May 13, 1930. J. A. ZUBLIN 1,758,814

ROTARY BIT HAVING RECIPROCATING MOTION

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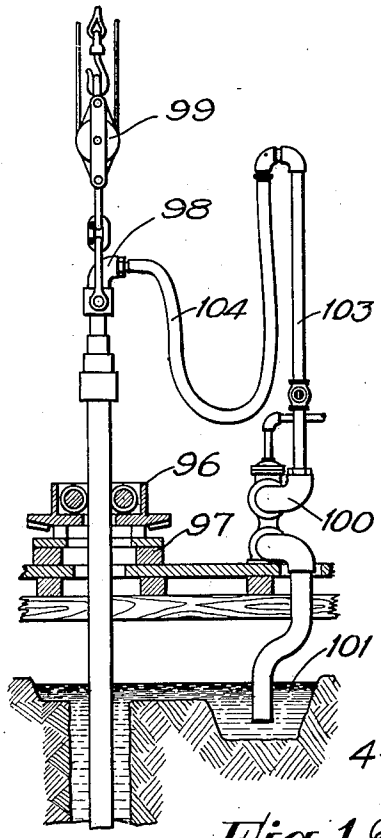


Fig. 1.

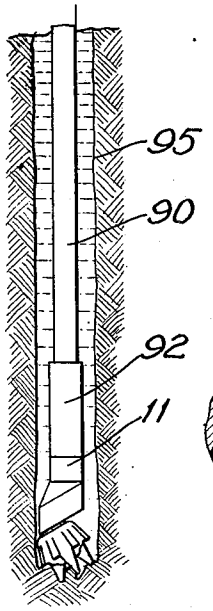
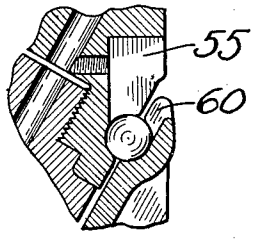


Fig. 7.



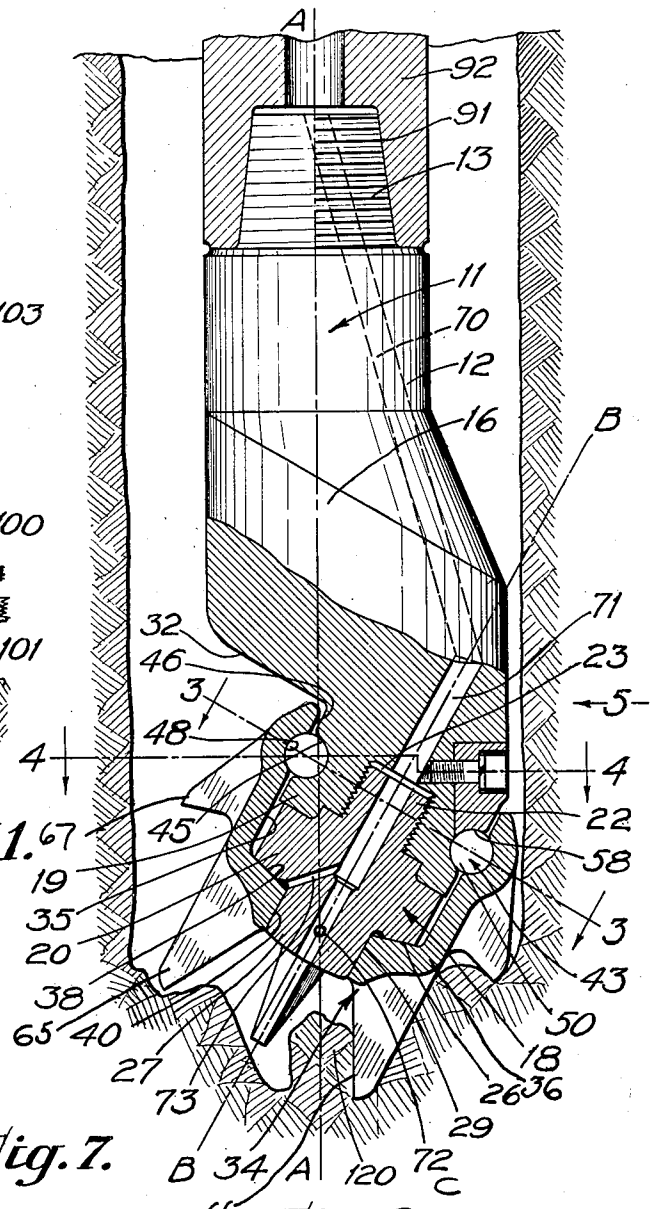


Fig. 2.

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ROTARY BIT HAVING RECIPROCATING MOTION

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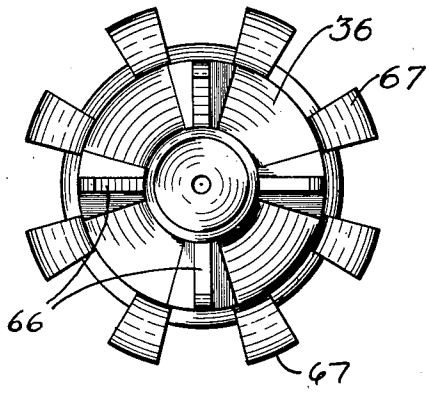


Fig. 6.

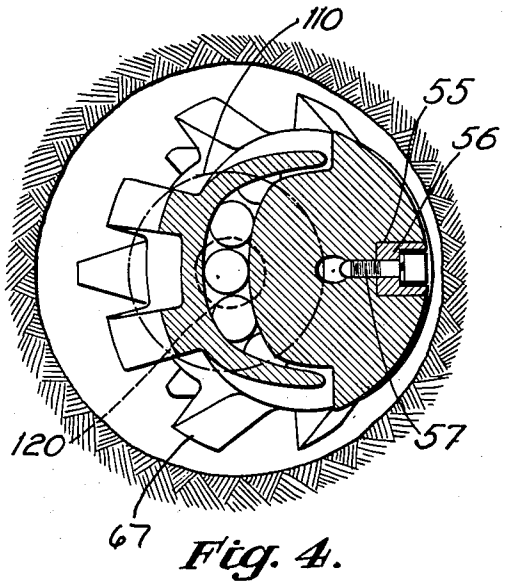


Fig. 4.

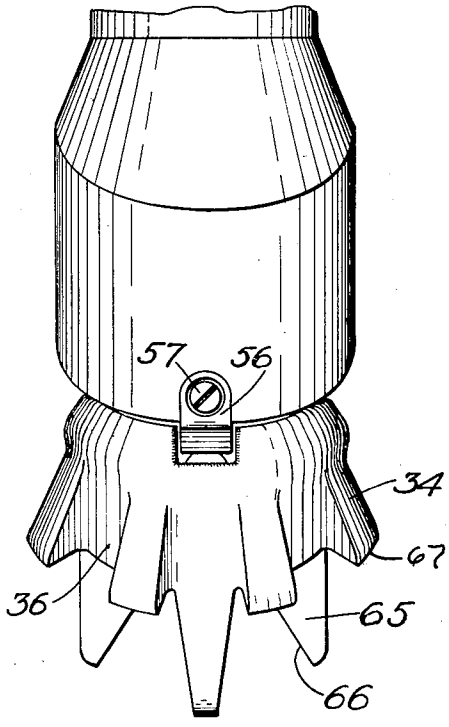


Fig. 5.

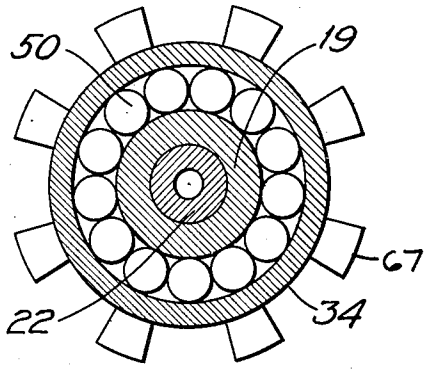


Fig. 3.

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ROTARY BIT HAVING RECIPROCATING MOTION

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Fig. 8.

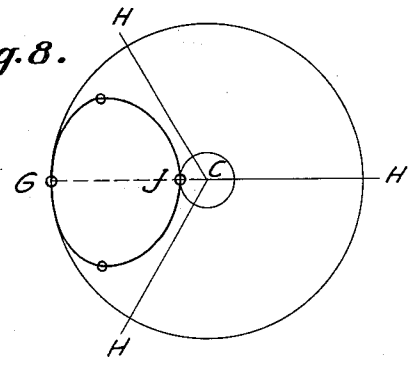


Fig. 9.

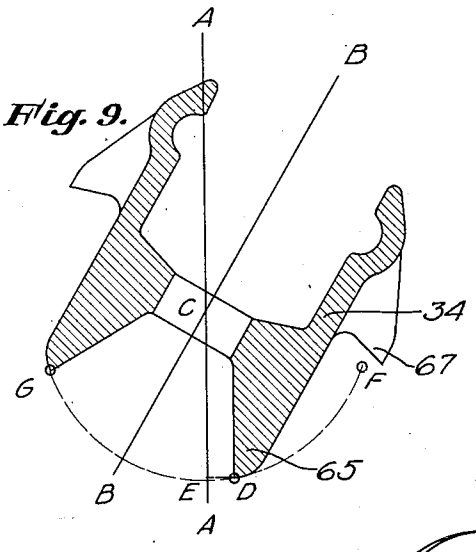
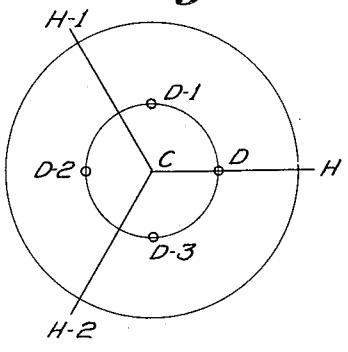


Fig. 10.



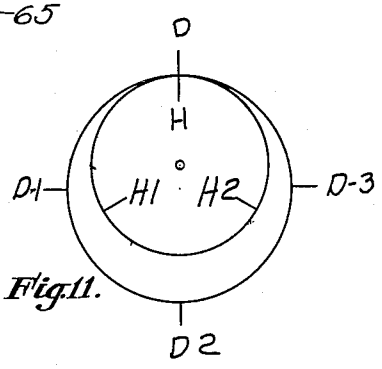


Fig.11.

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Patented May 13, 1930 1,758,814

UNITED STATES PATENT OFFICE

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ROTARY BIT HAVING RECIPROCATING MOTION

Application filed September 8, 1925. Serial No. 54,874.

My invention relates to rotary bits which are used for drilling wells in the rotary system of drilling.

According to the usual practice in this system, a bit is secured to the lower end of a drill pipe. This drill pipe extends through the rotary table of the rotary machine installed at the surface of the ground in the derrick of the well. A swivel head is attached to the end of the drill pipe extending above the rotary table and a traveling block is hooked thereto for supporting the drill pipe. A flexible hose extends from a stand pipe of a high pressure pump to the swivel head, for supplying rotary mud to the rotary bit through the drill pipe. The rotary table rotates the drill pipe and the bit is revolved therewith. The bit, being in engagement with the bottom of the well, deepens the well. The rotary mud is supplied to the bit, carrying the cuttings to the top of the well and floating the drill pipe from engagement with the wall of the well so that friction is reduced to a minimum.

From close observation of the actions of the types of rotary bits in common use in the oil fields, I have found that many of the difficulties encountered in drilling are a direct result of the theory on which these bits operate. Although there are many different designs of rotary bits, their operations are practically of the same theory. The cutters of all of these ordinary rotary bits operate on the bottom of a bore more or less in a horizontal plane and substantially at right angles to the axis of rotation of these bits. The action of these cutters is of a grinding or attritional character and removes the material from the bottom of the bore in a ground or powdered state.

It is an object of this invention to provide a rotary bit which, in boring a well, breaks large pieces of material from the bottom of the bore rather than grinding off small particles.

It is an object of my invention to provide a rotary bit which will cut rapidly.

It is also an object of this invention to provide a rotary bit which has a cutter that digs or chops the cuttings from the bottom of the bore.

It is another object of my invention to provide a rotary bit having a rotatable cutter having ample bearings, both thrust and radial, for the cutter.

It is a further object of my invention to produce a rotary bit having a rotatable cutter, in which the cutter bearings will not be liable to clogging by the cuttings entering thereinto.

It is another object of my invention to provide a novel means for rotatably securing the cutter to the body of the bit.

It is a still further object of my invention to provide a securing means for the cutter, which is so designed that the parts thereof are not exposed to wear and therefore no parts will be lost from the bit during its operation.

It is a still further object of my invention to produce a bit having few parts. This is desirable as the bit will be low in manufacturing cost, easy to assemble and dismantle and the parts, being few, may be made rugged so that they may endure severe strains and much wear.

Rotary bits of the standard pattern also have marked disadvantages in very soft, gummy formations. It is found that as the bit rotates, the scraping action tends to build a mass of the formation directly in front of the cutting edges thereof. As the cutting continues, these masses become quite large and do not mix readily with the rotary mud and are, therefore, not properly carried away from the cutting edges. These large masses offer enormous resistance to the rotation of the bit and seriously interfere with the action thereof. It is believed that many of the

twistoffs, that is, a twisting off in the drill pipe, result from the enormous resistance placed against the rotation of the bit by these masses of cuttings. Twistoffs of this character are very expensive. In most cases it necessitates a fishing job which consumes considerable time and labor, and sometimes means an entire loss of the well in event that the portion of the drill pipe twisted off becomes stuck or lodged in such a manner that it cannot be freed and removed from the hole. The ordinary form of fishtail bit exerts considerable pressure against the walls of the well. This is due to the scraping manner of cutting, and also due to the building up or "balling up" of the formation in front of the cutting edges. This side pressure very often results in cave-ins which are sometimes disastrous.

It is also an object of my invention to provide a rotary bit having a cutter which will not "ball up."

It is an object of this invention to provide a bit of the character mentioned having a replaceable bearing element.

It is another object of my invention to provide a rotary bit which will readily and thoroughly mix the cuttings with the rotary mud water so that they will be easily carried to the top of the well.

It is also an object of my invention to provide a rotary bit having a cutter which operates around a central core and utilizes the core to counteract the cutting force of the cutter.

It is a still further object of my invention to provide a rotary bit which will cut a hole of larger diameter than the largest diameter of its cutter.

Other objects and advantages of my invention will be made evident hereinafter.

Referring to the three sheets of drawings which are for the purpose of illustration,

Fig. 1 is a diagrammatic view illustrating the utility of my invention.

Fig. 2 is an elevational view of the bit of my invention.

Fig. 3 is a section taken on the line 3—3 of Fig. 2.

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

Fig. 5 is an elevational view of the lower end of my bit taken at right angles to Fig. 2 and substantially as indicated by arrow 5 of Fig. 2.

Fig. 6 is a bottom plan view of a cutter employed in the bit of my invention.

Fig. 7 is a fragmentary sectioned detail showing an entrance for placing the balls in an upper radial bearing of my invention.

Fig. 8 is a diagram on a horizontal plane.

Fig. 9 is a diagram on a vertical plane.

Fig. 10 is a diagram showing the successive movements of the prongs.

Fig. 11 is a diagrammatic gear train showing the manner in which the prongs engage the ground.

With particular reference to Figs. 2 to 7 inclusive, of the drawings, the bit 11 embodying the features of my invention has a body 12 from the upper end of which a threaded pin 13 extends by means of which the bit is attached to a string of drill pipe. The body 12 rotates on an axis A—A as shown in Fig. 2. An eccentric formation 16 is formed at the lower end of the body 12 and from this eccentric formation there extends a depending inclined pin 18. The pin 18 is made in two parts, an upper part 19 and a lower part in the form of a separate bearing element 20. The bearing element 20 has a threaded projection 22 which extends into a threaded cavity 23 of the upper part 19 of the inclined pin 18. The bearing element 20 has a lower beveled thrust bearing face 26 which surrounds the upper end of a central projection 27 of the bearing member 18. This projection 27 has a cylindrical radial-bearing face 29. The inclined pin 18 is disposed on an axis B—B, as shown in Fig. 2, which is at an angle with the axis of rotation A—A of the body 12. The axes A—A and B—B intersect at a point C inside the inclined pin 18. A lower face 32 of the body 12 is formed on a plane at right angles to the axis B—B of the inclined pin 18.

Carried by the inclined pin 18 is a rotatable cutter 34. The pin 18 extends into a cavity 35 provided by a cup-shaped portion 36 of the cutter 34. The thrust-bearing face 26 of the bearing element 20 engages a complementary thrust-journal face 38 of the cup portion 36 and the central projection 27 extends through an opening formed in the bottom of the cup portion 36, the radial-bearing face 29 thereof contacting a cylindrical-radial journal face 40 which surrounds the opening in the bottom of the cup portion 36.

At the upper end of the inclined pin 18 and near the upper part of the cup-shaped portion 36 there is provided a radial ball bearing 43 of my invention. On the upper part 19 of the inclined pin 18 an annular race 45 of semi-circular cross section is provided and on an internal cylindrical wall 46 of the cavity 35 an annular race 48 which is also semi-circular in cross section is provided. Operating in these races 45 and 48 are balls 50. This radial bearing 43 takes all of the side strains exerted by the cutter 34 against the upper part of the inclined pin 18 during the operation of the bit.

As shown in Figs. 2, 4 and 7, above the radial bearing 43 a recess 55 is formed in the body 12 near the upper end of the pin 18. This recess 55 receives a plug 56 which is secured in place by a suitable screw 57. The lower end of the plug 56 is arcuated at 58 and serves as a portion of the inner race 45 when in place. Extending from the race 48 to the

upper end of the cup portion 36 of the cutter 34 is a channel 60. The balls 50 may be removed from place through the channel 60 and the recess 55 when the plug is not in place. In Fig. 7 I show the plug 56 removed from place, leaving an entrance sufficient for the passage of the balls 50 therethrough. Not only does the radial bearing 43 serve as a bearing, but also retains the cutter 34 in place. As is obvious from the various views of the drawings it is impossible to remove the cutter from place when the balls 50 are in place in the races 45 and 48.

The cutter 34 is provided with prongs 65 which extend downwardly from the cup portion 36 and which have cutting faces 66. Extending outwardly from the cup portion 36 above the blades 65 are cutting wings 67. In the drawings I have shown the cutter 34 with four prongs 65. However, any number may be provided to suit conditions.

Lubricating fluid is supplied to the cutter 34 through a passage 70 which extends through the body 12. The lower end of the passage 70 connects with a passage 71 which extends through the upper part 19 of the inclined pin 18. This passage 71 is in communication with a central opening 72 which extends through the bearing member 20. A branch opening 73 connects between a central part of the opening 72 of the bearing element 20 and the thrust-bearing face 26. Lubricating fluid passing through this branch opening 73 serves to lubricate the thrust-bearing and thrust-journal faces 26 and 38, the radial-bearing and radial-journal faces 29 and 40 and also the upper radial ball bearing 43. The lubricating fluid being under high pressure is forced outwardly between the various bearing faces and the radial ball bearings 43 thoroughly lubricating same. The lubricating fluid which may be ordinary rotary mud passing through the lower end of the opening 70 supplies lubrication for the prongs 65 and the cutter wings 67 of the rotatable cutter 34.

With reference to Figs. 1 and 2, the bit 11 just described is secured to the lower end of a string of drill pipe 90, the upper threaded pin 13 being threadably secured in a socket 91 of a tool joint 92 secured at the lower end of the drill pipe 90. This drill pipe 90 extends upward through a well 95 and through a rotary table 96 of a rotary machine 97. Attached to the upper end of the drill pipe 90 is a swivel head 98 to which is connected a traveling block 99 for supporting the drill pipe 90. Lubricating fluid is supplied to the bit 11 by a high pressure pump 100 which receives its supply of lubricating fluid from a sump 101 and which pumps it into a drill pipe 90 through a stand pipe 103 and a flexible hose 104 which connects between the pump 100 and the swivel head 98. The lubricating fluid, as mentioned before, serves to lubricate the bearings of the bit and to wash the blades of the cutter 34, and it further serves to float the drill pipe away from the sides of the well 95, thus reducing friction.

The method of operation of my bit is most difficult to represent on plane surfaces since all portions of the cutter 34 have a continuous three dimensional movement over curved paths. Referring to the diagram, Fig. 9 A—A is the main axis of the bit itself and B—B is the cutter axis, that is, the axis about which the cutter is free to rotate with regard to the body of the bit. The bit body may be considered as rotating with a uniform motion about the axis A—A for purpose of analysis. Since the bit body is attached to a long string of pipe which is elastic and since the resistance to motion of the bit may not be uniform resulting in a variable torque, the actual motion of the bit about the axis A—A is not uniform, the bit slowing up due to twisting of the pipe under strain as the resistance increases and accelerating due to the elasticity of the pipe as the strain is released. So also while theoretically the point C is stationary in the axis A—A in practice it moves up and down as will hereafter be explained.

Assuming for the purpose of preliminary analysis that the point C is stationary and that the bit body is rotating at a uniform motion about the axis A—A it is evident that every point except C in the B axis is rotating in a circle in a plane at right angles to the axis A—A and about that axis as a center.

The cutter of the bit is free to turn about the axis B—B but it is not constrained to do so at any definite rate or according to any definite plan. The cutter being in contact with the walls and bottom of the hole its motion is determined by the resultant of the friction between the cutter and these walls. At any instant there is what may be called a frictional center at which point the cutter is stationary and in contact with the hole. This frictional center shifts constantly however and in actual service no point in the whole structure except the point C is stationary. For example, consider the point D at the end of one of the digging prongs. Obviously, if A—A is a rigid axis as the bit turns from the position shown in Fig. 9, that is as the B—B axis revolves out of the plane of the paper the point D must shift. If the cutter were locked to the body the point D would rotate at a radius E—D about the axis A—A. If on the other hand the point D were constrained to move in the plane of the paper (which it could do) it is evident that it would oscillate up and down over the path D—F.

Considering the point D as moving in the plane of the paper we find every other point in the cutter moving over a curved path

which it would be of little value to define. The point G of the diametrically opposite prong would then move in a path which may be represented by the oval path G—J in Fig. 8. This path cannot, of course, be shown in a plane as it is a non-circular path in a curved surface.

In practice, however, the point D cannot be, and is not, constrained to move in the plane of the paper, although in the position shown in Fig. 9 it may be nearly stationary and may tend to start along the line D—F or along a curved line on a spherical surface having its center at C and defined by the line D—F.

As soon, however, as the point D has moved a short distance from its position, as shown in Fig. 9, it ceases to control the motion of the cutter since an adjacent prong moves down as the prong containing the point D moves up and this adjacent prong first compromises with D as to control and then seizes control entirely throwing prong D out of engagement with the wall of the well and into the air where it can move freely under the successive control of the other three prongs until it is in turn thrown down to assume control.

Although the theoretical paths of the different points on the cutter 34 are impossible of accurate delineation on a plane surface the actual action of the cutter itself is not difficult to understood. I prefer to use four prongs 65 although three, five, six or even more may be used with a considerably lessened efficiency. With four prongs the bit digs three cavities in the bottom of the hole, these cavities having their centers on the radial lines C—H of Fig. 8. These bottom cavities are well defined and the cutter 34 acts as if it were geared to the bottom of the hole, each prong 65 passing downwardly into each cavity in succession and acting as a sort of gear tooth to swing the cutter into position for the engagement of a successive tooth. If the prongs are designated as shown in Fig. 10 as D, D^1, D^2 and D^3 and the center lines of the cavities are designated as H, H^1, and H^2, the prong D moves from H into H^1 and then into H^2. At the instant the prong D is in H the prong D^1 is swinging down into H^1, the prong D^2 is in its extreme upper position swinging over from H^1 to H^2 and the prong D^3 is swinging upwardly out of H^2 on its way to H.

Considering the controlling factors the sequence of operation is as follows: D being in H and therefore in control is swung out, D^1 then passing into H^1, D^2 passing into H^2, D^3 into H, D^1 into H^1, etc. The result is that each cutter acts in succession and progresses around the cavities exactly like a four tooth external gear working on a three tooth internal pinion, as shown in Fig. 11.

In the form of bit shown the point C is well above the point D which at its lowest position, as shown in Fig. 9, moves substantially towards and away from the axis A—A along a plane to which said axis is nearly perpendicular. The prongs 65 therefore not only serve as gear teeth to determine their own motion and that of the bit, but they act as digging members breaking away the bottom of the hole. In so doing they work towards and against a central stub or core of rock which is left at the bottom of the hole about the axis A—A and which serves to guide and direct the bit.

Since the point C falls well above the cutting prongs 65 and due in part to the guiding action of these prongs all points on the outside of the cutter and particularly the teeth 67 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 a purely digging action. Each prong as it is forced down digs away hunks of material from the walls of the cavities. Each prong in turn is called upon to support the entire weight which is exerted by the drill pipe on the bottom of the hole, this weight being in turn rapidly shifted from one prong in one cavity to an adjacent prong in an adjacent cavity. 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 assists the action of my bit. As each prong of my bit approaches the position D the load upon it increases as does the torque necessary to drive it. The drill pipe hanging free in the hole from the sheave 99 is stretched due to its weight and as a portion of this weight is exerted on the descending prong the point C moves upwardly. At the same time the increased torque twists the pipe slightly and puts it into torsion; as the prong passes its lower position and the torsion and weight are relieved, the elasticity of the pipe causes the next engaging prong to be chopped downwardly. This downward chop forms an ideal motion for breaking rock and large pieces are chipped away with little wear on the prong. The prongs act in this particular much like a pick in the hands of a skilled worker cutting by a digging and wedging action and not by abrasion. The members 67 cut in much the same way moving in nearly vertical paths to enlarge the hole already made by the prongs 66.

The success of my invention depends in a considerable degree upon the proportions shown in the drawings. It is desirable to use four or five prongs which should preferably have a length of about one quarter the diameter of the well, this allowing the prongs to swing freely in and out of the resulting cavities. It is also essential that the point C be

well above the base of the prongs for the same reason.

It is to be noted that the prongs 66 have substantially the same relation to the cutter hub or cup portion 36 that the legs of an ordinary table bear to the top thereof. It therefore may be desired to refer to the prongs 66 in certain claims as "legs" extending downward from the hub of the rotating cutter.

I claim as my invention:

1. A bit for use in drilling wells comprising: a body adapted to be rotated about a vertical axis; a cutter mounted to turn freely on said body about an inclined axis; and prongs formed on the bottom of said cutter projecting downwardly therefrom a sufficient distance so that the lower ends of said prongs swing inwardly from a point near the circumference of the well to a point near its center as the bit is rotated, said prongs having a length equal to about one quarter the diameter of the hole to be produced.

2. A bit for use in drilling wells comprising: a body adapted to be rotated about a vertical axis; an eccentric formation projecting downwardly about an axis inclined to said vertical axis; a cutter journaled on said eccentric formation; and prongs formed on the bottom of said cutter projecting downwardly therefrom a sufficient distance so that the lower ends of said prongs swing inwardly from a point near the circumference of the well to a point near its center as the bit is rotated, said prongs having a length equal to about one-quarter the diameter of the hole to be produced.

3. 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, a gyrating motion being imparted to said hub when said body rotates; and a plurality of prongs projecting downwardly from said hub and relatively sharpened at their lower ends, said prongs being relatively few in number and of considerable length compared to their thickness, so that each prong practically supports the weight imposed on said bit when said prong is in downwardmost position and while adjacent prongs are rising or descending due to said gyrating motion of said hub.

4. 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 hub carried by said body and rotatable on an axis inclined to the axis of rotation of said body, a gyrating motion being imparted to said hub when said body rotates; and a relatively small number of legs depending from said hub, in a similar relation thereto as the legs of a table bear to the top thereof, each of said legs being moved by the gyrating motion of said hub between an upward and outward position close to the wall of the well, and a downward and inward position close to the center of the well, there being a series of definite positions disposed about the center of the bottom of said well, from one to another of which positions said legs progress in a regular order.

5. 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 hub carried by said body and rotatable on an axis inclined to the axis of rotation of said body, a gyrating motion being imparted to said hub when said body rotates; and a relatively small number of legs depending from said hub, in a similar relation thereto as the legs of a table bear to the top thereof, said legs forming a series of definite depressions in the bottom of said well, as said hub gyrates, each of said legs extending into one of said depressions upon each revolution of said body.

6. 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 hub carried by said body and rotatable on an axis inclined to the axis of rotation of said body, a gyrating motion being imparted to said hub when said body rotates; and a relatively small number of legs depending from said hub, in a similar relation thereto as the legs of a table bear to the top thereof, said legs forming a series of definite depressions in the bottom of said well, as said hub gyrates, each of said legs extending into one of said depressions upon revolution of said body, said depressions being one less in number than said legs.

7. 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 hub carried by said body and rotatable on an axis inclined to the axis of rotation of said body, a gyrating motion being imparted to said hub when said body rotates; a relatively small number of legs depending from said hub, in a similar relation thereto as the legs of a table bear to the top thereof, said legs forming a series of definite depressions in the bottom of said well, as said hub gyrates, each of said legs extending into one of said depressions upon each revolution of said body; and cutters formed on said hub to cut away material between said depressions and the wall of said well.

8. In a bit suited for use in well drilling, the combination of: a body adapted to be rotated in a well; a cutter rotatably mounted on said body and adapted to receive a gyrating motion when said body is rotated; and cutting teeth provided on said cutter which form a series of definite depressions in a surface of said well, from one to another of which depressions said teeth progress in a regular order as said cutter gyrates.

9. In a bit suited for use in well drilling, the combination of: a body adapted to be rotated in a well; a cutter rotatably mounted

on said body and adapted to receive a gyrating motion when said body is rotated; and cutting teeth provided on said cutter which form a series of definite, non-annular depressions in a surface of said well, from one to another of which depressions said teeth progress in a regular order as said cutter gyrates.

10. In a bit suited for use in well drilling, the combination of: a body adapted to be rotated in a well; a cutter rotatably mounted on said body and adapted to receive a gyrating motion when said body is rotated; and cutting teeth provided on said cutter which form a series of definite depressions in a surface of said well, from one to another of which depressions said teeth progress in a regular order as said cutter gyrates, said depressions being one less in number than said teeth.

11. In a bit suited for use in well drilling, the combination of: a body adapted to be rotated in a well; a hub rotatably mounted on said body and adapted to receive a gyrating motion when said body is rotated; and legs extending downward from said hub, said legs being relatively sharpened at their lower ends and moving up and down with the gyration of said hub so as to successively come into contact with the bottom of the well, so that when drilling in hard formation, the bit substantially rides upon each leg while this is disposed downward in contact with the bottom of the well, said legs being sufficiently few in number that said bit body is raised a considerable distance while riding upon each leg so that the next following leg is brought down into contact with the bottom of the well with an accelerated movement.

12. In a bit suited for use in well drilling, the combination of: a body adapted to be rotated in a well; a hub rotatably mounted on said body and adapted to receive a gyrating motion when said body is rotated; and legs extending downward from said hub, said legs being relatively sharpened at their lower ends and moving up and down with the gyration of said hub so as to successively come into contact with the bottom of the well, said legs being sufficiently few in number so that said bit tends to assume a position of rest in which an adjacent pair of said legs rests upon the bottom of said well, rotation of said body in a given direction thus being caused to vary in rate, said rotation accelerating as each leg moves downward into contact with said well bottom.

13. A rotary bit comprising: a body; an inclined pin extending from said body, said inclined pin having a thrust-bearing face and a radial-bearing face, said radial-bearing face being situated below said thrust-bearing face; a cutter having a cup-shaped portion into which said inclined pin extends, said cup-shaped portion having a thrust-journal face and a radial-journal face which respectively engage said thrust-bearing face and said radial-bearing face; and means for locking said cutter on said inclined pin, but permitting said cutter to rotate on said inclined pin, said radial-bearing face being formed on a cylindrical projection on said inclined pin, which projection extends through an opening formed in the lower part of said cup-shaped portion.

14. A rotary bit comprising: a body adapted to be rotated in a well; said body being formed at its lower end with a stud, which is disposed at an angle relative to the body, a cutter mounted to turn freely on said stud; and boring legs extending downward from said cutter, said boring legs being of greater length than their thickness and being circumferentially spaced from each other a distance at least equal to the thickness of each boring leg, said boring legs being spaced to form a central recess, and arranged so as to have a single boring leg in the same radial plane on one side of the axis of said cutter.

15. A rotary bit comprising: a body adapted to be rotated in a well; said body being formed at its lower end with a stud which is disposed at an angle relative to the body, a cutter mounted to turn freely on said stud; and boring legs extending downward from said cutter, said boring legs being relatively long and slender with respect to their thickness and generated about a central recess, there being but one boring leg in the same radial plane on one side of the axis of said cutter.

16. A rotary bit comprising: a body adapted to be rotated in a well; a cutter mounted to turn freely on said body and rotatable on an axis which is disposed at an angle relative to the body; and boring legs extending downward from said cutter, each of said boring legs having cutting edges formed at right angles to a radial line extending through each boring leg, said cutting edges being substantially at right angles to a center line extended downwardly or substantially vertically through the respective boring legs, the cutting edges being radially spaced to form a central recess.

17. A rotary bit comprising: a body adapted to be rotated in a well; a cutter mounted to turn freely on said body and rotatable on an axis which is disposed at an angle relative to the body; and boring legs extending downward from said cutter, said boring legs being circumferentially spaced from each other a distance at least equal to the thickness of each boring leg, each of said boring legs having cutting edges formed at right angles to a radial line extending through each boring leg, said cutting edges being substantially at right angles to a center line extended downwardly or substantially vertically through the respective boring legs, the cut-

ting edges being radially spaced to form a central recess.

18. A rotary bit comprising: a body adapted to be rotated in a well; a cutter mounted to turn freely on said body and rotatable on an axis which is disposed at an angle relative to the body; and boring legs extending downward from said cutter, there being but one boring leg in the same radial plane on one side of the axis of said cutter, each of said boring legs having cutting edges formed at right angles to a radial line extending through each boring leg, said cutting edges being substantially at right angles to a center line extended downwardly or substantially vertically through the respective boring legs, the cutting edges being radially spaced to form a central recess.

19. A rotary bit comprising: a body adapted to be rotated in a well; a cutter mounted to turn freely on said body and rotatable on an axis which is disposed at an angle relative to the body; and boring legs extending downward from said cutter, said boring legs being circumferentially spaced from each other a distance at least equal to the thickness of each boring leg, said boring legs having substantially flat inner faces in order that cutting be done by virtue of the inward movement of said boring legs, the boring legs terminating in cutting edges formed at right angles to radial lines extended therethrough, and at right angles to a center line extended downwardly or substantially vertically through the respective cutter legs.

20. A rotary bit comprising: a body adapted to be rotated in a well; a cutter mounted to turn freely on said body and rotatable on an axis which is disposed at an angle relative to the body; and boring legs extending downward from said cutter, said boring legs having substantially flat inner faces in order that cutting be done by virtue of the inward movement of said boring legs, the boring legs terminating in cutting edges formed at right angles to radial lines extended therethrough, and at right angles to a center line extended downwardly or substantially vertically through the respective cutter legs.

21. A rotary bit comprising: a body adapted to be rotated in a well; a cutter mounted to turn freely on said body and rotatable on an axis which is disposed at an angle relative to the body; and boring legs extending downward from said cutter, said boring legs being circumferentially spaced from each other a distance at least equal to the thickness of each boring leg, said boring legs having substantially flat inner faces in order that cutting be done by virtue of the inward movement of said boring legs, the boring legs terminating in cutting edges formed at right angles to radial lines extended therethrough, and at right angles to a center line extended downwardly or substantially vertically through the respective cutter legs.

22. In a cutter assembly, the combination of: a bit body, a bearing member having a threaded pin formed thereon, there being a threaded recess in said body adapted to receive the pin, said bearing member having a thrust bearing face formed on the lower end thereof; a cutter mounted for rotation on said bearing member, a cylindrical projection extending from the bearing member adjacent to said thrust bearing face and on the same axis, said cylindrical projection having a radial bearing face, the cutter being formed with a central bore through which the projection is adapted to extend, a main lubricating passage formed in the central portion of said bearing member and extending through the cylindrical projection, and a branch lubricating duct leading therefrom to the said thrust bearing face.

23. In a cutter assembly, the combination of: a drill body, a bearing member formed with a threaded pin, said body having a threaded recess adapted to receive said pin, the bearing member being formed with a frusto-conical thrust bearing face on the lower end thereof, a cutter mounted for rotation on said bearing member, a cylindrical projection extending from said bearing member, said cylindrical projection having a radial bearing face, the cutter having a central aperture through which the cylindrical projection extends, there being a passage formed through said bearing member from said threaded pin through said cylindrical projection, and a branch passage extending from the aforesaid passage to the said thrust bearing face.

24. 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 picks extending downwardly from said cutter hub and separated at their inner edges to define a central recess, each of said picks being sufficiently sharpened at its lower end and extending a sufficient distance below the position of nearest approach of said axes of rotation that when said body is rotated, said picks dig on paths extending downwardly and inwardly beneath said bit on the bottom surface of said well, 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.

25. In a bit fitted 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 picks extending downwardly from said cutter hub and separated at their inner edges to define a central recess, each of said picks being sufficiently sharpened at its lower end and extending a sufficient distance below the position of nearest approach of said axes of rotation that when said body is rotated, said picks dig on paths extending downwardly and inwardly with a picking or chiseling action beneath said bit on the bottom surface of said well, 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.

26. 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 picks extending downwardly from said cutter hub and disposed symmetrically relative thereto about a central recess, each of said picks being sufficiently sharpened at its lower end and extending a sufficient distance below the position of nearest approach of said axes of rotation that when said body is rotated, said picks dig on paths extending downwardly and inwardly beneath said bit on the bottom surface of said well, 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.

27. 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 extending 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, said cutting elements 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 cutting element practically supports the weight imposed on said bit when said element is in downwardmost position and while the adjacent cutting elements are rising or descending.

28. In a bit suited for 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, each of which has a plurality of downwardly directed 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, said cutting elements 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 cutting element practically supports the weight imposed on said bit when said cutting element is in downwardmost position and while the adjacent cutting elements are rising or descending.

29. A rotary bit adapted for well drilling, comprising a bit body terminating in an eccentric portion at its lower end, a stud angularly disposed on the bottom of said eccentric portion, a cutting member rotatably mounted on said stud, boring legs disposed about said cutting member and circumferentially spaced from each other, said boring legs extending downwardly from said body and forming a central recess, and terminating in cutting edges below said body, the oppositely disposed blades being radially spaced from each other, 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 boring leg practically supports the weight imposed on said bit when said boring leg is in its downwardmost position and while the adjacent boring legs are rising or descending.

30. A rotary bit comprising: a body adapted to be rotated in a well; said body being formed at its lower end with a stud which is disposed downwardly relative to the body; a cutter mounted to turn freely on said stud; and boring legs extending downwardly from said cutter; said boring legs being of greater length than their thickness and being circumferentially spaced from each other a distance at least equal to the thickness of each boring leg; said boring legs being spaced to form a central recess, and arranged so as to have a single boring leg in the same radial plane on each side of the axis of said cutter.

31. A rotary bit comprising: a body adapted to be rotated in a well; said body being

formed at its lower end with a stud which is disposed downwardly relative to the body; a cutter mounted to turn freely on said stud; and boring legs extending downwardly from said cutter; said boring legs being relatively long and slender with respect to their thickness and generated about a central recess, there being but one boring leg in the same radial plane on one side of the axis of said cutter.

In testimony whereof, I have hereunto set my hand at Los Angeles, California, this 2nd day of September, 1925.

JOHN A. ZUBLIN.