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BIT FOR DRILLING A HOLE LARGER THAN THE BIT

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BIT FOR DRILLING A HOLE LARGER THAN THE BIT

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While the present invention has to do generally with drill bits for drilling wells, it is more particularly concerned with bits that drill an oversize hole, that is a hole that is greater in diameter than the size of the bit.

Bits as generally constructed have all the cutting edges and surfaces so disposed that they are symmetrical to the vertical geometric axis of the bit, and also often symmetrical to one or more horizontal axes. As the bit revolves in the well, it contacts the earth formation on the sides and bottom of the well and at these points of contact resistance is encountered. This resistance as an entirety may be considered as composed of several smaller forces acting at these various points; and these forces created by the removal of material from the well will be found to be symmetrically disposed relative to the bit axis just as are the cutting edges. The result is that for each such force acting on the bit, there is another force of substantially equal and opposite effect so that all the resistance forces on one side of the bit are fairly evenly balanced by forces on the other side of the bit and the center of moments of these forces coincides substantially with the geometric axis of the bit. As long as this condition prevails, the bit will rotate about its own axis, as it naturally would do were it free of all external forces, for there is no unbalanced external force tending to create a new axis of revolution. Consequently, the bit follows the path of least resistance and drills the smallest possible hole determined by the size of the bit.

The hole drilled will, at the top, be the full original diameter of the bit, but at the bottom will be reduced in size by the amount of wear on the bit. With a tight hole of this character, drilling is slower and more difficult than with an oversize hole, and there is always the serious danger that the bit may jam in the hole and twist off, thus necessitating a very expensive fishing or milling job. In order to continue with a well, each section of hole must be full gauge all the way to bottom, and if the bit fails to drill it so, then the hole must be reamed before drilling is resumed, and this is an expensive and time-consuming operation.

It is therefore a general object of my invention to provide a bit which will drill a hole larger than the bit by at least an amount sufficient that the hole will remain as large as the original bit diameter.

It is also a main object of the invention to provide a bit which, when rotated, is forced to revolve about an axis other than its geometric axis and so revolves in a path of greater diameter than the bit.

I have found that these aims are attained in a bit constructed according to my invention by having the several cutting edges so arranged that at least one cutting edge is asymmetrical to the geometric axis of the bit. The resistance to the bit is then greater or lesser against that cutting edge; and the forces opposed to the drilling torque, being unbalanced with respect to the geometric axis, force the bit to revolve about some new axis around which all the forces and their moments are in equilibrium.

Now the above and other objects and advantages of my invention are attained will be more readily seen from the following description and the annexed drawing, in which:

Fig. 1 is a side elevation of a three blade drag bit;
Fig. 2 is a bottom view of the same bit;
Fig. 3 is a diagrammatic view, in plan, showing the cutting action of the bit;
Fig. 4 is a side elevation of a four blade bit; and
Fig. 5 is a view similar to Fig. 2 showing a four blade bit.

Figs. 1 and 2 show a three blade bit with a body 10 on which is a screw threaded pin 11 for attaching the bit to the drill pipe which rotates the bit. On the lower part of the body is one long or primary blade 14, which extends from the outside diameter of the bit to the center, and two short blades 15 which extend a shorter distance inwardly from the full bit diameter, as shown in Figs. 2 and 3. Though the lower edges of the blades are not necessarily horizontal, all blades extend down from the body 10 approximately the same distance in order that being approximately the same length they all can cut on the same surfaces of the hole being drilled. The blades are preferably radial, or nearly so, and are spaced about evenly around the body. Short blades 15 are placed away from the bit center as shown to provide additional digging surface out where the path travelled by the blades is longest, and the most material is to be removed, while in the central portion of the hole, the inner part of blade 14 is adequate to remove the smaller amount of material. Because they work on the bottom of the hole, the lower edges of the blades are termed bottom cutting edges, and the vertical side edges of the blades are termed reaming edges since they cut or ream the hole sides to produce a hole of larger diameter than produced by the bottom cutting edges.
Cutting action will best be understood by reference to Fig. 3 which shows diagrammatically the conditions and forces at the bottom of the hole. At the outset it may be explained that the external reactions or forces on the bit, as opposed to the internal forces or the rotating torque imparted by the drill pipe, may be divided into two classes. The first of these may be termed circular forces; that is, those resisting forces exerted against the cutting edges as they rotate and which oppose the drilling torque by the moments they produce. The second, the radial forces exerted on the bit by the side-walls of the hole in opposition to the reaming action and tend to constrict the bit to the hole produced by the bottom cutting edges.

If it is assumed that the bit rotates about its geometrical vertical axis 17, the hole cut will be represented by the dash-line circle 18; and if the direction of rotation is clockwise as indicated by arrow 20, the circular forces exerted against the advancing faces of blades 14 and 15 will be as indicated by arrows 21. All three blades extend inwardly from circle 18, which also represents the full gauge of the bit, to circle 24, so that all the cutting edges outside circle 24 are symmetrically disposed with respect to vertical axis 17 and the moments produced by these forces are balanced; but the cutting edge on blade 14 against the inner side wall of the hole will act against the radius of rotation of the bit and will result in a corresponding decrease of the face of blade 14 and there is a corresponding decrease from the maximum in radial force at each of blades 15, until finally the resultant of all forces on blade 14 exactly counterbalances the resultant of forces on blades 15 so that radial forces against these two blades are no longer required for equilibrium. The bit then rotates about axis 25. Thus the reaming tendency is greatest when the hole is smallest and, since it progressively decreases as the hole increases in diameter, there will be a limited maximum size bit or limit for the drill.

The exact position of actual center 28 of rotation will depend on several factors. Speed of rotation, weight on the bit, hardness of the formation, size and shape of the blades all determine the external forces acting on the bit and so influence the equilibrium position of the center of rotation. From this it will be seen that the position of axis 28 will likely shift from time to time as the bit progresses. However, the magnitude of the forces involved is always sufficient to drive one or more of the reasons far enough into the hole wall against the radial forces that the hole is larger than the original bit diameter, even after the bit has become worn and is under gauge.

Although certain latitude in proportions is permissible, I prefer that the short blades 15 have a width equal to one fourth the width of primary blade 14 lying half the width of primary blade 14 so that blade 14 is at least twice as wide as either of the other blades.

As typical of the performance of this bit, a 12 1/2 inch cutter under actual field conditions drilled a hole which was larger less than 12 3/4 inches and, as nearly as could be determined, was mainly about 14 inches in diameter. The reaming edge on blade 14 was but slightly worn while the reaming edges on blades 15 were heavily worn, especially the short blade next behind the long blade which indicated that the axis 28 was slightly in advance of blade 14.

The invention is not limited to any particular style of bit, size or shape of blades, or number of cutting edges, and may be made in many variations of the form described. The invention is illustrated in Fig. 4, which illustrates the application to a four blade or, by omitting two blades, to a two blade bit. The bit shown has a body 19a provided with four blades asymmetrically arranged, comprising one or more wide blades 30 and one or more narrow blades 8. This type of bit may be used in formations which are rather hard and brittle so that they ream with difficulty. Under these circumstances it is desirable to increase the circular forces to obtain increased reaming effect, and this is done by lengthening the bottom cutting edge on blade 8. Since the cutting edges are inclined upwardly and inwardly there will be between the blades a core-like projection of formation. In other respects the cutting action will involve the same principles already described.

Fig. 5 shows another variation in which the bit of Fig. 1 has four blades instead of three. An extra short blade 15a has been added, the blades still being radial but now spaced only 90° apart. The blade 15a may be the same as the other two blades 15, but is shown here as an extra heavy blade of increased thickness and reaming surface next behind the long blade 14 and is thus reinforced to withstand the extra heavy wear falling on that reaming edge, and is typical of the many various types of cutting edges that may be employed.
It will be understood that various shapes and arrangements of the blades and cutting edges may be made without departing from the spirit and scope of the appended claims.

I claim as my invention:

1. A rotary well drilling bit comprising a body and a plurality of individual cutting blades thereon spaced at intervals around the body and all extending below the body approximately the same distance, the outer edges of the blades being substantially equi-distant from the bit axis, and one of the blades being a primary blade that extends inwardly substantially to the bit axis and is at least twice the width of any other blade.

2. A rotary well drilling bit comprising a body and a plurality of individual cutting blades thereon spaced at intervals around the body and all extending below the body approximately the same distance, the blades having outer reaming edges substantially equi-distant from the bit axis, and one of the blades being a primary blade having a bottom cutting edge that extends substantially to the bit axis while the remaining blades have bottom cutting edges between a quarter and a half the width of the primary blade.

3. A rotary well drilling bit comprising a body and a plurality of individual cutting blades thereon spaced at intervals around the body and all extending below the body approximately the same distance, the outer edges of the blades being substantially equi-distant from the bit axis, and one of the blades being a primary blade that extends inwardly substantially to the bit axis and is at least twice the width of any other blade, and the blade next behind the primary blade being a reinforced blade of materially greater thickness and reaming surface than the other blades.

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