

June 30, 1931.

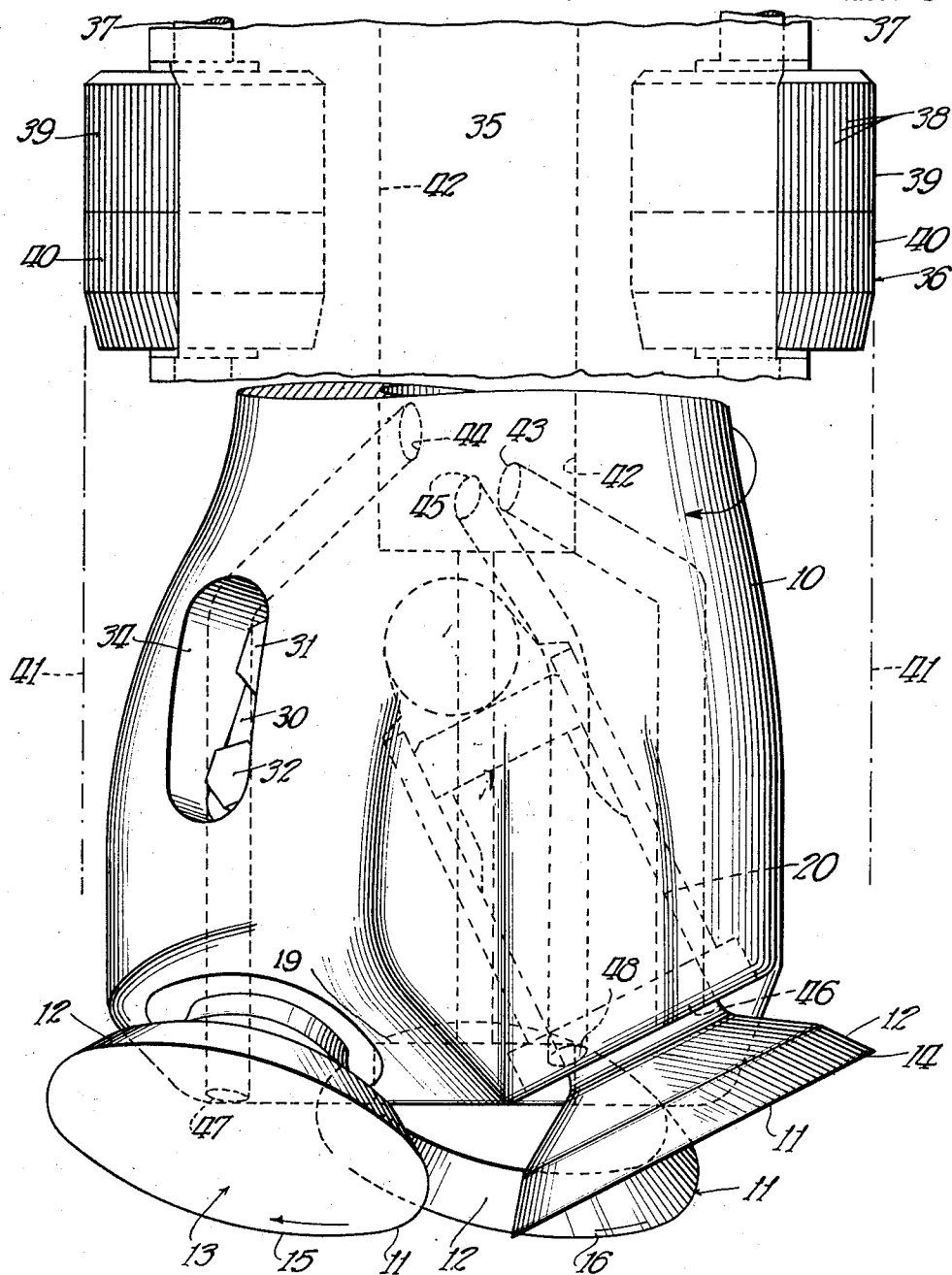
A. M. GILDERSLEEVE ET AL

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DRILLING DEVICE

Filed March 19, 1927

2 Sheets-Sheet 1



Inventors:
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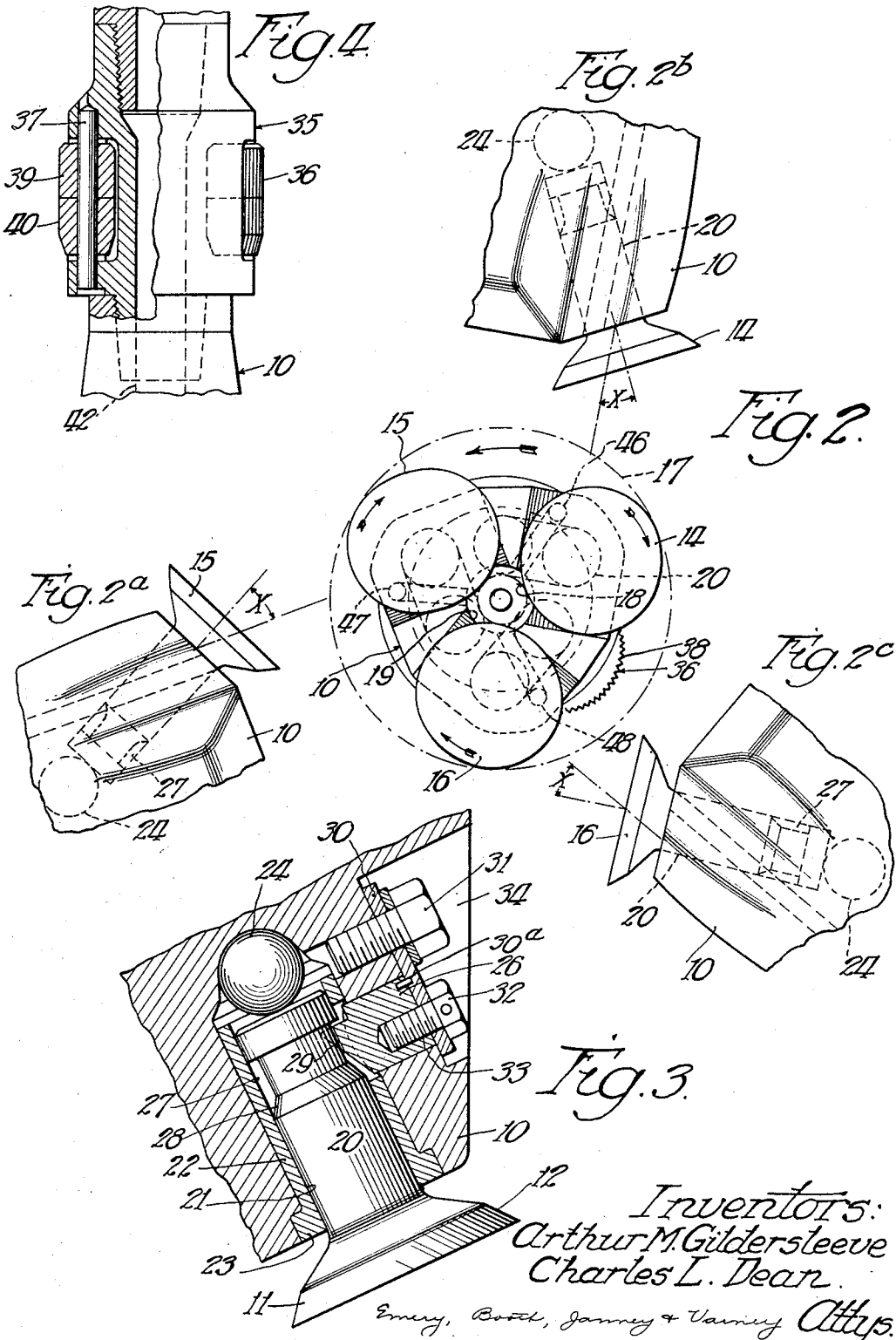
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UNITED STATES PATENT OFFICE

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TO THE UNIVERSAL ROTARY BIT COMPANY, OF DENVER, COLORADO, A CORPORATION OF COLORADO

DRILLING DEVICE

Application filed March 19, 1927. Serial No. 176,610.

This invention relates to drilling devices of the type generally disclosed in our co-pending application Serial No. 147,415, filed November 10, 1926; and aims to provide a durable and efficient drilling device of a different design.

The nature of the invention may be readily understood by reference to an embodiment thereof in the form of a bit for earth and rock drilling, such as oil well drilling, said bit together with one method of use being disclosed and illustrated in the specification and accompanying drawings.

In said drawings:

Fig. 1 is an elevation of the illustrative bit detached from the drill stem which rotates it, certain unimportant sections having been broken away to enable illustration on a larger scale. As indicated by the arrow the bit is designed to rotate in a clockwise direction, or, if viewed from its lower end, in a counter clockwise direction. This elevation is taken in a vertical plane parallel to the axis of cutter 14.

Fig. 2 illustrates, in a somewhat diagrammatical fashion (and on a smaller scale), an end view of the bit, together with an outline of a section of the hole which the bit drills. The dotted lines associated with the respective cutters indicate the endwise projection of the cutter axes and shafts and their angular position with respect to the center line of the bit.

Associated with Fig. 2 are fragmentary elevations (Figs. 2^a, 2^b, and 2^c) of the lower end of the bit when viewed respectively from directions perpendicular to vertical planes (or planes parallel to the axis of the bit) containing the axes of the respective cutters, in order to represent the true angular position of the respective cutters with reference to the vertical axis of the bit. For example, when the bit is viewed in the direction indicated by the dot and dash line connecting Fig. 2^c, the axis of the cutter 16 has the inclination to the vertical indicated in Fig. 2^c.

Fig. 3 is a fragmentary section through a cutter illustrating a locking device for removably holding the cutter in place.

Fig. 4 is an elevation, on a reduced scale, of the reamer section.

The illustrative rotary bit comprises a bit body 10, in this instance of more or less cylindrical outline, provided with a plurality of boring tools herein represented by wedging cutters. This bit exemplifies a construction in which a plurality of cutters (three in this case) cut or travel in the same path as contrasted with an arrangement in which each cutter cuts in a different path. The cutting edges of the tool are advantageously arranged at a substantial angle relative to the vertical or axis of the bit and also at an angle (other than a right angle) to the (instantaneous) direction of travel of the cutter, i. e., to the tangent to the path of travel, to engage the rock or other material to be cut with both a wedging and sliding cut,—thereby increasing the efficiency of the wedging cutting action by which the material is chipped or split loose.

In the illustrative bit these wedging cutters are represented by circular discs 11 having conical cutting faces 12 and arranged to rotate on their own axes to facilitate the wedging or chipping action effected by the angularly disposed cutting edge and to provide for a continuously changing cutting edge. The sharp cutting edge on the cutters is provided by the termination of the conical face 12 with the outer face 13 of the disc, which latter face is shown flat but may be concave to make a keener cutting edge.

In other words, each disc bites into the rock or other material with both a cutting and upward wedging action (and as distinguished from a scraping or grinding action), the adjacent upper conical surface of the disc (located at a substantial angle to the vertical or axis of the bit) acting as the wedge to chip and split off relatively large pieces of rock or other material and to force them upward and out of the path of the cutter, whence they may be carried away as later described. The wedging action of the cutters whereby relatively large pieces of rock and hard material are chipped and split loose, is somewhat analogous to the action of the stone cutter's chisel,—namely, the particles of rock are de-

tached by an entering cut which sets up wedging forces which split the balance of the material by which a given particle is attached, with a much less expenditure of power than if the material were loosened by a continuous cut. This cutting by the discs from the solid material to the clear space above the discs not only minimizes the resistance of the material to the drilling operation but maintains the cutters free from interference and blocking by accumulations of already cut material and saves the energy which would otherwise be wasted in crushing and grinding already cut material if it were permitted to lodge between the cutters and the solid or uncut material.

To place the cutting edges of the cutters in the above described favorable position for efficient action and also to leave a clearance between the uncut material and the non-cutting portions of the cutters, the axes of the cutters are inclined (forwardly in the direction of rotation) to the vertical or axis of the bit (in the present bit about twenty-six degrees, see angle α) and inclined horizontally or laterally to the direction of travel of the cutter (to "skew" the cutter). The skewing of a cutter shifts the active cutting edge in or out (as the case may be) from a position directly in front of its axis and results in a tendency for the cutter to rotate on its axis toward the side where the cutting occurs. This inclination of the faces of the discs, moreover, causes them to be self-sharpening,—that is a relatively sharp cutting edge is maintained as the discs wear away.

The bit is here shown with three cutters designated respectively as 14, 15, and 16 arranged at a common level and at equal distances from and at the same inclination to, the axis of the bit,—whereby the cutters travel substantially in the same cutting path.

The above mentioned rotation of a cutter on its axis may generally be explained by the fact that the resultant of the force acting against the cutter edge does not intersect the axis (extended) of the cutter. The particular direction in which a cutter rotates depends upon the direction of such resultant force relative to the axis of the cutter. In the present arrangement the cutters rotate in a direction opposite to that of the bit. That is, the bit here rotates in a clockwise direction (viewed from above) and the cutters rotate in a counter clockwise direction, because the forces resisting them have a tangential component in a counter clockwise direction relative to the active portions of the cutter edges. The relative speed of axial rotation of a cutter obviously depends to some extent upon the position of the cutter relative to the axis of the bit, i. e., on how much the cutter is "skewed" relative to its path of cutting.

The path cut by the cutters lies (in plan view) between the dotted circle 17 (representing the hole drilled) and the circle 18,

leaving a small knob of material at the center of the hole to be progressively broken away by the body of the bit as the latter advances. The cutters are constructed and arranged so that this knob of material is limited to a size which may be readily broken away without substantial interference with the progress of the bit. In the present case the bit body is provided with a central depression 19 (into which the uncut knob of material enters) to permit the knob to grow to a greater height, thereby increasing the ease with which the knob is progressively broken away because of the greater likelihood that the knob will develop weak spots.

Where substantially larger holes are to be drilled, or more cutters are desirable for any other reason, an additional cutter or cutters may be located closer to the axis of the bit and advantageously lower down (as illustrated in said co-pending application) to bore the central portion of the hole and to lessen the duty on, and if desired, the number of, the outer concentric cutters as well as to keep the size of the cutters within practical limits. Thus the inventive bit may be constructed and arranged to keep the work required of a given cutter or series of concentric cutters within practical limits by the use of a larger number of cutters. Since the loss of time in replacing worn cutters (including, of course, the time spent in raising and lowering the bit and drill pipe) represents a very substantial item of drilling cost, a considerable saving may be effected by employing (for larger holes) a larger number of cutters of a smaller and more practical size having collectively a greater life. The number and location of the cutters is preferably such as will result in practically uniform wear on the cutters, thereby increasing to a maximum the period of active operation of the bit before withdrawal becomes necessary.

In the present case, the cutters are carried on integral stems or shafts 20 which stems are carried in cylindrical openings 21 arranged in the body of the bit to give the axes of the cutters the desired inclination. Within these openings are mounted removable bushings 22 (advantageously of hard and tough alloy steel) which terminate flush with the outer face of the body of the bit and serve as bearings for the cutter stems. The lower ends of the bushings are enlarged as at 23 to add strength at the point of greater strain. The juncture of the cutter shaft with the back of the (see Fig. 3) cutter is generously filleted, to eliminate any weak spot which might develop a crack. The cutter stems preferably fit loosely within their bushings in order to admit readily (for purposes of lubrication) some of the flushing liquid which is pumped into the hole, as presently explained. Steel balls 24 represent thrust bearings to receive and withstand without undue friction the

thrust against the cutters and the weight of the bit and drill shaft, which in some instances and under some conditions may approximate fifty tons for deep wells.

5 The cutters and cutter shafts are conveniently held in place by releasable means represented in this instance, by lock pins 26 which project into circumferential grooves or recesses 27 in the respective cutter shafts (Fig. 3). Each groove 27 is filleted at 28 at its lower edge to avoid creating a weak point in the cutter shaft. The end 29 of each pin is curved to conform with the contour of the cutter shaft in the region of contact (see Fig. 3). The pin also prevents any loose bushings from dropping down or out. Each lock pin is held in place by a lock plate 30, secured to the bit body by the screw 31 and to the lock pin by screw 32. The screw hole 33 in the lock pin is eccentric to the axis of the pin, thereby insuring the correct positioning of the lock pin in the cutter shaft groove (see Fig. 3). A dowel pin 30^a carried by plate 30 and entering an appropriately located dowel hole in pin 26 not only assists in making it evident at once when pin 26 is improperly located but holds the pin firmly against any tendency to twist and bind against the cutter shaft. The lock plate and screws are located in a recess 34 in the body of the bit so that they will not project beyond the outer bit surface. To remove a cutter it is necessary simply to withdraw the screws 31 and 32 until the lock pin clears the groove in the cutter shaft.

The bit stem or upper end of the bit (broken away in Fig. 1) is slightly tapered and provided with external screw threads for making a driving connection with the drill shaft. The bit is advantageously provided with a safety or protecting element. In the present bit this element is in the form of a signaling device comprising an under sized reamer section 35 in this instance separable from the bit and provided with internal and external threaded upper and lower ends respectively which receive the threaded extremities of the bit stem and body, respectively (see Fig. 4). If the reamer section be omitted the bit stem is arranged to screw directly into the internal threads on the main part of the bit body. The signaling device is provided with material engaging elements represented by a plurality of rotatable reaming cutters preferably 50 equally spaced on the circumference of the reamer and having their axes arranged substantially parallel with the axis of the bit, and being mounted in the reamer body by shafts 37, which carry loose washers to provide bearing surfaces at the upper and lower ends of the cutters. The cutting faces of the reaming cutters 36 are appropriately provided with a series of cutting teeth or ridges 38. Each reaming cutter may be divided into a plurality of sections (two sections 39 and 40

being shown in this instance) to permit seasonable replacement of the particular sections exhibiting the greater wear.

The effective or reaming diameter of the reamer is advantageously only slightly larger 70 than the body of the bit and less than the cutting diameter of the bit, the difference in diameter being indicated by the dot and dash lines 41 which represent the effective diameter of the reamer. Thus the safety device is idle 75 until in the operation of the bit the wear on the cutters reduces the cutting diameter of the bit (and consequently that of the hole cut) to that of the reamer whereupon the material engaging elements take hold of the 80 sides of the hole and the increased drag on the drill pipe is of such a steady and prolonged character as to be noticed and recognized by the driller. Thus the safety device serves to signal the driller when the wear on 85 the cutters is such as to endanger the body of the bit. The driller would then raise the bit and supply it with fresh cutters before there has been any destructive wear on the body of the bit. Since the safety device may 90 be relied upon to give an effective signal or warning of the limit in reduction of bit diameter, the bit may be operated to the full life of a set of cutters with the assurance that the bit itself will not be damaged. This avoids 95 premature and frequent withdrawals of the bit which otherwise might be resorted to as a guard against destructive wear on the bit body. This is particularly advantageous since the life of a set of cutters depends 100 largely on the character of the material cut and not on the length of time the cutters have been operating. This practice effects a material reduction in drilling costs since the loss of time and labor involved in bit withdrawals 105 is a large item of drilling expense. When the reamer takes hold and until the driller appreciates the signal, the hole will be maintained thereby at a diameter sufficiently large to clear the cutters readily when the bit is 110 withdrawn.

The bit is rotated by a hollow drill shaft or pipe screwed to the upper end of the bit. Power is applied to the drill pipe according to well known practices. The passage 115 through the hollow drill shaft communicates with the interior of the bit through a relatively large passage 42 extending through the reamer sections and the upper portion of the bit body. From the lower extremity of 120 passage 42 a number of smaller passages 43, 44, and 45 extend to the lower surface of the bit body with their respective outlets 46, 47, and 48 directed against and adjacent the cutter edges in their cutting regions (see Figs. 1 125 and 2). In this case an additional outlet is formed through the axial center of the bit to provide an ample volume of flushing liquid. Other outlets may be provided in this or other designs to secure an ample flow of 130

liquid. During the drilling operation water or a mixture of water and mud or other solid material, is forced under pressure through the drill pipe and the bit body and through the holes 43, 44, and 45 which direct it against the cutters, as described, to carry or float away the cuttings and chips as fast as they are loosened. The water and material are carried upwardly around the outer surface of the bit and drill stem to the surface of the hole. This procedure avoids clogging or "balling up" of the bit, for example, by sticky gumbo which might otherwise accumulate and harden around the cutting discs to render the bit inoperative. In this connection, the bit body, particularly its lower portion, is designed (see Fig. 1) to provide ample water spaces around and adjacent the cutters to provide for the escape of the flushing liquid laden with chips and cuttings.

The improved bit will cut rapidly through hard material, such as sandstone, limestone and other rock, customarily encountered in drilling deep wells, as well as through softer materials such as clay, shale, and gumbo (cutting those softer materials with a slicing action),—thus avoiding the expensive and time consuming procedure of changing bits whenever the bit is about to pass from hard to soft material, and vice versa. The relatively longer life of the cutters (which may readily be made of the most efficient hard and tough alloy steel) also reduces the number of times a sharp bit must be provided to drill to a given depth.

The efficiency of the cutting action of the cutter enables the bit to be operated with less power, thereby greatly reducing the strain on the drill stem (with the consequent increase in its life) and permitting a deeper hole to be drilled within a limited expenditure of power.

Although for purposes of convenience the bit has been described as rotating about a vertical axis, as would be the case in drilling an oil well, for example, it is obvious that it may rotate about any other axis, if used, for example, in drilling a horizontal or an inclined opening.

Obviously the invention is not limited to the details of the illustrative bit or the method of drilling here disclosed, since these may be variously modified. Moreover, it is not indispensable that all features of the invention be used conjointly since various features may be advantageously employed (without others) in different combinations and sub-combinations.

Having described one embodiment of our invention, we claim:

1. A bit for deep well drilling through earth and rock comprising in combination a rotary bit body of generally cylindrical outline, a plurality of circular cutters having shafts carried in holes in said body and ar-

anged to support said cutters so that they engage the material to be cut at a cutting angle substantially less than ninety degrees, said cutters being made of hard steel so as to cut or chip hard rock as well as softer materials, said cutter shafts each being provided with a retaining recess, a locking pin projecting into said recess to hold the shaft and cutter in place, the end of said pin being arranged to conform substantially to the contour of said recess, said pin being provided at its outer end with an eccentric retaining element, and a fastening element on said bit body constructed and arranged to cooperate with said retaining element to hold said pin in place when said pin is properly positioned but which will not register with said retaining element when said pin is improperly positioned.

2. A bit for deep well drilling through earth and rock comprising in combination a rotary bit body of generally cylindrical outline, a plurality of circular cutters having shafts carried in holes in said body and arranged to support said cutters so that they engage the material to be cut at a cutting angle substantially less than ninety degrees, said cutters being made of hard steel so as to cut or chip hard rock as well as softer materials, said cutter shafts each being provided with a retaining recess, a locking pin projecting into said recess to hold the shaft and cutter in place, the end of said pin being arranged to conform substantially to the contour of said recess, and a locking plate removably secured to said bit body, said plate and pin being provided with a cooperating projection and recess arranged to register when the pin is properly positioned, and to hold said pin against the tendency to twist and bind against the cutter shaft.

3. A bit for deep well drilling through earth and rock comprising in combination a rotary bit body, a plurality of hard steel cutters projecting from said body and arranged to cut a hole larger in diameter than said body, and a reamer above said cutters mounted in said body at a reaming diameter sufficiently less than the normal cutting diameter of said cutters that normally it performs no work but of a greater diameter than the maximum diameter of the bit body.

4. A bit for deep well drilling through earth and rock comprising in combination a rotary bit body of generally cylindrical outline, three or more circular cutters having shafts carried in holes in said body and arranged to support said cutters so that they travel in paths of equal diameter and engage the material to be cut at a cutting angle substantially less than ninety degrees, said cutters being made of hard steel so as to cut or chip hard rock as well as softer materials, the shafts of said cutters being substantially inclined laterally of the direction of travel

of the respective cutters to skew the latter
a substantial angle to the instantaneous di-
rection of travel of the active portion of the
cutter edge whereby to secure a sliding cut-
5 ting action of the cutter and provide a com-
ponent of force of sufficient strength to insure
the continuous rotation of the cutter so as to
effect a continuous change of cutting edge.

In testimony whereof, we have signed our
10 names to this specification.

ARTHUR M. GILDERSLEEVE.
CHARLES L. DEAN.

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