May 24, 1932. J. A. ZUBLIN 1,859,947

ROTARY BIT

Original Filed Sept. 8, 1925 4 Sheets-Sheet 1

Fig. 1.

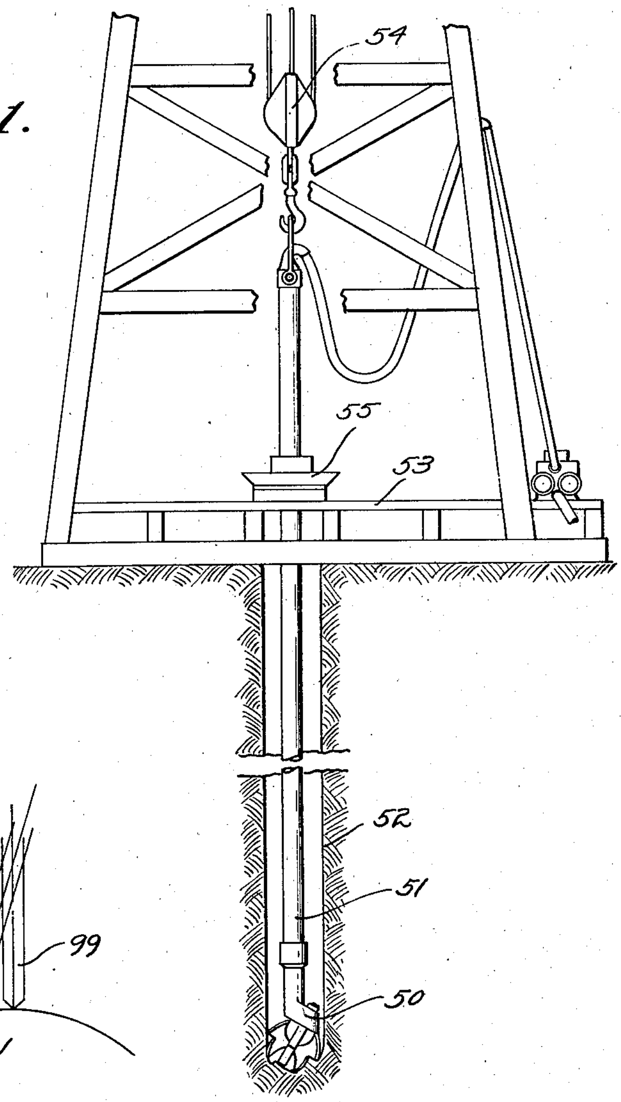
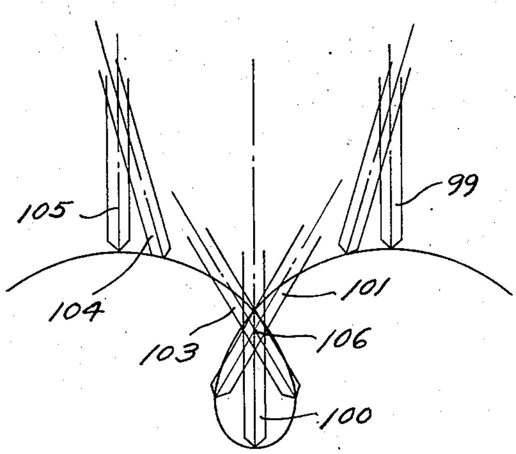


Fig. 8.



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ROTARY BIT

Original Filed Sept. 8, 1925 4 Sheets-Sheet 2

Fig. 2.

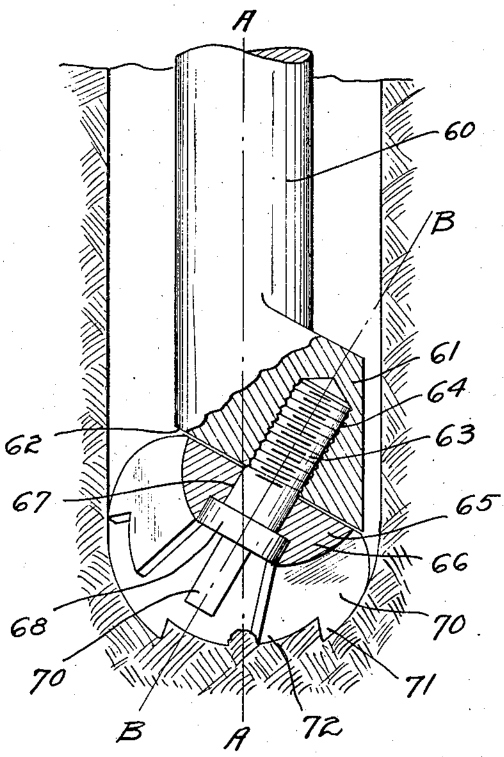

Fig. 9.

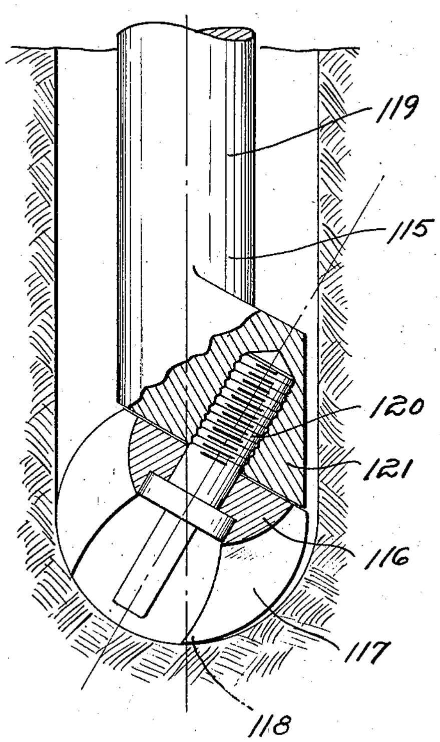

Fig. 3.

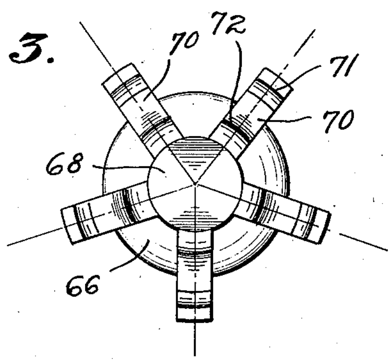

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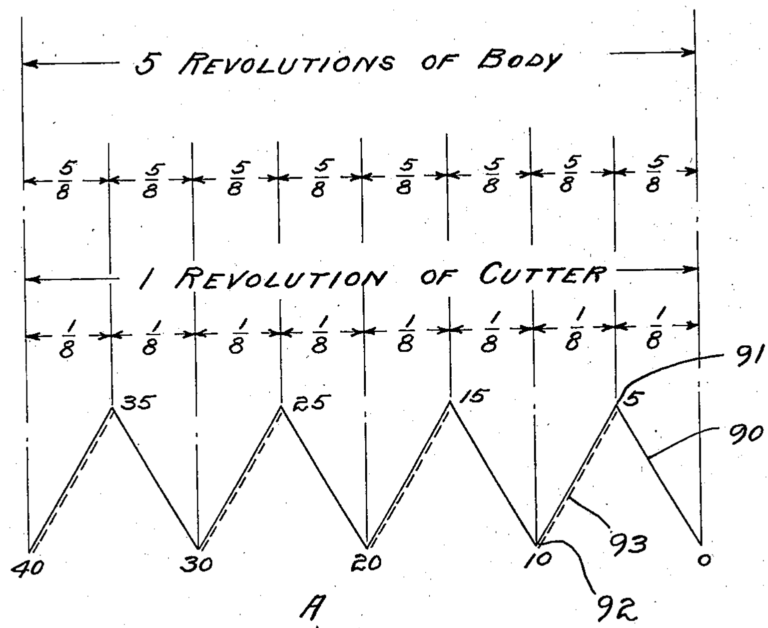
Fig. 7.



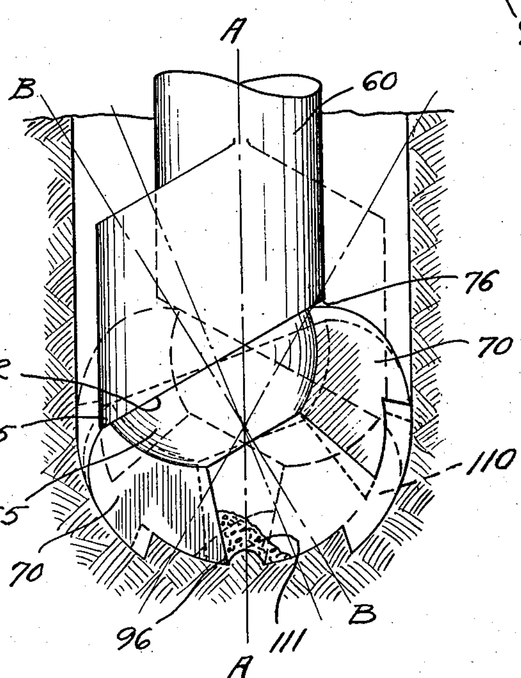


Fig. 4.

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Fig. 6.

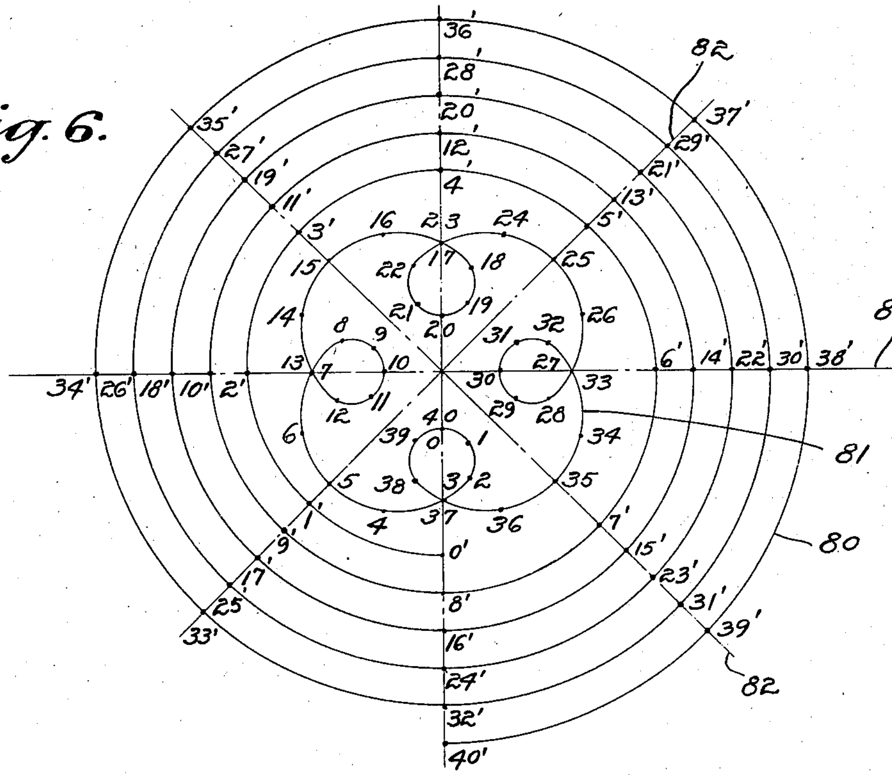
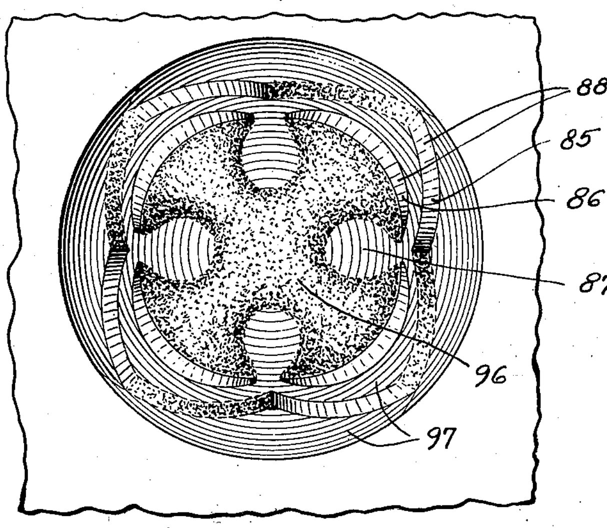


Fig. 5.



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Patented May 24, 1932

1,859,947

UNITED STATES PATENT OFFICE

JOHN A. ZUBLIN, OF LOS ANGELES, CALIFORNIA, ASSIGNOR TO UNIVERSAL ENGINEERING COMPANY, OF LOS ANGELES, CALIFORNIA, A CORPORATION OF CALIFORNIA

ROTARY BIT

Application filed September 8, 1925, Serial No. 54,875. Renewed November 16, 1929.

This invention relates to the art of drilling wells, and it relates particularly to cutting tools employed in this art.

The present methods of producing wells may be divided into two general classes; namely, the rotary system and the percussion system.

In the rotary system of producing wells the rotary cutter is rotated at the lower end of a drill pipe, which drill pipe extends upwardly through the well and through a rotary machine on the derrick floor of a derrick of the well. This rotary machine imparts rotation to the drill pipe, thus rotating the rotary cutter so as to produce the well. The drill pipe is usually supported by a travelling block which connects with the drill pipe by means of a swivel head. Rotary mud for removing the cuttings from the rotary cutter, and for floating the drill pipe away from the sides of the hole so as to reduce friction, is introduced into the drill pipe by means of high pressure pumps which connect with the swivel head by means of a stand pipe and a flexible hose. Rotary mud is pumped downwardly through the drill pipe and passes out of the rotary cutter or rotary drill adjacent to the cutting edges thereof.

In the percussion system of drilling wells a percussion cutter or tool is secured at the lower end of a cable which extends upwardly through the well and is attached to a suitable reciprocating means situated on the floor of a derrick of the well. The tool is elevated by the reciprocating means and allowed to fall so as to percuss the bottom of the hole and to break the bottom away so as to produce the well. It is customary to keep the well being drilled full of rotary mud or water.

Both of these systems have their advantages in certain formations, the rotary system being suited for softer formations and the percussion system being suited for the harder rock and shale formations. Both of these systems, however, have deficiencies which are overcome in my invention.

In the rotary system the cutters or bits employed cut entirely by scraping or attritional action, that is to say, the cutting edges are moved over the surface being cut at substantially right angles to the plane thereof. The principle of operation or the manner of cutting of rotary cutters is substantially the same, although there are various forms of rotary bits.

When rotary bits arrive at harder formations, such as shale or rock, much difficulty is experienced. The cutting of the bit is very slow, and the wear on the cutting edges is enormous. The reason for such slow cutting and excessive wear is the manner of operation of the blades. These blades, due to their cutting by scraping or attrition, are subjected to considerable attrition themselves. When drilling through rock with rotary tools, the wear thereon is so great that they must be replaced at very frequent intervals.

It is an object of my invention to provide a bit which will cut effectively and rapidly in hard formations such as rock and shale. An important consideration of my invention is the fact that it does not produce the hole by attritional action, but produces the hole by a digging or chopping action. In other words, a bit of my invention cuts through rock, not by scraping or attrition, but by disintegration. Investigation tends to show that certain of the harder formations are composed of particles which are held together by a binder. The action of my bit tends to separate these particles by an impacting or percussion action, rather than by a scraping or grinding action.

Rotary bits also have marked disadvantages in very soft, gummy formations. It is found that as the bit rotates, the scraping action thereof tends to build a mass of the formation directly in front of the cutting edges of such bits. As the cutting continues, these masses become quite large and do not mix readily with the rotary mud and are, therefore, not carried away from the cutting edges as they should be or as is intended. These large masses offer enormous resistances to the rotation of the bit and seriously interfere with the cutting thereof. It is alleged that many of the twistoffs, that is, a twisting off in the drill pipe, result from the enormous resistances 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 of the formation in front of the cutting edges. This side pressure very often results in cave-ins which are sometimes disastrous.

It is an object of my invention to provide a bit which is so constructed that the cuttings thereof are thoroughly and readily mixed with reciprocating mud and carried away from the cutting edges thereof. A thorough mixing of cuttings with water entirely prevents the formation of a mass adjacent to the cutting edges and eliminates the resistance to the cutting as in the ordinary types of fishtail bit. This also reduces the power required to operate the bit. By thoroughly mixing the cuttings with water, they are readily carried away, and the efficient operation of the bit will not be impeded.

It is a further object of my invention to provide a bit, the operation of which will not conduce to cave-ins. The bit of my invention operates or cuts in such a manner that there is no side pressure against the walls of the hole as in the ordinary types of bit, and therefore there are no strains placed thereon which would tend to cause cave-ins.

It is a further object of my invention to provide a bit of the character mentioned in which it will not be impossible for such bit to cause a twistoff of the drill pipe, due to a jamming of the cutter. The bit of my invention is of such a construction that the resistance placed against the cutter thereof is transferred to the drill pipe in such a manner that the drill pipe is placed under compression rather than subjected to a twisting action. It is also constructed in such a manner that in the event the cutter becomes jammed, there will be no noticeable twisting action on the drill pipe and the drill pipe will move up and down as it rotates. I accomplish this by providing a bit having a cutter which is not rigidly secured to the body.

The percussion system of drilling wells is applicable substantially entirely to hard formations, this system being exceptionally well suited for rock formations which are most effectively penetrated by percussion. When cable tools, that is, tools employed in the percussion system of drilling wells, reach a soft formation, the cutting action is very ineffective. For example, when the cable tool is dropped into a softer formation, it naturally penetrates this soft formation a substantial distance as compared with the distance it would penetrate the rock formation. In raising the cable tool, it is necessary to pull the tool from the formation. As the tool is raised, a considerable suction or vacuum is created below the tool, which greatly opposes an upward motion thereof. Considering that the fluid pressure in the well is 3000 pounds per square inch, it is obvious that the power necessary to elevate this tool is enormous. Likewise, it is seen that the percussion of the cable tool against the soft formation would not be effective in drilling a hole, as this formation is not chipped away or disintegrated as in the case of rock.

It is an object of my invention to provide a bit which cuts by a reciprocating action but does not have the disadvantages present in the cable tools when such tools are drilling in soft formations. In my invention the blades or teeth of the cutters move in a reciprocating manner, but also have a sideward motion which eliminates any suction that resists the raising of said blades. It is effective in producing the hole, due to the fact that it tends to force the cuttings inwardly, so that they may be readily mixed with water and moved away from the cutter.

It is another object of my invention to provide a bit of the character mentioned which will drill a large hole and require only a comparatively small drill pipe to operate same. This is possible due to the fact that the construction of my invention allows the drill pipe to rotate at a much greater speed than the cutter. For this reason the strain placed upon the drill pipe is greatly reduced, as compared with the strain which would be placed thereon were the cutter rotated at the same rate of speed as the drill pipe.

In a certain type of rotary bit for drilling deep wells, a cutter engages the bottom of the well and is rotatably mounted on the lower end of the drill pipe on an axis oblique to that of the drill pipe. Thus, when the drill pipe rotates, the cutter is given a gyratory movement causing it to have a rolling action upon the bottom of the well. A large number of relatively shallow teeth provided on the rolling surfaces of the cutter are thus caused to abrade the bottom of the well and gradually wear this away.

It is another object of my invention to provide a bit of the gyratory type in which the cutting action is much faster than when this action is merely one of abrasion.

In accomplishing the foregoing object, I have provided a gyratory cutter having a relatively small number of relatively large downward extending teeth which form a central concave depression in the bottom of the well which guides and controls the action of the bit. I have found that these teeth, if properly formed, will cause the cutter to assume a motion in said concave depression similar in character to that of the ball to the socket in a ball-and-socket joint and that such a motion greatly increases the cutting action of the bit over the rolling motion used in former gyratory bits.

It is therefore an object of my invention to provide a gyratory bit cutter with teeth which are formed in a manner to cause the cutter to assume a ball-and-socket motion in a depression dug by said teeth.

Other objects and important advantages of my invention will be presented hereinafter.

Referring to the four sheets of drawings in which I diagrammatically delineate my invention,

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

Fig. 2 is an enlarged partially sectioned view of a rotary bit providing the features of my invention, the bit shown in Fig. 2 being a type of bit having five wings, each of which has a plurality of teeth.

Fig. 3 is a bottom plan view of the cutter of the bit shown in Fig. 2.

Fig. 4 is an enlarged view of the bit shown in Figs. 2 and 3, this view illustrating various positions of the cutter of the bit.

Fig. 5 is a plan view showing the contour of the bottom of a hole being produced by a bit of my invention.

Fig. 6 is a diagrammatic view illustrating very clearly the movements and the ratio of movements between the cutter and the shank of the bit of my invention shown in Figs. 1 to 4 inclusive.

Fig. 7 is an extremely diagrammatic development showing relative movement between the cutter and the shank of the bit and illustrating the manner of cutting of the cutter.

Fig. 8 is a diagrammatic view illustrating the motion of the cutting wings of the cutter bit of my invention.

Fig. 9 is a view of the bit of my invention being provided in an alternative form.

In Fig. 1 of the drawings, I show a bit 50 embodying the features of my invention attached at the lower end of a drill pipe 51 which extends upwardly through a well 52, through the floor of a derrick 53, and being supported by a suitable travelling block 54. A rotary table 55 is provided on the floor of the derrick 53 for the purpose of rotating the drill pipe 51, thus imparting rotation to the bit 50 of my invention.

The details of construction of the bit 50 are clearly shown in Figs. 2 to 8, inclusive, of my invention. With reference to these figures, the bit 50 provides a body or shank 60 which is secured at the lower end of the drill pipe 51, said shank being concentric on an axis of rotation A—A which is the axis of rotation of the drill pipe 51. At the lower end of the shank 60 is an eccentric formation or foot 61 having an angular lower face 62. An angular pin 63 is threaded into an opening 64 formed in the eccentric foot 61 and extending upwardly thereinto from the lower angular face 62.

A cutter 65 is carried by the angular pin 63. This cutter 65 has a hub or body 66 having an opening 67 through which the pin 63 extends, said pin 63 having a head 68 by virtue of which the cutter is retained in place. Extending from the hub or body 66 of the cutter 65 are a plurality of cutter wings 70 which are preferably of radial extension and equally spaced, as shown clearly in Fig. 3. The bit 50 is shown as having a cutter 65 provided with five cutter wings 70. Each of the cutter wings 70 provides teeth 71 and 72. The axis of rotation of the cutter 65 is disposed on an axis B—B which as clearly shown in Fig. 2 is at an angle with respect to the axis of rotation A—A of the body 60.

The bit of my invention, by virtue of its construction operates in such a manner as to possess various important features. When the body 60 of the bit is rotated, the cutter 65 is moved through a reciprocating motion which accomplishes the cutting of the hole and passes through a rotating movement, which moves the cutting edges in such a manner that the cutter will produce a round hole.

The reciprocating motion of the cutter 65 is clearly shown in Fig. 4 of the drawings. The full lines in this figure show the position of the parts when the shank 60 has moved half a revolution with respect to the showing in Fig. 2. It is evident that the cutter 65 has been swung so as to be at an angle to the opposite side of the axis A—A equal to the angle at which it rested in Fig. 2. When the lower portion 75 of the face 62 of the body 60 rests adjacent to a wing 70, such wing is at the lower end of its stroke, and when an upper portion 76 of the face 62 is adjacent to a wing 70, such wing is at the upper end of its stroke. Therefore, as the body rotates, the upper and lower portions move into the adjacency of the wings 70, forcing them up and down. The ratio of rotation between the body of the bit and the cutter is determined by the number of wings 70 of the cutter. This has been found to be true by experiment. For example, with a cutter of five teeth, the ratio of rotation between the cutter and the body is one to five, that is to say, there will be one revolution of the cutter at five revolutions of the body. This is clearly illustrated in the diagram shown in Fig. 6.

In Fig. 6 a spiral line 80 represents revolutions of the body 60 of the cutter, and the line 81 represents the orbit of a wing 70 of the cutter 65. The rotation of the bit is divided into eight equal parts by radius lines 82.

Considering that the bit rests in the position shown in Fig. 2, the lower tooth 72 of a wing 70 of the cutter 65 rests at a point 0 on the orbit 81, and the lower portion 75 of the face 62 rests at a point 0′ on the spiral line 80. As the body rotates, the point 75 moves consecutively through the points 0′ through a point 40′, having completed five entire revolutions. A point on a tooth 72 during these five revolutions of the body 60 moves through points 0 to 40 on the orbit 81. When the portion 75 of the body moves from 0′ to 1′, a point on a tooth 72 moves from 0 to 1 on the line 81. When the body has moved a revolution and a quarter to a point on the line 82 indicated by 10′, said point on the cutter has moved through substantially one quarter of a revolution, reaching a point 10 on the orbit 81. When the body has revolved another revolution and a quarter, arriving at a point 20′, the point on the cutter has completed substantially another quarter of a revolution, arriving at a point 20 on the line 81. When said point on the body moves another revolution and a quarter, arriving at a point 30′, said point on the cutter has moved a third quarter of a revolution, arriving at a point 30. Another revolution and a quarter of the body moves said point of said body to a point 40′, which completes five entire revolutions of the body, and said point on said cutter moves from the point 30 to the point 40 on the orbit 81, completing one entire revolution. The diagram in Fig. 6 clearly and accurately shows corresponding positions of the mentioned points on the body, and the cutter at 45 degrees of angular rotation of the body 60. The lower tooth 72 of each of the wings 70 passes through a peculiar motion, as indicated by the orbit 81.

Fig. 5 is a plan view showing the bottom of a hole cut by a bit of my invention. By inspection of this figure, it will be seen that there are outer and inner ledges 85 and 86. Further, it will be seen that these ledges are symmetric, being of even shape and size. The outer ledge 85 is cut by upper teeth 71 of the cutter wings 70 and the inner ledge 86 is cut by lower teeth 72 of the wings 70. The outer ledge 85 is of V-shaped formation, as shown, this being due to the fact that the wings 70 pivot substantially at the cutting edge of the teeth 71. Because of the pivoting at this point, the lower tooth 72 of each of the wings 70 is caused to swing through a circular path, as indicated by the orbit 81, and for this reason forms cavities 87 in the bottom of the hole being drilled, as clearly shown in Fig. 5.

In actual experience it is found that at each revolution of the shank 60, the cutter moves slightly less than a quarter of a revolution so that the cutting edges of the wings cut on the sides 88 of the ledges 85 and 86.

For clearly illustrating this action, reference is had to Fig. 7. Fig. 7 is solely for illustration, and either of the ledges 85 and 86 is indicated by the line 90. 91 indicates crests of the ledges 85 or 86, and 92 indicates troughs thereof. The crests 91 represent the positions of a tooth of the wing 70 when it is in uppermost position, such position being indicated at 5, 15, 25 and 35 in Fig. 6. The troughs 92 represent the lowermost position of a tooth of a wing 70, such position being indicated by points 0, 10, 20, 30 and 40 in Fig. 6. When the drill pipe rotates a revolution and a quarter as indicated on the line 80 from 0′ to 10′, the cutter actually moves slightly less than a quarter of a revolution, as indicated by 0 to 10 in Fig. 6.

With reference to Fig. 7, 0 to 40 represents five revolutions of the body and one revolution of the cutter. Five-eighths of a revolution of the body moves the cutter substantially one-eighth of a revolution or from 0 to 5, this motion constituting an upward stroke of a reciprocation. When the body rotates another five-eighths of a revolution, the cutter travels substantially another eighth of a revolution, the cutter moving through its downward stroke of a reciprocation; however, in actual practice the cutter revolves slightly less than one-fourth of a revolution when the body has revolved one and one-fourth revolutions. Therefore, either of the teeth 71 and 72 will cut away surfaces 88 of either of the ledges 85 or 86, as indicated by dotted lines 93 of Fig. 7. This indicates that the cutting of the ledges takes place on one side only, the other side of the ledges being formed at a termination of a tooth of a wing of the cutter.

The core 96 which tends to form during the drilling crumbles away as the cutter 65 operates. Rounded portions 97 at the bottom of the hole being drilled are formed by a swinging of the wings 70, this being clearly illustrated in the diagrammatic view in Fig. 8.

With reference to this figure, at the crest of a ledge or at the uppermost position of any of the wings 70 such wings extend in a vertical direction, as indicated at 99. At the trough of a ledge or at the lowermost position during a reciprocation, any of the teeth also extend in a vertical direction as indicated at 100 in Fig. 8. However, at a quarter of a revolution of the body, a wing or tooth extends at right angles to the angle of the face 62 of the body 60 as indicated at 101. It is evident then that during the downward stroke of a reciprocation, a tooth swings from vertical position through a series of positions into the position shown in 101, and then swings again into vertical position. On the up stroke of a reciprocation, a wing or tooth swings from vertical position into an angular position 103 through a position 104 and into a vertical position 105. Further, it will be seen from Fig. 8 that the wings 70 pivot above the lower end thereof, as previously described, substantially at a point 106, this accounting for the formation of the cavities 87. In passing through this swinging motion, during a complete reciprocation, the wings form the rounded portions 97 shown in Fig. 5.

By inspection of the various figures and diagrams, there are certain features which are very pronounced. For example, by inspecting Fig. 5, it will be seen that the cutter 65 having five wings cuts four cavities which is one less than the number of wings. This is accounted for by the fact that there is at all times one wing which is entirely out of engagement with the formation being cut. It is due to the peculiar wobbling motion of the cutter that one wing is always in the air while the other wings penetrate more or less, according to their position. Each of the teeth after they are raised from the formation fall back into a following cavity, passing through a regular geometric cycle as is clearly evident from Figs. 5 and 6. However, it is found that the cavities 87 tend to shift in position as the cutter drills. This is due to the fact that the cutter revolves slightly less than a quarter of a revolution, thus causing the cutter to remove material entirely on one side and to gradually rotate the crests and troughs and cavities in a direction reverse to the rotation of the shank 60 of the drill, and the rotation of the cutter 65.

Another point which becomes evident is that all of the cutting is done by a reciprocating motion, that is to say, the teeth 71 and 72 of the wings 70 cut on their down stroke and do not cut by virtue of their rotation. It is by reason of rotation of the cutter that a round hole is produced, that is to say, the reciprocating motion does the digging work, and the rotating motion moves the digging edges of the cutter around so as to produce a round hole.

The lawful motion of a cutter connected with the body 60, as shown and described, depends upon the position of the cutter, and the number of wings of the cutter. In other words, the distance of reciprocation of the wings of the cutter is governed by the angle between the axes A—A and B—B. By increasing this angle, the reciprocating travel of the wings 70 may be increased. Similarly by decreasing this angle the reciprocating travel of these wings may be decreased.

Also the ratio of rotation between the body 60 and the cutter 65 may be varied by changing the number of wings 70. In the drawings the ratio between the body 60 and the cutter 65 is five to one, this being due to the fact that the cutter 65 has five wings 70. By changing the number of the wings of the cutters 65, the ratio of rotation between the cutter and the body 60 may be varied. For example, a cutter with four wings would have a ratio of one to four; a cutter with six wings would have a ratio of one to six with the body 60. From this it is evident that by varying the angle and by changing the number of wings, a bit suitable for any formation may be provided.

The wings 70, owing to the character of their action, may be likened to and described as chisels or picks in order to distinguish them from other forms of cutters on gyrating bits previously known in the art. In gyrating bits previously devised, an exceedingly large number of cutting teeth were provided which were disposed close together so as to form an abrasive or grinding surface. In contrast to this character of cutter, my cutters are relatively few in number and spaced a relatively large distance apart so that each operates in an independent manner entirely absent in the gyrating bits previously known.

From the foregoing description it is evident that a bit of my invention produces a hole by a digging or disintegrating action and not by a scraping or attritional action as in the case of the present types of rotation bit. For this reason the wear thereupon in hard materials is a minimum and the speed at which it cuts is a maximum. The bit of my invention is very successful in gummy formations, due to the fact that by virtue of its motion a mass will not collect on the cutting edges, and cuttings will be readily mixed with water so that there will be no such opposition to the cutting progress of the drill.

With reference to Fig. 5, it will be seen that in passing through a reciprocation a wing 70 moves in such a manner as to tend to force the cuttings inwardly towards the center of the hole being bored. A wing 70 moves from an upper position shown in full lines in Fig. 4 into the lower position shown by dotted lines 110 of Fig. 4. This causes the cuttings to collect at the center of the hole, as indicated at 111. It will be impossible for such cuttings to collect on the cutting edges of a wing 70 due to the fact that the wing 70 backs away from the cuttings on its upward stroke of a reciprocation, as clearly shown in this figure. The motion of the wings is such that the cuttings 111, as they are forced to the center of the hole, are readily mixed with rotary mud and are carried away as they collect, as shown in Fig. 4.

The side motion of the wings 70, as clearly indicated diagrammatically in Fig. 8, eliminates any suction or vacuum action as is present in the cable tool drilling in soft materials. It will be seen that a swinging to the side allows the fluid to pass to the side of the cutter, and there will be no suction therebelow when the wing is elevated.

In Fig. 9 I show a bit 115 which is very similar to the bit shown in the other figures of the drawings. However, by inspection it will be seen that this bit has a cutter 116 having five wings 117, each wing having one cutting edge 118. In other words, each wing 117 comprises a tooth. The bottom of the hole being cut by the bit 115 is of slightly different contour than the bit 50. The cutter 116 is secured at angles to the axis of rotation of a body 119 by means of a pin 120 which extends into an eccentric foot 121 of the body 119, as shown.

I claim as my invention:

1. In a well drilling bit the combination of: a body adapted to be secured to a drill-pipe and to be rotated thereby; a cutter rotatably supported by said body on an axis inclined downwardly and inwardly towards the axis of rotation of said body; and cutter blades projecting downwardly from said cutter, each of said cutter blades having a plurality of digging points and an outer curved face connecting to one of said digging points and adapted to engage the side wall of the hole.

2. In a well drilling bit the combination of: a body adapted to be secured to a drill-pipe and to be rotated thereby; a cutter rotatably supported by said body on an axis inclined downwardly and inwardly towards the axis of rotation of said body; and cutter blades projecting downwardly from said cutter, each of said cutter blades having a plurality of digging points, and an outer curved face connecting to each of said digging points.

3. In a well drilling bit the combination of: a body adapted to be secured to a drill-pipe and to be rotated thereby; a cutter rotatably supported by said body on an axis inclined downwardly and inwardly towards the axis of rotation of said body; and cutter blades projecting downwardly from said cutter, each of said cutter blades having inner and outer digging points, and an outer curved face connecting to the outer of said digging points.

4. In a well drilling bit the combination of: a body adapted to be secured to a drill-pipe and to be rotated thereby; a cutter rotatably supported by said body on an axis inclined downwardly and inwardly towards the axis of rotation of said body; means providing circumferentially spaced inner digging points below said cutter; and means providing circumferentially spaced outer digging points below said cutter and outside said inner digging points, and outer curved faces connecting to said outer digging points and adapted to engage the side wall of the hole.

5. In a well drilling bit the combination of: a body adapted to be secured to a drill-pipe and to be rotated thereby; a cutter rotatably supported by said body on an axis inclined downwardly and inwardly towards the axis of rotation of said body; means providing circumferentially spaced inner digging points below said cutter; and means providing circumferentially spaced outer digging points below said cutter and outside said inner digging points, and outer curved faces connecting to said outer digging points, said outer curved faces being generated around a point at the center of motion of the bit and having scraping contact with the side wall of the well being drilled.

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

JOHN A. ZUBLIN.