May 24, 1932. J. A. ZUBLIN 1,859,948

BIT WITH CUTTERS HAVING SCRAPING AND ROLLING MOTIONS

Filed July 29, 1929 2 Sheets-Sheet 1

Fig.1.

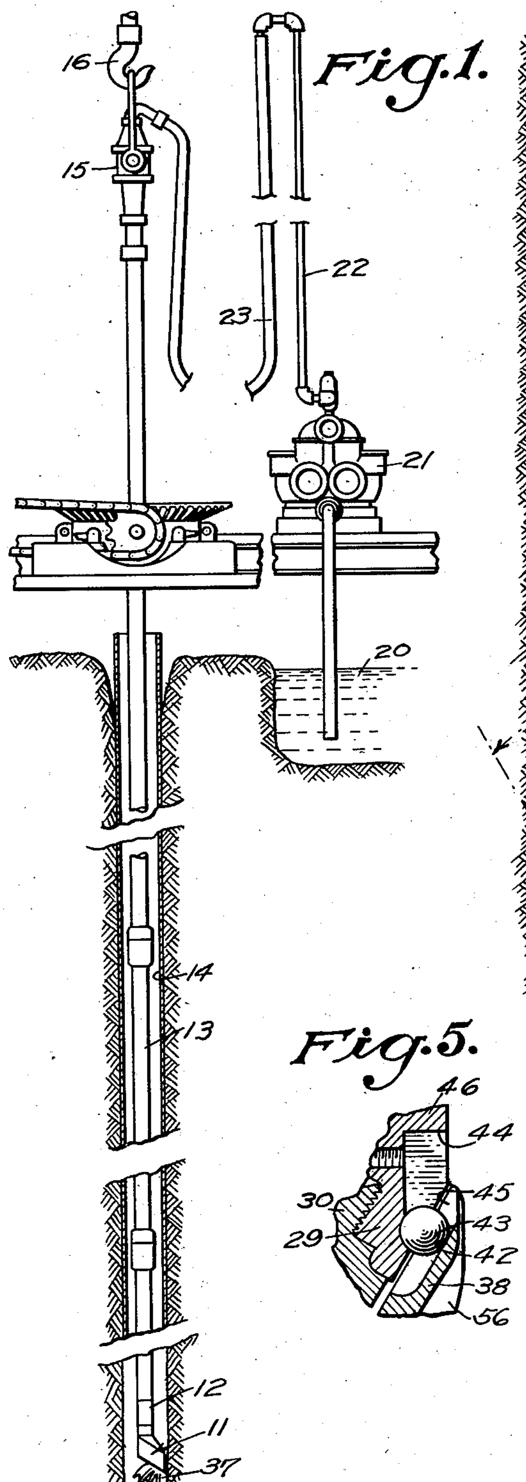

Fig.2.

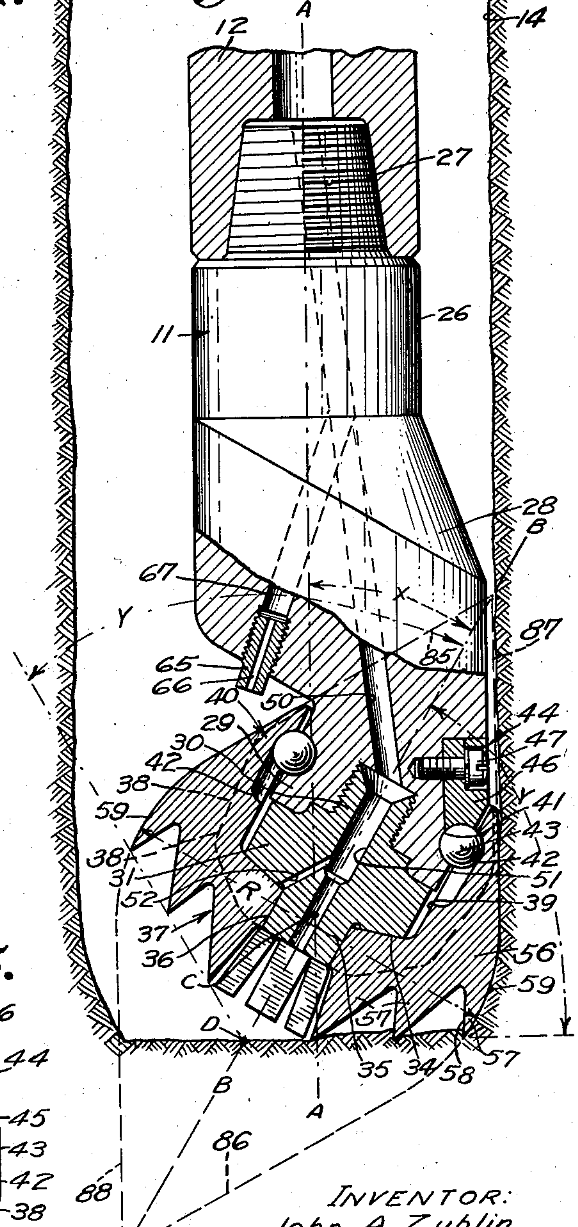

Fig.5.

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Fig. 3.

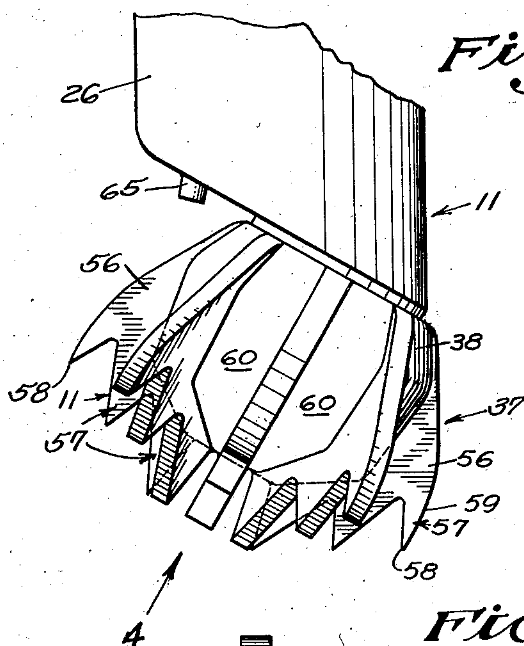


Fig. 6.

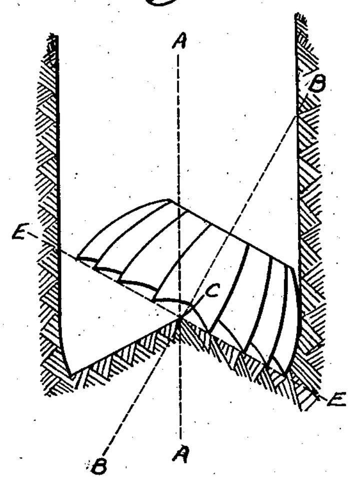


Fig. 4.

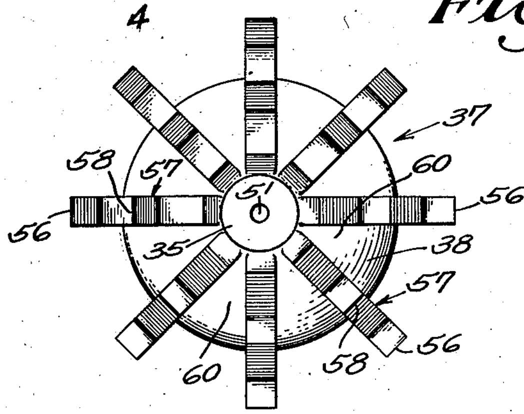


Fig. 7.

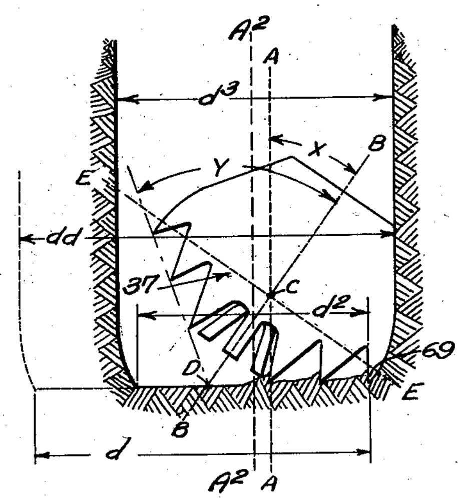
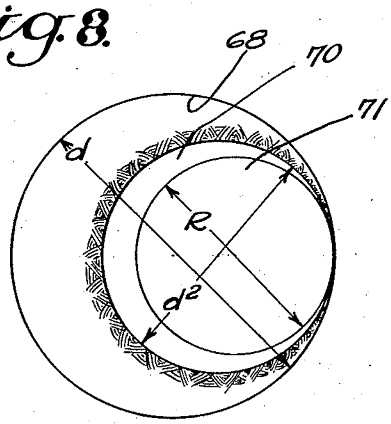


Fig. 8.



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Patented May 24, 1932

1,859,948

UNITED STATES PATENT OFFICE

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BIT WITH CUTTERS HAVING SCRAPING AND ROLLING MOTIONS

Application filed July 29, 1929. Serial No. 381,704.

My invention relates to bits for drilling oil wells in which the cutter is mounted to rotate on an axis inclined to the axis of rotation of the bit, and in which the teeth dig away the bottom of the hole by a combined rolling and scraping action.

An object of my present invention is to provide a bit in which the digging is accomplished by inwardly moving teeth which are consecutively brought into operating position by the revolving motion of the cutter.

A further object of my invention is to provide a bit of this character in which the revolving cutter is forced outward against the wall of the hole so that reaming edges thereof will ream the hole.

A still further object of my invention is to provide a bit in which the cutter rotates on its own axis and at the same time is rotated around the axis of rotation of the bit and in which the relation of the axes and digging teeth are such that the cutter is constantly crowded inward during the operation of the bit, thus causing the digging teeth to dig inwardly on the bottom of the hole.

Another object of the invention is to provide a bit of the character referred to in the preceding paragraph in which reaming edges are located to engage the side wall on the same side of the hole as the digging teeth are operating, the reaming edges pressing against the side wall due to the crowding action so as to ream the hole.

A still further object of my invention is to provide a bit having a cutter rotatable on an axis inclined to the major axis of the bit and the center line of the well, and in which digging teeth are provided which are rolled into engagement with the bottom of the hole and which are so positioned that they bite against the bottom of the hole and force the cutter outward against the wall of the hole so that reaming edges of the cutter ream the wall of the well.

Another object is to provide a novel cutter for bits of the character mentioned, constructed to cooperate with the other parts of the bit, to produce the desired cutting action.

Other objects of my invention will be pointed out in the following description of a preferred form of my invention.

In the attached drawings in which I have shown a preferred form of my invention:

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

Fig. 2 is a partly sectioned view of my bit showing the arrangement of the parts.

Fig. 3 is an elevational view showing the appearance of the cutter for my bit.

Fig. 4 is a bottom view of the cutter taken in the direction of the arrow 4 in Fig. 3.

Fig. 5 is a fragmentary sectional view showing the entrance opening for installing balls in a ball-bearing of my invention.

Fig. 6 is a diagrammatic view showing the operation of a cutter having a true rolling motion.

Fig. 7 is a diagrammatic view showing the operation of my cutter.

Fig. 8 is a diagrammatic plan view corresponding with Fig. 7 to illustrate the characteristic actions of my new bit which cooperate to cause the bit to produce a hole of larger diameter than the bit.

Referring to Fig. 1 of the drawings, I show a bit 11 of my invention which is secured to a tool joint 12 at the lower end of a drill pipe 13, which pipe 13 extends upwardly through a well 14 and is supported at the upper end thereof by a swivel 15 and a traveling block, the hook of which is indicated at 16. Rotary mud from a sump 20 adjacent the well 14 is supplied by a pump 21 through a stand pipe 22, a mud hose 23, the swivel 15, and the interior of the hollow drill pipe 13 to the drill bit 11. The rotary mud issuing from holes in the drill bit carries the cuttings from the drill bit teeth to the surface.

As best shown in Fig. 2, the bit 11 includes a body 26 which has an axis A—A. A pin 27 is formed at the upper end thereof, which is screwed into the tool joint 12 so that the axis A—A and the axis of the drill pipe coincide. At the lower end of the body 26 is an eccentric formation 28 which provides a depending inclined stub pin 29 having an axis B—B which is disposed at an angle X to the axis A—A and which intersects the axis A—A at a point C, the angle X between the axis A—A and B—B for convenience of reference being termed the included angle. This angle X is preferably less than forty-five degrees. Threaded into an opening in the inclined pin 29 is a threaded projection 30 formed on the upper end of a bearing element 31 and which secures the bearing element 31 in axial alignment with the inclined stub pin 29. The bearing element 31 has a lower bearing face 34, and depending below the face 34 is a projecting pin 35 which provides a cylindrical bearing face 36. The stub pin and bearing element constitute a cutter supporting pin of the bit.

Carried by the cutter supporting pin is a cutter 37 having a cutter body 38 which is rotatable on the axis B—B. The cutter body 38 has a central cavity 39 which receives the cutter supporting pin, a bearing surface inside the cavity engaging the lower bearing face 34 and an opening through the bottom of the cutter 38 providing an internal cylindrical bearing surface which engages the surface 36 of the projecting pin 35.

Formed between the cutter body 38 and the inclined stub pin 29 is a ball-bearing 40. The ball-bearing 40 consists of an inner race 41 formed by an annular groove in the pin 29, an outer race 42 formed by an annular groove on the inner surface of the cavity 39, and by balls 43 which are rotatably received between the inner and outer races 41 and 42. The balls 43 provide a rolling contact between the stub pin 29 and the cutter body 38 and when installed in position serve as a retaining means for retaining the cutter 37 on the cutter supporting pin. In the peripheral face of the pin 29 near the upper end thereof is a recess 44 which provides communication between the inner and outer races 41 and 42 of the ball-bearing 40 and the exterior of the drill bit 11. As best shown in Fig. 5, a slot 45 formed in the inner surface of the cutter body 38 so as to extend from the outer race 42 to the upper edge of the cutter 38 provides a means for inserting or removing the balls 43 when the cutter is rotated so as to bring the recess 44 and the slot 45 in alignment. A plug 46 which fits in the recess 44 and is secured in place by a screw 47 normally serves to close the recess 44.

Communicating with an opening in the center of the drill pipe 13 and extending downwardly through the body 26 is a fluid passage 50 which communicates with a fluid passage 51 formed through the inclined pin 29 and the bearing element 31, and which communicates with the lower exterior surface of the cutter 37. Communicating with the fluid passage 51 is a side passage 52 which communicates with an annular groove in the lower bearing face 34 of the bearing element 31. The passage 52 permits the introduction of mud water or rotary mud to the bearing surfaces and the ball-bearing 40 so as to lubricate these parts.

As best shown in Figs. 3 and 4, the cutter body 38 has radial wings 56 of substantially uniform thickness which are evenly spaced. The wings 56 extend downward from the bottom of the cutter body and outward from the side thereof. I prefer to use and have shown eight depending wings, but a greater or less number may be used. The lower edges of the wings 56 provide digging teeth 57, three teeth being formed on each of the wings 56. The teeth 57 have cutting edges 58 which are formed at substantially right angles to a line radiating from the axis B—B and are therefore tangential to a circle generated around the axis B—B. The cutting edges 58 of all of the teeth 57 lie in the surface of an inverted cone whose axis lies along the line B—B. The lower side of the conical surface is approximately horizontal, and the apex D thereof lies on the axis B—B a distance below the point C as shown clearly in Figs. 2 and 7.

It will be noted that the angle Y included between the surface of the cone and axis B—B is complementary to the included angle X. In other words, the two angles total ninety degrees, which is necessary if the lower teeth are to lie in a horizontal plane.

The edges 59 of the wings 56 which meet the lower edges thereof and extend along the sides of the cutter 37 constitute reaming edges. The reaming edges at their lower edges lie in an imaginary spherical surface generated around the point C, and owing to the combined rotating, slicing, and impact cutting action which is characteristic of the bit determine the diameter of the hole bored. The upper parts of the reaming edges lie in the surface of a cone which has a base and altitude which disposes the upper part of the reaming edge when in lowest position, in a vertical plane. This design is preferable in order that the entire reaming edge will be brought into operation upon reaching the lower position and so that the side wall of the hole may be reamed vertically. The conical surface in which the upper parts of the reaming edges lie is tangential to the lower curved parts. The cutting edges 58 and the reaming edges 59 may have a hard metal alloy applied to them to increase their lives.

The wings 56 have fluid passages 60 therebetween, which passages 60 are segment shaped, increasing in size as they extend farther from the axis B—B. The outward divergence of the fluid passages 60 permits the rotary mud to readily carry away the cuttings.

For the purpose of removing cuttings from the channels or fluid passages 60 of the cutter and for cleaning the wings or blades 56 thereof, I provide a nozzle 65 placed as indicated in Figs. 2 and 3 in such position that the relatively small opening 66 thereof will direct into the spaces 60 and against the blades 56 a jet of fluid received under pressure through a passage 67 of the body 26 and connect with the main fluid passage 50 of such body. The jet of fluid directed under pressure by the nozzle functions to wash out accumulations of cuttings or other material from the passage 60 existing between the wings or blades 56.

The motion of the cutter 37 is similar to that motion described in my copending application entitled Rotary bit, Serial No. 54,875, filed Sept. 8, 1925.

The peculiar motion of the cutters on a bit of my invention is particularly difficult to explain since the motion is three-dimensional and is difficult to represent on a plane surface. However, in view of the fact that my new bit partakes of the characteristics of bits having a slicing or scraping action, bits having an impact action, and bits having a rolling motion, discussion of the operation of a cutter having a true rolling motion will be perhaps advantageous as a comparison for rendering an understanding of the operation of my cutter clearer, since such discussion will permit a comparison of the operation of my bit with the operation of a bit having a true rolling motion.

In Figs. 6 and 7, which views respectively show a cutter having a true rolling motion and a cutter of my invention, I have shown the axes A—A and B—B intersecting at the point C, as explained in connection with my bit. From Fig. 6 it may be seen that a cutter having teeth which lie in a plane E—E, which passes through the point C perpendicular to the axis B—B, would have a true rolling motion on a conical surface generated by the rotation of the plane E—E about the axis A—A, and that in such a bit there will be no scraping action on the bottom of the hole. Such a cutter would cut a hole having a conical bottom with an apex at the point C and would have a true rolling motion on the conical bottom of the hole.

As shown in Fig. 7, my cutter is provided with digging teeth which project below the plane E—E and, as they are moved into working position, engage the bottom of the hole in a substantially horizontal plane. If the cutter, as shown in this figure, were allowed to roll with a true rolling motion on a flat surface, it would follow a path concentric with the point D which is the apex of the cone, and in so rolling the cutter would traverse a circular area 68, Fig. 8, having a diameter *d* equal to twice the distance from the center of pivot D to the point of the outer tooth particularly indicated at 69, with the result of forming a hole with the cooperation of the reaming edges having substantially the diameter *dd* as shown in Fig. 7.

The cutter, however, is not free to roll in a natural manner as it would if it were free to roll as guided by the conical surface in which the teeth are located but is constrained by the presence of the vertical side walls of the hole being drilled to operation in a limited area 70, Fig. 8, having approximately the diameter d^2, indicated in both Figs. 7 and 8, because the side wall pressure crowds the cutter inward and forces the cutter to rotate within an area which is smaller than the area which it would naturally traverse were it rolled upon a flat surface and without the constraining effect of the side walls of the hole being drilled, and forces the cutter to oscillate around an axis A^2, Fig. 7, between the points C and D.

As near as can be determined by observing the operation of the bit, the cutter operates as follows:

We will consider that one wing 56 is just moving into its zone of operation, which is before it reaches its lowest position, as shown in Figs. 2 and 7. The digging teeth of this wing are forced by the weight of the drill column into engagement with the bottom of the hole, a penetration of the digging teeth occurs, and the reaming edge 59 of this particular wing is brought into engagement with the side wall of the hole.

At this time there are two opposite forces working on the cutter: one force resulting from the tendency of the cutter to follow a path around the point D so as to traverse the circular area 68 having the diameter *d*, and the other force resulting from the engagement, in lateral direction, of the reaming edges 59 and the material in which the drill is operated, such lateral engagement tending to hold the cutter to a rotation or oscillation within an area 71, Fig. 8, having a diameter R which is equal to the diameter of the cutter 37. From the foregoing, it will be perceived that there are two conditions influencing the operation of the cutter and influencing those factors which determine the area that the cutter shall traverse during its operation. One of these conditions results in the tendency for the cutter to traverse the area 68, and the other of these conditions tends to hold the cutter to an oscillation or rotation within the minimum area 71.

It is evident, however, that in the operation of this bit within a solid material, such as an earth structure, both of the before mentioned conditions will be in effect, but it is evident that it is impossible for one condition to predominate to the entire exclusion of the other condition, with the result that the reaction of one condition against the other produces a desired digging action on the bottom of the hole and a reaming action is performed on the side walls of the hole, with the result that the cutter traverses neither the area 68 or 71 but actually traverses the area 70 of intermediate size and produces a hole having a diameter d^3, as indicated in Fig. 7, which diameter d^3 is materially greater than the diameter R of the cutter 37.

If the digging teeth 57 could get a sufficient bite on the bottom of the hole and if this bottom material were strong enough to completely overcome the crowding force of the side walls of the hole, the cutter would roll around the point D and traverse the area 68; but the side walls of the hole being drilled are disposed within the maximum area 68 so as to be engaged by the cutter 37 as it tends to traverse the area 68. Owing to the engagement of the cutting teeth of the cutter with the bottom of the hole, the cutter when rotated in engagement with the bottom of the hole must either traverse the area 68 or the teeth of the cutter must slide inwardly in a scraping manner. As the cutter rotates, its positive tendency to traverse the area 68 owing to the engagement of the cutter teeth with the bottom of the hole causes the reaming edges of the blades to force outwardly against the side walls of the hole being drilled, and meeting this outward force with which the reaming edges of the cutter engage the side walls of the hole is a reaction or reacting force which operates to continuously force the cutter inwardly from a natural rotation over the area 68; therefore, in the operation of the bit the tendency for the cutter to traverse a large area brings the reaming edges into forcible contact with the side walls of the hole being drilled, with the result that the hole is reamed to a diameter larger than that of the cutter, and the reaction of the side walls of the hole against the reaming edges or reaming faces of the blades 56 produces a desired slicing action or sliding inwardly of the cutter teeth after they have penetrated the bottom structure of the hole.

A novel and valuable characteristic of my new cutter 37 is its development around and on a body having a form determined by the position in which it oscillates and rotates. This will be made clear by reference to Fig. 2 in which the vertical axis of rotation A—A of the drill shank and drill pipe is indicated and an angular axis B—B on which the cutter 37 rotates is shown. It has been explained that the cutter 37 rotates bodily on the axis B—B and also rotates or gyrates around the axis A—A owing to the fact that the rotation of the shank of the bit on the axis A—A produces a rotation of those parts determining the position of the axis B—B. My cutter forms part of or defines part of a body of largest size which will rotate within a hole of a given size on an inclined axis and around a vertical axis. This body has a composite sphero-conical form or, in other words, consists of a spherical central portion, as defined by the outer curved lower edges or faces of the blades or wings 56, and oppositely disposed upper and lower end portions, as indicated by the dotted lines 85 and 86. The largest possible size of cutter which will go through a hole of a given size, such as the interior of a casing, has to conform its dimensions within a sphero-conical body of this character having a maximum diameter or diameter of its spherical central portion R the same or slightly smaller than the hole through which the cutter must pass.

The conical end portions 85 and 86 of the sphero-conical body are so formed that the outer face of each cone, as indicated at 87 and 88, will be parallel to the axis A—A. It will be perceived that the lower outer edge portions of the wings 56 define the central spherical portion of the sphero-conical body and that the upper edge portions of these wings 56 define the cone 85. As the cutter 37 rotates, the straight upper edge portions of the wings 56 will come consecutively into vertical engagement with the side walls of the hole being drilled.

The diameter of hole cut depends on the cutting ability of the reaming blades and the pressure at which they are forced against the side walls of the hole, which pressure in turn depends on the bite of the teeth on the bottom of the hole. When the cutter is new and the cutting teeth are sharp, a better bite is obtained and consequently a larger hole may be cut.

The true fulcrum of the cutter is located on the line B—B between the points C and D. The greater the bite of the digging teeth on the bottom of the hole, the closer will be the true fulcrum to the point D. The length of the side of the conical surface defined by the digging teeth must be long enough to tend to move the cutter through a path having a maximum diameter, such as d, which is greater than the diameter R, since this is necessary to accomplish the scraping action. In Fig. 6, the surface E—E is the maximum diameter of the cutter, and there is no scraping action owing to the absence of forces tending to displace the cutter from a path it normally tends to follow.

The length of the side of the cone, however, must not be too long in proportion to the diameter R; otherwise there will be insufficient rolling action and an excess of scraping action, which would not accomplish the type of digging explained heretofore. The best results are obtained when the angle of the cone defined by the cutter teeth is greater than ninety degrees and the practical fulcrum of the cutter is between the points C and D.

Another phase of importance is that the cutter has a great number of teeth over which the wear is distributed but only a few teeth are working at a time. This produces a concentrated digging and reaming action on one side of the hole and accomplishes a digging and breaking away action by reason of sufficient penetration followed by a sliding action of the teeth.

One very important consideration of the invention is the design of the cutter which accomplishes the reaming of the hole. As explained, when the bit rotates, the cutter tends to follow a path concentric with the point D or, in other words, the area 68, but due to the crowding action of the wall it is continuously displaced from its natural path of movement and is caused to follow a smaller diameter of path, as represented by the area 70. The crowding action of the wall is met by an equivalent reactionary force in the cutter, and the reaming edges are thereby pressed against the wall so as to ream it. The characteristic tendency of the cutter to traverse a circular area of larger diameter than the hole being drilled produces a lateral reaming pressure by which the reaming edges are enabled to ream the hole. The preferred form of the invention includes the digging teeth and reaming edges on one wing. The principle of operation here involved requires a reaming edge to be positioned adjacent the digging teeth sc that when the crowding action occurs the reaming edge will be in position to react to ream the hole. My invention comprehends this principle even though the reaming edges and digging teeth are made separate.

I claim as my invention:

1. In a bit for drilling wells, the combination of: a body adapted to be secured to a drill column; a cutter rotatably carried by said body and rotatable about a cutter axis, said cutter axis being inclined relative to the axis of the body; digging teeth on said cutter, said teeth having cutting edges lying in the surface of a cone whose axis coincides with said cutter axis and whose apex is situated below said point of intersection of said axes; and reaming edges adjacent said teeth, said reaming edges having curved lower portions generated about said point of intersection of said axes, and having flat upper portions lying in the surface of a cone.

2. As an article of manufacture, a cutter for use on a drill bit, comprising: a cutter body adapted to be rotatably carried by said drill bit so as to rotate about a cutter axis; teeth on said cutter body; cutting edges on said teeth, said cutting edges lying in the surface of a cone whose axis coincides with said cutter axis; and reaming edges adjacent said teeth, said reaming edges having curved portions generated about a point on said cutter axis.

3. As an article of manufacture, a cutter for use on a drill bit, comprising: a cutter body adapted to be rotatably carried by said drill bit so as to rotate about a cutter axis; teeth on said cutter body; cutting edges on said teeth, said cutting edges lying in the surface of a cone whose axis coincides with said cutter axis; and reaming edges adjacent said teeth, said reaming edges having primary lower portions defining a sphere generated about a point on said cutter axis, and having flat upper portions lying in the surface of a second cone.

4. As an article of manufacture, a cutter for use on a drill bit, comprising: a cutter body adapted to be rotatably carried by said drill bit so as to rotate about a cutter axis; teeth on said cutter body; cutting edges on said teeth, said cutting edges lying in the surface of a cone whose axis coincides with said cutter axis; and reaming edges adjacent said teeth, said reaming edges having primary lower portions defining a sphere generated about a point on said cutter axis, and having secondary upper portions lying in the surface of a second cone whose axis coincides with said cutter axis, the angle included between the surface of said second cone and said cutter axis being complementary to the angle included between the surface of the cone formed by said cutting teeth and said cutter axis.

In testimony whereof, I have hereunto set my hand at Los Angeles, California, this 24th day of July, 1929.

JOHN A. ZUBLIN.