Feb. 27, 1934. S. R. HOPKINS 1,949,049

ROTARY DRILLING BIT

Filed Oct. 29, 1929 2 Sheets-Sheet 1

Fig. 1.

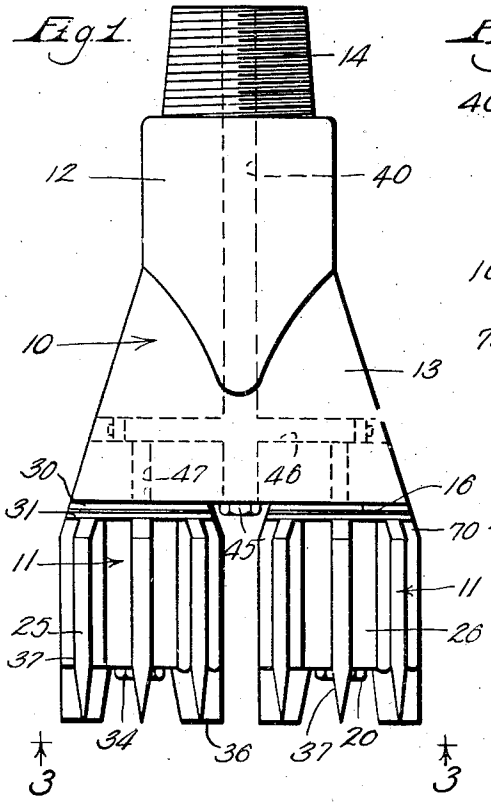
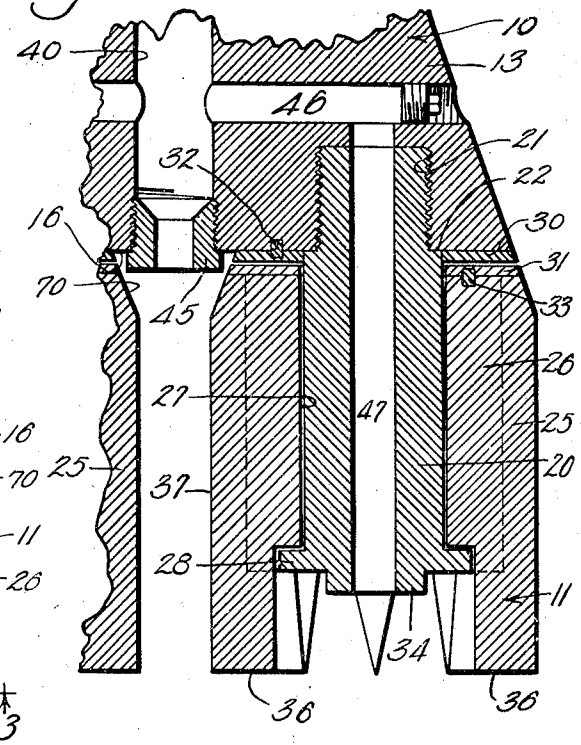


Fig. 2.



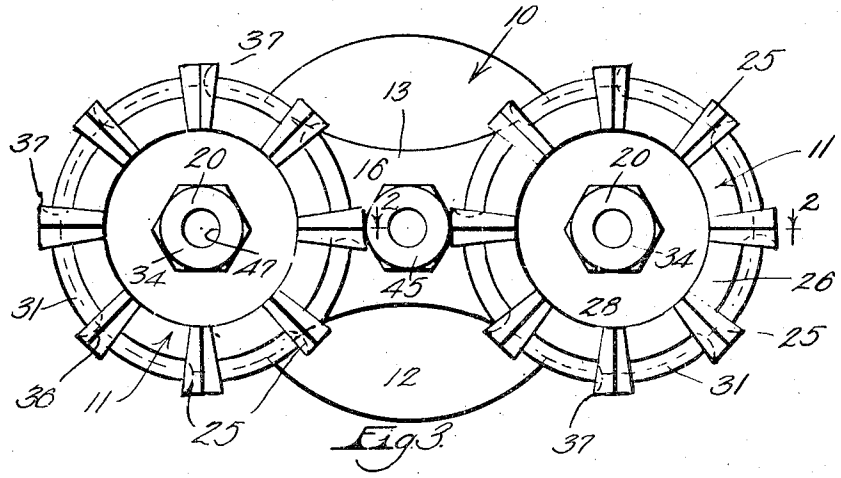


Fig. 3.

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Fig 4.

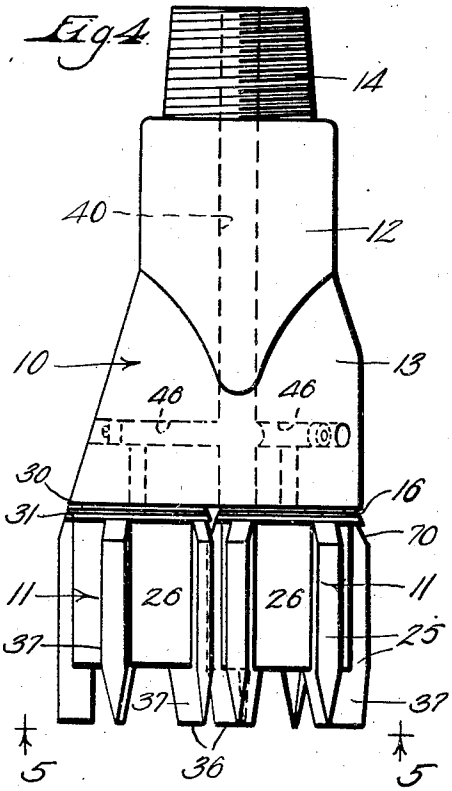


Fig 5.

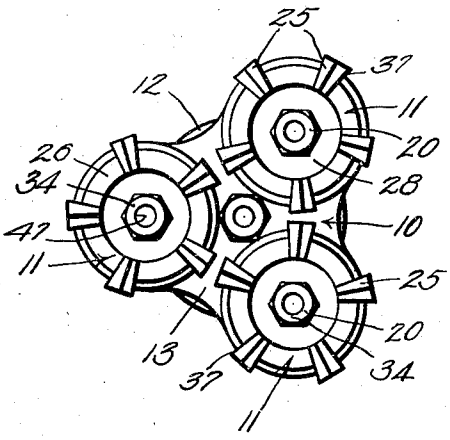


Fig. 6

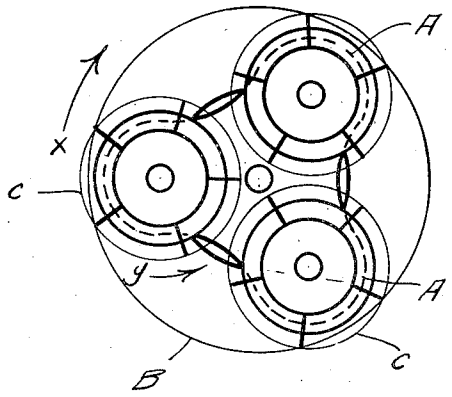
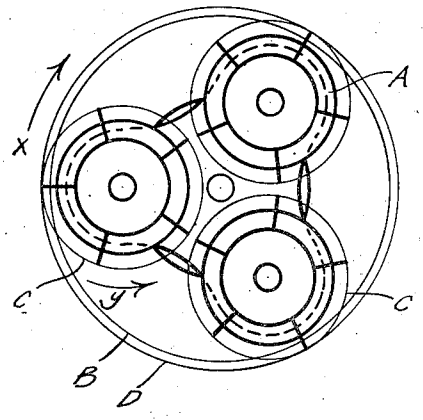


Fig 7.



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Patented Feb. 27, 1934 1,949,049

UNITED STATES PATENT OFFICE

1,949,049

ROTARY DRILLING BIT

Samuel Ray Hopkins, Long Beach, Calif., assignor, by mesne assignments, of one-half to Jesse C. Wright and one-half to William H. Maxwell, both of Los Angeles, Calif.

Application October 29, 1929. Serial No. 403,223

10 Claims. (Cl. 255—71)

This invention has to do with a well drilling bit, and it is a general object of the invention to provide an efficient, improved and practical tool of this character.

This application is filed as a continuation in part of my application entitled Rotary drilling bit, filed March 28, 1927, Serial Number 178,926.

It is, of course, well known that there are in use two distinct and fundamentally different methods of drilling deep wells; one the standard tool method, the other the rotary method. It is recognized that the equipment and tools used in connection with these two methods are distinctly different. The present invention is concerned, in fact confined, to a drilling tool or bit for use with the rotary method of drilling, and its various phases are to be considered with this in mind.

With the rotary method of drilling the drill or bit is fixed to the lower end of an operating member in the form of a string of pipe known as a drill pipe. The bit is operated by rotation of the drill pipe from the upper end of the well and by lowering the drill pipe to feed the bit into the formation. Simultaneously with the rotation and feed of the bit, circulating fluid, usually mud laden fluid known as rotary mud, is forced down through the drill pipe to discharge into the well bore at the bit. The circulating fluid is introduced for the purpose of keeping the bit clean and free to operate, for flushing or carrying cuttings out of the bore as it circulates upwardly around the drill pipe, and for coating the walls of the bore.

The matter of rotating the drill pipe is an important consideration in drilling, it being obvious that rapid or excessive speed of rotation has a tendency to result in a whipping action in the drill pipe and on the bit and sets up strains in the drill pipe that are destructive and liable to cause its failure. On the other hand, it is obvious that a reasonably rapid movement of the cutting parts of the bit with reference to the formation being cut is desirable in cutting many formations.

In drilling wells, particularly very deep wells, it is important to drill as straight as possible and to maintain the well bore to gauge. In practice the pitch or inclination of the strata through which the bore passes has a distinct tendency to throw the bit out of line so that the resultant bore is crooked, and with the bits heretofore available in the oil fields the gauge of the bore is lost after the bit has been operated but a short time.

It is a general object of this invention to provide a well drilling bit of the character mentioned, that is, of the rotary type, which is practical and operates effectively under a wide range of drilling conditions. The bit provided by this invention is effective and practical in drilling soft formations or those formations ordinarily requiring scraper or drag type bits, and is likewise effective in drilling harder formations such as usually require bits of the rock type.

It is another object of this invention to provide a bit having rotatable cutting parts which operate or turn during drilling. Through the present invention the bit may be turned bodily at a reasonable rate of speed to obtain a comparatively rapid and effective speed of engagement between the cutting parts and the formation being drilled.

Another object of this invention is to provide a bit of the character mentioned in which the movable or rotatable cutting parts are related to the body so that the tool will effectively withstand the severe strains and pressures encountered in actual drilling operations. In accordance with the present invention the cutters are perpendicular or parallel with the longitudinal axis of the tool and bear straight upwardly against the bottom of the body so that resting of the bit on the bottom of the well bore does not tend to bend or twist the cutters as is the case in bits in which the cutters are pitched or inclined with reference to the axis of the body.

It is another object of this invention to provide a bit of the character mentioned having provision for effective distribution of circulating fluid so that the operating parts, that is, the rotatable cutters, are kept effectively flushed or free to operate even in formation which tends to stick or ball up.

It is another object of this invention to provide a bit of the character mentioned in which the rotatable cutters have cutting edges across their lower ends and also vertically along their sides so that the bit is not only effective in cutting the bottom of the well bore, but also has effective cutting parts to engage the side of the hole to keep the hole to gauge.

Another object of this invention is to provide a bit of the character mentioned in which the rotatable cutters are mounted in a particularly effective, secure and dependable manner. It is one feature of the invention that the cutters are carried on studs or projections on the body so that the wear, due to operation, takes place

between the cutters and the mounting studs for the cutters, leaving the body unimpaired.

It is another object of the present invention to provide a bit of the character mentioned in which the several cutters projecting downwardly from the body are entirely free to rotate independently. By the present invention the cutters operate independent of each other so that the cutting action of the bit is not totally impaired even though one of the cutters may, for some reason or other, be fouled or stuck so that it does not operate to the best advantage.

A further object of the invention is to provide a bit of the character mentioned in which the rotatable cutters present horizontal cutting edges to engage the bottom of the well bore and in which the cutters are related to the body so that the horizontal cutting edges act on the formation at various angles during the operation of the bit.

Another object of the present invention is to provide bit of the character mentioned which has an underreaming action, that is, an action which operates to make a bore somewhat larger in diameter than that required to pass the bit.

It is a further object of the invention to provide a bit of the character described having rotatable cutters with teeth the lower ends of which are horizontally disposed to act on the bottom of a well bore and the outer ends or edges of which are vertically disposed to act on the wall of the bore.

It is another object of the invention to provide a simple, practical, effective construction of the type above referred to in which the rotatable cutters rotate on their individual axes in a direction opposite to their bodily rotation about the axis of the tool.

There are other objects and features of the invention which, together with those above referred to, will be best and more fully understood from the following detailed description of typical forms and applications of the invention, throughout which description I refer to the accompanying drawings, in which:

Fig. 1 is a side elevation of a typical and simple form of bit embodying the invention, being a view of a bit employing two rotatable cutters. Fig. 2 is an enlarged detailed sectional view taken at the lower portion of the bit showing in detail the mounting of a cutter and the provision made for circulating fluid. Fig. 3 is an enlarged bottom elevation of the bit, being a view taken as indicated by line 3—3 on Fig. 1. Fig. 4 is a view similar to Fig. 1 showing a form of the invention employing three cutters. Fig. 5 is a bottom end elevation of the bit shown in Fig. 4, being a view taken as indicated by line 5—5 on Fig. 4, and Figures 6 and 7 are diagrammatic views illustrating the action of the bit provided by my invention.

The bit provided by this invention includes, generally, a body 10 and a plurality of individually rotatable cutters 11 projecting downwardly from the lower end of the body to be rotatable about axes parallel with the longitudinal axis of the body. The invention contemplates the provision of a plurality of cutters in connection with the body; for instance, it may be carried out with two or more cutters. In Figures 1, 2 and 3 of the drawings I have illustrated the invention carried out with two cutters, whereas in Figures 4 and 5 of the drawings I have illustrated the manner in which the invention may be carried out with more than two cutters.

The body 10 is primarily a holder or mounting for the cutters 11 and is therefore subject to considerable modification or variation without departing from the spirit of the invention. In the particular case shown, reference now being had to Figures 1 to 3 of the drawings, inclusive, the body includes a stem or shank portion 12, and an enlarged or laterally projecting lower end portion 13. The stem or shank portion 12 of the body is provided at its upper end with means for connecting the bit with a string of drill pipe, or the like. In the case illustrated the shank is provided with an upwardly extending tapered screw threaded projection or pin 14 for the purpose of making this connection. The lower or enlarged end portion 13 of the body is preferably flattened in one direction and projects laterally in the opposite direction to support the cutters 11 in the desired position with reference to the central axis of the tool, the portion 13 is preferably made as thin as possible between the cutters. In the preferred construction the lower end of the body portion 13 is finished so that it is in the form of a flat face 16 lying in a horizontal plane. It is to be understood, of course, that the body is proportioned to form the necessary support or carrier for the cutters 11 at the same time occupying as little of the well bore as possible so that the circulating fluid discharged at the bit is allowed to circulate freely upward around the bit.

In accordance with the invention, the cutters 11 are symmetrically disposed with reference to the central axis of the bit, that is, in the case of a bit having two cutters they are located diametrically opposite each other, while in the case of a bit having three cutters they are located 120 degrees apart around the central axis of the bit. By symmetrically arranging the cutters about the central axis of the bit, the structure is balanced so that it operates smoothly and drills straight into the formation.

The cutters are proportioned, that is, made of such diameter with reference to the size of the body, and are so located on the bottom end of the body as to project laterally beyond the margins of the body and at the same time more or less closely approach the central axis of the body. The cutters are related, however, so that there is clearance between them thus eliminating danger of the cutters fouling each other or the danger of a small object, such as a piece of the formation, getting between the cutters in a manner to foul them.

In accordance with the invention the cutters are mounted to project downwardly from the lower end face 16 of the body and to rotate freely about vertical axes, that is, about axes parallel with the longitudinal axis of the bit. In accordance with the broader principles of the invention the cutters may be mounted on or attached to the body in various manners so that they have the desired action with reference to the body. In the preferred form of the invention each cutter 11 is mounted on a spindle or stud 20 which projects downwardly from the face 16 of the body 10. In the particular case illustrated each cutter carrying stud is detachably connected with the body, being screw threaded into a socket 21 formed upwardly in the body portion 13 from the end face 16. The stud fits tightly in the socket 21 and may be provided with a shoulder 22 to seat against the end face 16 in the manner clearly illustrated in Fig. 2 of the drawings.

Each cutter 11 is cylindrical in its general con-

figuration, the cylinder being flat at its ends; the upper end for communication of vertical thrust to the body, and the lower end for engagement with the bottom of the bore. The cutter is, however, not a solid or continuous cylindrical structure but is formed of a plurality of teeth 25 which are preferably spaced a substantial distance apart circumferentially to give circulation clearance and to obtain the underreaming effect which will be apparent from the diagrams Figures 6 and 7.

The teeth are joined together or formed on a central hub 26 which is rotatably supported on the spindle 20. In the particular case shown the hub 26 has a central longitudinal bore 27 extending through it from one end to the other, which bore receives the spindle 20. In practice the hub may be secured on the spindle in any suitable manner; for instance, where the bore 27 extends completely through the hub the spindle may project slightly beyond the lower end of the hub where it may be provided with a radial flange 28 to overhang the lower end of the hub in the manner clearly illustrated in Fig. 2 of the drawings. The upper end of the cutter, for instance, the upper end of the hub 26 is flat and adapted to communicate vertical thrust to the body. In the case shown thrust washers 30 and 31 of suitable material are interposed between the upper end of the cutter and the face 16 of the body to take the wear between the cutter and body.

The thrust washer 30 engages the face 16 of the body and is held against rotation relative to the body by a pin 32, while the thrust washer 31 engages the upper end of the cutter and is held against rotation relative to the cutter by a pin 33. When employing the form of mounting for the stud shown in the drawings, the stud may be provided at its lower end with a head part 34 adapted to be engaged by a wrench, or the like, to facilitate screwing the stud into and from the socket 21.

The teeth 25 of the cutter are an important phase of the present invention and in their preferred form they have horizontally disposed lower end cutting edges 36 and perpendicular or vertically disposed side cutting edges 37. The end cutting edges 36 extend inwardly from the periphery of the cutter. In a case where the cutter is mounted by a stud passing upwardly through it from its lower end, the edges 36 terminate before reaching the center of the cutter, as will be apparent from the drawings. The pitch or angularity of the edges 36 across the end or face of the cutter may vary. In the case illustrated the edges 36 are arranged to extend radially with reference to the axis of rotation of the cutter. The teeth are provided on, for instance formed integral with the hub 26, and preferably extend or project a substantial distance downwardly below the hub as illustrated throughout the drawings. The teeth 25 project radially outward beyond the hub 26 and preferably extend longitudinally of the cutter from one end to the other. The side or outer edges of the teeth may be finished or dressed to present cutting edges 37 adapted to act on the side wall of the bore as the tool operates. By thus extending the teeth 25 vertically the entire length of the cutter, the bit is provided with ample side cutting parts to maintain the hole to gauge. It is to be understood, of course, that the teeth, for instance, the cutting edges 36 and 37 of the teeth, may be dressed or finished to cut the formation to the best advantage and that the parts may be suitably treated or faced with hard material in accordance with the practice followed in tools of this character.

For the purpose of handling the circulating fluid the body 10 is provided with a central longitudinal circulation opening 40 adapted to receive the circulating fluid from the part to which the bit may be attached. The circulation opening 40 preferably extends vertically through the body from one end to the other, and at the lower end of the body it is preferably restricted or reduced, as by a reducer 45, so that the circulating fluid jets downwardly at the center of the bit at a high velocity. The circulating fluid thus discharged will, after leaving the body, pass radially outward around and through the cutters in a manner to effectively flush them to keep them in operation condition. Further, in accordance with the preferred form of the invention provision may be made for discharging circulating fluid at the individual cutters. In the form of the invention shown branch circulation openings 46 are provided in the body to introduce circulating fluid into central circulation passages 47 formed through the studs 20. Circulation passages 47 in the studs discharge downwardly at the lower ends of the studs. Circulating fluid discharged from the studs 47 circulates out between the downwardly projecting teeth-like parts below the studs, thus keeping them flushed clean and in proper operating condition. By making the several discharge openings the same size, the discharge from them will be substantially equal.

It will be obvious that the principles of the invention are present in both of the forms illustrated in the drawings, that is, in the bit employing two cutters as shown in Figures 1, 2 and 3 as well as in the bit employing three cutters as shown in Figures 4 and 5. The general mode of operation of either form of the invention is the same, and, in fact, the general construction of the two forms of the general invention is the same. In the case of a three-way or three-cutter bit, as shown in Figures 4 and 5, the body part 13, instead of being flattened to project laterally in diametrically opposite directions, is made to project in three different directions equally spaced around the axis of the bit as will be apparent from the drawings.

By properly relating and proportioning the parts of the tool, the desired undercutting or underreaming action may be obtained. The underreaming action of the bit will be best understood from consideration of the diagrams Figures 6 and 7. In Fig. 6 the cutters indicated diagrammatically at A are rotatably positioned so that the bit will pass through a casing or opening having internal diameter corresponding to the circle B. In Fig. 7 I illustrate by the circles C the cuts made by the individual rotation of the cutters, and I indicate by the circle D the cut made by the entire bit. It will be apparent that the bit when in operation cuts a larger hole or bore than is required to pass it. The independence of the individual cutters allows them to assume the positioning shown in Fig. 6 so that the tool can be raised and lowered through an opening the size of the circle B. In practice it is desirable to bevel the upper end of the laterally projecting portions of the cutters as at 70 to facilitate withdrawal of the bit, for instance, the drawing of the bit upwardly into a casing which may have an internal diameter such as is represented by the circle B in Fig. 6.

In operation the bit applied to the lower end of a string of drill pipe is lowered into the well bore and as the bit is rotated by the drill pipe, it is lowered into engagement with the bottom of the bore. The engagement of the bit with the formation, for instance, with the bottom of the bore and the side walls of the bore, causes the cutters to rotate individually about their axes as the bit rotates bodily. The bodily rotation in the general direction of rotation of the bit represented by the arrow X in Fig. 7 is opposite to that of the individual rotation of the cutters as indicated by the arrows Y in Fig. 7. It will be apparent that the individual cutters will turn on their axes faster than the bit turns about its axis, thus gaining an effective speed of engagement of the cutting parts with the formation without rotating the drill pipe or the bit rapidly. As the bit is lowered against the formation, the edges 36 of the cutters have a combination twisting, grinding, and scraping action on the formation which effectively cuts it away. The parts of the cutters may be so spaced and proportioned that the cuttings are effectively flushed or washed away by the circulating fluid, leaving the bit free for efficient operation. The vertical thrust coming upon the cutters due to lowering the bit against the bottom of the bore, is transmitted to the body in an effective manner without tending to distort or bind the cutters.

Having described only typical, preferred forms and applications of my invention, I do not wish to limit myself to the specific details set forth, but wish to reserve to myself any changes or variations that may appear to those skilled in the art or fall within the scope of the following claims.

Having described my invention, I claim:

1. A bit for use on an operating string of drill pipe including, a body having a central longitudinal fluid passage, cutters, means mounting the cutters on the lower end of the body for independent rotation about vertical axes symmetrically spaced about the central longitudinal axis of the body including tubular spindles rotatably supporting the cutters, and longitudinal cutting parts on the cutters spaced substantial distances apart circumferentially of the cutters, the said central longitudinal fluid passage discharging from the lower end of the body between the cutters and the spindles being in communication with the said passage to discharge from the lower end of each cutter.

2. A rotary well drilling bit including, a body adapted to be rotated, a plurality of cutters, drilling blades on the cutters spaced substantial distances apart circumferentially of the cutters and being in planes radial relative to the cutters, and means mounting the cutters on the lower end of the body to rotate free of one another about axes parallel with and spaced from the axis of rotation of the body, the cutters being proportioned and positioned with respect to the body so that the said blades project beyond the periphery of the body during operation of the bit to make a bore of greater diameter than the body and so that the cutters may be positioned where all of the said blades are within a circle of substantially the same diameter as the body whereby the bit may be passed through an opening of less diameter than said bore.

3. A rotary well drilling bit including, a body adapted to be rotated, a plurality of cutters, drilling blades on the cutters spaced substantial distances apart circumferentially of the cutters and being in planes radial relative to the cutters, cutting teeth projecting downward from the lower end of the cutters, and means mounting the cutters on the lower end of the body to rotate free of one another about axes parallel with and spaced from the axis of rotation of the body. the cutters being proportioned and positioned with respect to the body so that the said blades project beyond the periphery of the body during operation of the bit to make a bore of greater diameter than the body and so that the cutters may be positioned where all of the said blades are within a circle of substantially the same diameter as the body whereby the bit may be passed through an opening of less diameter than said bore.

4. A rotary well drilling bit including, a body adapted to be rotated, a plurality of cutters, drilling blades on the cutters spaced substantial distances apart circumferentially of the cutters and being in planes radial relative to the cutters, and means mounting the cutters on the lower end of the body to rotate free of one another about axes parallel with and spaced from the axis of rotation of the body, the cutters being proportioned and positioned with respect to the body, so that the said blades project beyond the periphery of the body during operation of the bit to make a bore of greater diameter than the body and so that the cutters may be positioned where all of the said blades are within a circle of substantially the same diameter as the body whereby the bit may be passed through an opening of less diameter than said bore, the said means including tubular studs rotatably carrying the cutters, the studs being in communication with a circulation opening in the body.

5. A rotary well drilling bit including, a body adapted to be rotated, a plurality of cutters, projecting cutting parts on the cutters spaced a substantial distance apart circumferentially of the cutters, and means rotatably mounting the cutters on the bottom of the body to project downwardly therefrom and in positions where the cutting parts may project beyond the periphery of the body to drill a bore of greater diameter than the body, the cutters being independently rotatable whereby they can be turned to positions where the cutting parts are all within a circle of the same or less diameter than the body so that the bit can be passed through an opening of less diameter than that of the bore made by the bit.

6. A rotary drilling bit including, a body adapted to be rotated, a plurality of cutters each having a plurality of substantially radially projecting blades spaced substantial distances apart circumferentially of the cutter, and means mounting the cutters on the body to project downwardly therefrom and to be independently rotatable about axes spaced from and substantially parallel with the axis of rotation of the body, the cutters being proportioned and positioned relative to the body so that the bit can be passed through an opening smaller in diameter than the bore made when the cutters rotate about their axes when the body rotates about its axis.

7. A rotary drilling bit including, a body adapted to be rotated, a plurality of cutters each having a plurality of blades projecting substantially radially of the cutter and spaced substantial distances apart circumferentially of the cutter, and means mounting the cutters on the body to project downwardly therefrom and to be independently rotatable about axes spaced from and substantially parallel with the axis of rotation of the body, the cutters being proportioned and posi-

tioned relative to the body so that the bit can be passed through an opening smaller in diameter than the bore made when the cutters rotate about their axes when the body rotates about its axis, the blades of each cutter having straight side cutting edges parallel with the axis of rotation of the cutter.

8. A rotary drilling bit including, a body adapted to be rotated, a plurality of cutters each having a plurality of blades projecting substantially radially of the cutter and spaced substantial distances apart circumferentially of the cutter, and means mounting the cutters on the body to project downwardly therefrom and to be independently rotatable about axes spaced from and substantially parallel with the axis of rotation of the body, the cutters being proportioned and positioned relative to the body so that each cutter cuts from a point close to the axis of rotation of the body to a point outward of the outermost part of the body and so that the bit can be passed through an opening smaller in diameter than the bore made when the cutters rotate about their axes when the body rotates about its axis.

9. A rotary drilling bit including, a body adapted to be rotated and having a flat lower end at right angles to its axis of rotation, a plurality of cutters each having a plurality of blades projecting substantially radially of the cutter and spaced substantial distances apart circumferentially of the cutter, and means mounting the cutters on the flat lower end of the body to project downwardly therefrom and to be independently rotatable about axes spaced from and substantially parallel with the axis of rotation of the body, the cutters being proportioned and positioned relative to the body so that the bit can be passed through an opening smaller in diameter than the bore made when the cutters rotate about their axes when the body rotates about its axis.

10. A rotary drilling bit comprising a body, a plurality of cutters rotatably mounted upon the body for rotation about substantially vertical axes, each of the several cutters having more than two radially extending blades and being adapted during rotation to rotate independently of adjacent cutters about an axis which is spaced from the axis of rotation of the body, the cutting edges of each blade being horizontally arranged, and the cutters being arranged near the sides of the bit so that during rotation their blades may swing through arcs which project materially beyond the sides of the bit.

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