the pressure of the mud water there against from the inner end of the opening 49. By flaring the opening at 51, relief is given and the cuttings or other foreign matter are readily forced therefrom. A portion of the mud water is forced through the branch opening 53, traveling into the channels 54 and 56. The mud water passing into the channel 54 flows downwardly around the cylindrical projection 45 between the radial bearing and journal faces 46 and 64, keeping them well lubricated at all times, and since the mud water is under high pressure prevents an entrance of any cuttings or foreign matter therebetween. The mud water passing through the channel 56 flows upwardly around the pin 38 and through the radial bearing at the upper end thereof, thoroughly lubricating this bearing and keeping it free from cuttings or other foreign matter. The lubricating fluid passes from the cavities 61 by means of the upper end of the cup portion 60. This outflowing stream through the bearings of the cutter and pin is extremely important to the invention. This mud water is under extremely high pressure which is greater than the exterior pressure in the bottom of the well. For this reason, none of the cuttings or any foreign matter in the well can enter between the bearing surfaces, and there will therefore be no clogging of the bearings which would prevent the cutter 59 from rotating on the pin 38. Some of the mud water passes through the ducts 88 and 89, washing the spaces between the reaming blades.

From the foregoing description it will be seen that the bit of my invention contains but few parts, all of which are very rugged in construction and may therefore withstand the severe strains which are placed thereupon in drilling. The parts are of simple design and may be manufactured at a lower cost and are easy to assemble and dismantle. Because of the peculiar gyrating and reciprocating motion of the cutter, the liability of my bit to ball up is negligible. Reconsideration of the motion will show that the teeth move inwardly and then recede or move away from the cuttings. This permits the flushing fluid which is introduced directly into the pilot bore to thoroughly mix with the cuttings.

A very important feature of this invention is the manner in which the cutter 59 digs the hole. It is clearly explained in the foregoing description that the cutter does not form the well by means of an abrasive action, but by means of an impacting or percussion action which is very much quicker than the abrasive action as in the ordinary bit and there is but little wear on the blades.

The extremely important feature of the invention is the fact that the bit will cut a hole which is of larger diameter than the maximum diameter of the cutter 59. This feature of the invention is extremely important since it eliminates reaming which is necessary with the ordinary form of rotary drill bit. From the foregoing description it will be seen that the bit of my invention cuts a hole which is larger than the casing through
which it is extended. As the cutter of the bit wears, the section of the wall being cut thereby will gradually taper off. This tapering, however, will not require reaming unless the hole tapers down to a size of less diameter than the casing through which the bit was passed. I have found in practice that the bit of my invention will very easily cut a hole which is 10 per cent larger than the smallest size of casing through which it can be passed. There is, therefore, little danger of the cutter ordinarily wearing down to a size so that it will cut a hole smaller than the internal diameter of the casing through which it was extended.

In order to distinguish the blades 80 of my bit from the small abrasive cutting edges provided on former gyrating bits, I may prefer to describe these blades as related to the cutter hub in the same manner as legs of a table are related to the top thereof. In case such an illustration is used, it is to be understood that the legs of such a table extend downward from the top thereof practically vertically. I do not wish to limit myself, however, in using this expression to a bit in which the blades thereof extend exactly vertically downward from the cutter hub, as the requirements of design may dictate that these blades be inclined somewhat from parallelism with the axis of the cutter.

In the drawings the reaming teeth consist of two rows, the teeth of each row being offset with respect to the other row. It may be desirable in some instances to place the teeth of the two rows in alignment or to eliminate entirely one row of teeth. Obviously, these minor changes of design are within the scope of my invention as defined in the following claims.

I claim as my invention:

1. A rotary bit comprising: a body formed concentric of a body axis; an inclined pin extending downwardly from said body axis; and a cutter carried rotatably on said pin, said cutter having a plurality of pilot blades adapted to form a pilot bore eccentric of said body axis, said pilot blades having outer curved faces generated around a point located on the rotating axis of the cutter.

2. A rotary bit comprising: a body formed concentric of a body axis; an inclined pin extending downwardly from said body axis; and a cutter carried rotatably on said pin, said cutter having a plurality of pilot blades adapted to form a pilot bore eccentric of said body axis, said pilot blades having outer curved faces generated around a point located on the rotating axis of the cutter.

3. A rotary bit comprising: a body formed concentric of a body axis; an inclined pin extending downwardly from said body axis; and a cutter carried rotatably on said pin, said cutter having a plurality of pilot blades adapted to form a pilot bore eccentric of said body axis, said pilot blades having outer curved faces generated around a point located on the rotating axis of the cutter.

4. A rotary bit comprising: a body formed concentric of a body axis; an inclined pin extending downwardly from said body axis; and a cutter carried by said pin, said cutter having a cup-shaped portion surrounding said pin and journaling thereon, there being channels formed between said pin and said cup-shaped portion for permitting a flow of fluid between said pin and said cup-shaped portion to exclude foreign matter, and having pilot blades extending from said cup-shaped portion adapted to form a pilot bore eccentric of said body axis, said bit turning on a rotating axis concentric with said pilot bore and eccentric of said body axis, said pilot blades having outer curved faces generated around a point located on the rotating axis of the bit.

5. A rotary bit comprising: a body formed concentric of a body axis; an inclined pin extending downwardly from said body axis; and a cutter carried by said pin, said cutter having a cup-shaped portion surrounding said pin and journaling thereon, there being channels formed between said pin and said cup-shaped portion for permitting a flow of fluid between said pin and said cup-shaped portion to exclude foreign matter, and having pilot blades extending from said cup-shaped portion adapted to form a pilot bore eccentric of said body axis, said bit turning on a rotating axis concentric with said pilot bore and eccentric of said body axis, said pilot blades having outer curved faces generated around a point located on the rotating axis of the bit.

6. A rotary bit comprising: a body formed concentric of a body axis; an inclined pin extending downwardly from said body axis; and a cutter carried by said pin, said cutter having a cup-shaped portion surrounding said pin and journaling thereon, there being channels formed between said pin and said cup-shaped portion for permitting a flow of fluid between said pin and said cup-shaped portion to exclude foreign matter, and having pilot blades extending from said cup-shaped portion adapted to form a pilot bore eccentric of said body axis, said bit turning on a rotating axis concentric with said pilot bore and eccentric of said body axis, said pilot blades having outer curved faces generated around a point located on the rotating axis of the bit, and said cutter having reaming blades for cutting said pilot bore to the size of the well.

7. In a bit suited for use in drilling a well, the combination of: a body adapted to be rotated in said well about a given axis; a hub provided on said body and rotatable about an
axis which is inclined relative to said body axis; pilot blades extending downwardly from said hub in a similar manner as the legs of a table extend from the top thereof; and means on said hub above said blades and having substantially a rolling engagement with the wall of said well causing said blades to form a concave pilot bore when said body rotates.

8. In a bit suited for use in drilling a well, the combination of: a body adapted to be rotated in said well about a given axis; a hub provided on said body and rotatable about an axis which is inclined relative to said body axis; pilot blades extending downwardly from said hub in a similar manner as the legs of a table extend from the top thereof; and reaming teeth formed on said hub above said blades and having substantially a rolling engagement about the axis of said hub with the wall of said well causing said blades to form a concave pilot bore when said body rotates, the lower extremities of said blades moving from positions near the edge of said pilot bore to positions near the center thereof.

9. In a bit suited for use in drilling a well, the combination of: a body adapted to be rotated in said well about a given axis; a hub provided on said body and rotatable about an axis which is inclined relative to said body axis; and pilot blades extending downwardly from said hub in a similar manner as the legs of a table extend from the top thereof, said blades having arcuate outer edges near their lower ends which form a concave pilot bore when said body rotates.

10. In a bit suited for use in drilling a well, the combination of: a body adapted to be rotated in said well about a given axis; a hub provided on said body and rotatable about an axis which is inclined relative to said body axis; and pilot blades extending downwardly from said hub in a similar manner as the legs of a table extend from the top thereof, said blades forming a semi-spherical pilot bore when said body rotates, the concave surface of said bore being generated substantially about a center point near the intersection of said axes of rotation.

11. In a bit suited for use in drilling a well, the combination of: a body adapted to be rotated in said well about a given axis; a hub provided on said body and rotatable about an axis which is inclined relative to said body axis; and pilot blades extending downwardly from said hub in a similar manner as the legs of a table extend from the top thereof, said blades having arcuate outer edges, the curves of which are generated substantially by a uniform radius about a center point near the intersection of said axes of rotation, said blades forming a concave pilot bore when said body rotates.

12. In a bit suited for use in drilling a well, the combination of: a body adapted to be rotated in said well about a given axis; a hub provided on said body and rotatable about an axis which is inclined relative to said body axis; and pilot blades extending downwardly from said hub in a similar manner as the legs of a table extend from the top thereof, said blades having arcuate outer edges, the curves of which are generated substantially by a uniform radius about a center point near the intersection of said axes of rotation, said blades forming a concave pilot bore when said body rotates, the lower extremities of said blades moving from positions near the edge of said pilot bore to positions near the center thereof.

13. In a bit suited for use in drilling a well, the combination of: a body adapted to be rotated in said well about a given axis; a hub provided on said body and rotatable about an axis which is inclined relative to said body axis; radial pilot wings, relatively few in number, extending downwardly from said hub and engaging the bottom of said well in a manner to form a concave pilot bore when said body rotates; and reaming cutters provided on said hub above said wings, said cutters being alternately staggered relative to each other.

14. In a bit suited for use in drilling a well, the combination of: a body adapted to be rotated in said well about a given axis; a hub provided on said body and rotatable about an axis which is inclined relative to said body axis; radial pilot wings, relatively few in number, extending downwardly from said hub and engaging the bottom of said well in a manner to form a concave pilot bore when said body rotates; and reaming cutters provided on said hub above said wings, said cutters being alternately staggered relative to each other and adapted to have a downward cutting action.

15. In a bit suited for use in well drilling, the combination of: a body adapted to be rotated about a given axis in a well; a cutter hub carried by said body and rotatable on an axis inclined to the axis of rotation of said body; and a plurality of cutting elements provided on said hub which terminate at their lower ends in relatively sharpened surfaces and which are disposed about a central recess and extend a sufficient distance downward, in the direction of said hub axis, from the position of nearest approach of said axes of rotation so that when said body is rotated, said cutting elements dig on paths extending downwardly and inwardly beneath said bit on the bottom surface of said well, each of said cutting elements having a curved outer edge which causes said digging paths to be substantially uniformly curved, said picks being relatively few in number and of considerable length as compared with their thickness in a direction parallel to the axis of rotation of the hub so that each pick practically supports the weight.
imposed on said bit when said pick is in downwardmost position and while the adjacent picks are rising or descending.

16. In a bit suited for use in well drilling, 
that combination of: a body adapted to be rotated about a given axis in a well; a cutter hub carried by said body and rotatable on an axis inclined to the axis of rotation of said body; and a plurality of cutting elements provided on said hub which terminate at their lower ends in relatively sharpened surfaces and which are disposed about a central space and extend a sufficient distance downward, in the direction of said hub axis, from the position of nearest approach of said axes of rotation so that when said body is rotated, said cutting elements dig on paths extending downwardly and inwardly beneath said bit on the bottom surface of said well, each of said cutting elements having a curved outer edge which causes said digging paths to be substantially uniformly curved and which has a shaving action on the bottom of said well due to the motion of said hub on said body.

17. In a bit suited for use in drilling a well, the combination of: a body adapted to be rotated in said well about a given axis; a pin provided on said body, the axis of said pin being inclined relative to the axis of rotation of said body; a cutter hub having a cavity adapted to receive said pin so that said hub may rotate thereon, a space being formed between said pin and said hub, there being passage means in said body and said pin for supplying fluid to said space; and cutters provided on said hub, there being discharge passages formed in said hub to open exteriorly between said cutters and inwardly into said space.

18. A combination as in claim 17 in which said cutters are formed on a peripheral portion of said hub.

19. A combination as in claim 17 in which said discharge passages are substantially radial.

20. A well drilling bit of the character described including: a body adapted for axial rotation within a well; cutter bearing means defining a cutter axis non-parallel relative to the axis of said well; and a cutter rotating on said bearing means and said cutter axis; said cutter consisting of an upper portion having ability to cut freely in a lateral direction and lower secondary cutting elements having outer curved surfaces characterized by the ability to cut with greater facility in a downward than in a lateral direction and to resist lateral cutting under the influence of side thrust due to cutting reaction of the upper portion, and being adapted to cut a central pilot bore of less diameter than the hole to be drilled.

21. A well drilling bit of the character described, including: a body adapted for axial rotation within a well; cutter bearing means defining a cutter axis nonparallel relative to the axis of the well; and a cutter rotating on said cutter axis, said cutter having upper primary cutting elements having ability to cut freely in a lateral direction and lower secondary cutting elements having outer curved surfaces characterized by the ability to cut with greater facility in a downward than in a lateral direction and to resist lateral cutting under the influence of side thrust due to cutting reaction of the upper portion, and being adapted to cut a central pilot bore of less diameter than the hole to be drilled.

In testimony whereof, I have hereunto set my hand at Los Angeles, California, this 15th day of March, 1926.

JOHN A. ZUBLIN.
CERTIFICATE OF CORRECTION.

Patent No. 1,758,773. Granted May 13, 1930, to

JOHN A. ZUBLIN.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 7, line 45, claim 10, for "semi-spherical" read "concave"; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 24th day of June, A. D. 1930.

M. J. Moore,
Acting Commissioner of Patents.