

Dec. 12, 1967

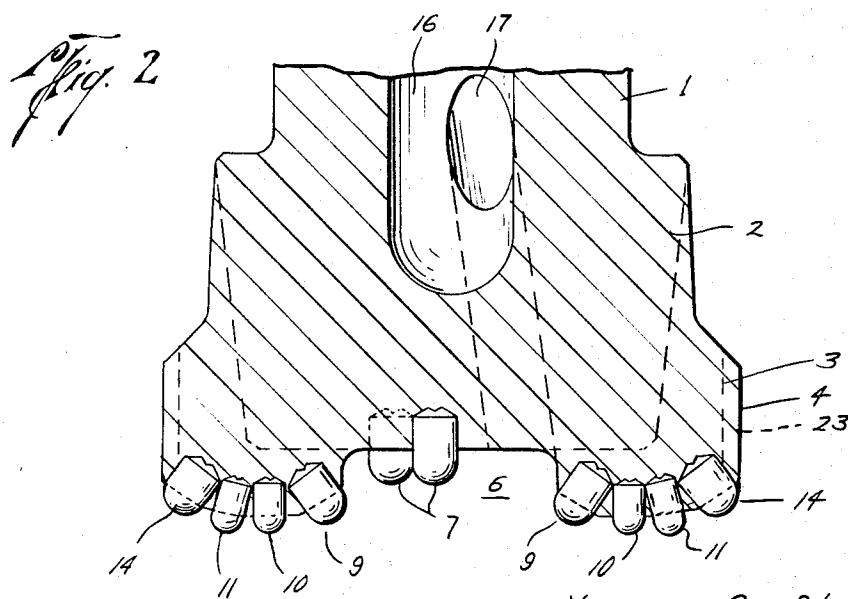
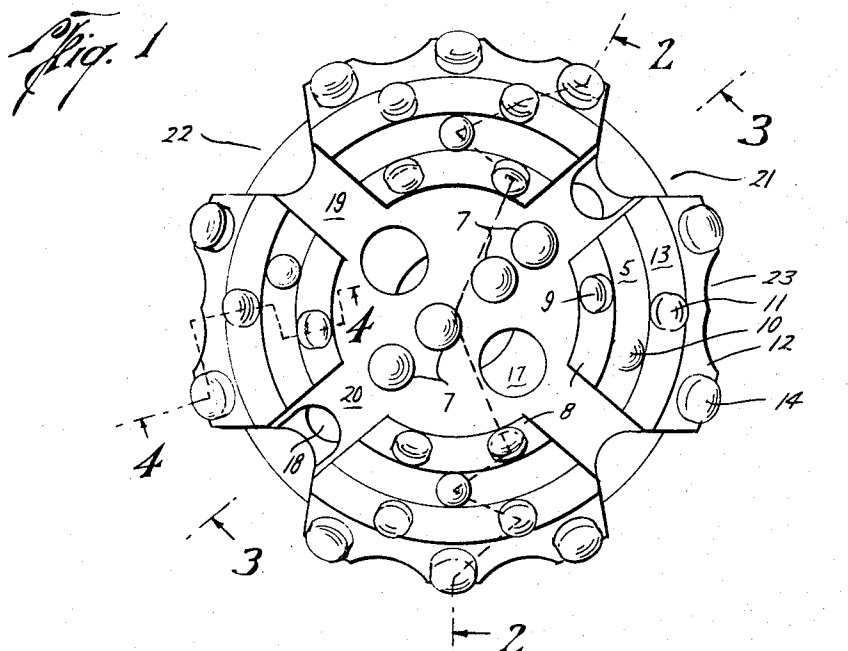
V. G. STEWART

3,357,507

PERCUSSION BIT

Filed Oct. 24, 1965

2 Sheets-Sheet 1



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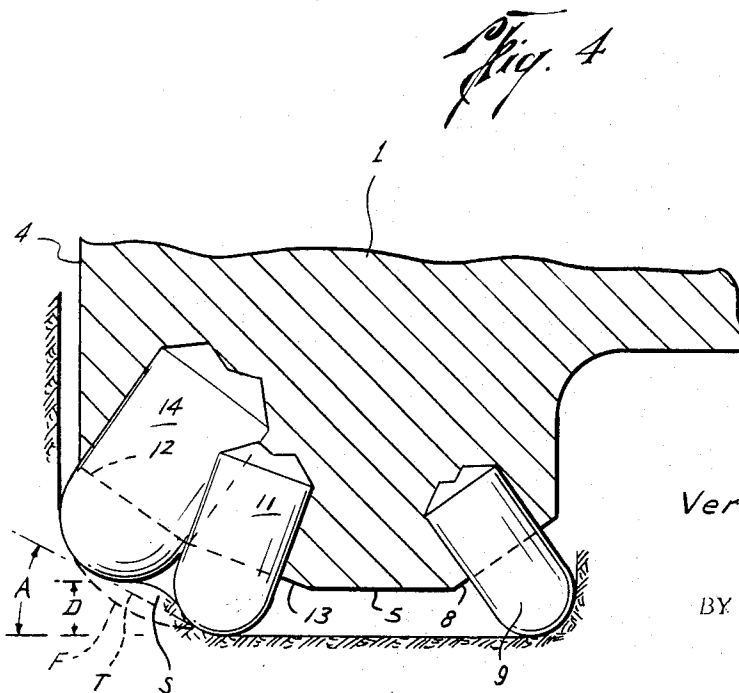
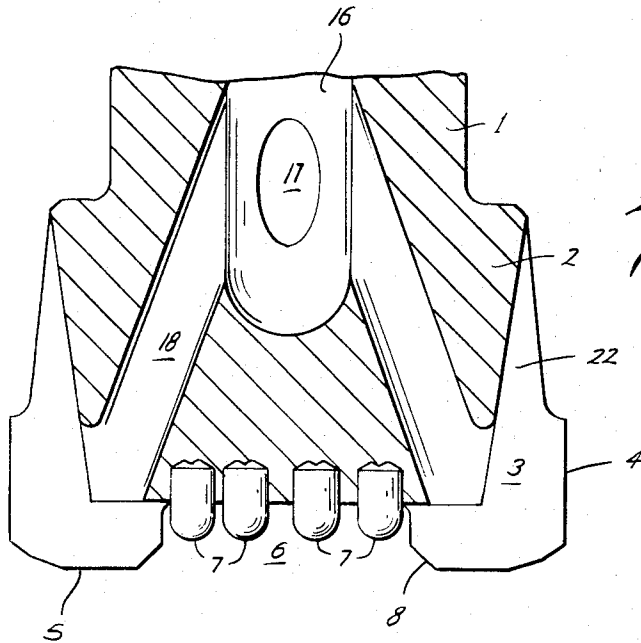
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ABSTRACT OF THE DISCLOSURE

A solid, button-insert-type percussion bit in which two rows of cutter inserts are provided at or adjacent the periphery inclined outwardly at different angles. The outer row of inserts are disposed to maintain the hole at gauge, and the inner row of these inserts cut only the hole bottom. The cutting extremities of the outermost row of inserts are spaced substantially upwardly and outwardly from the extremities of the inner inserts to form a shoulder or shelf at the periphery of the hole bottom which facilitates chipping out this part of the hole. The bit may be provided with a drop center and a row of inwardly- and downwardly-inclined cutter inserts at the edge thereof to assist in chipping away the center core.

This invention relates to a drill bit. More particularly, this invention relates to a bit of the solid, button-insert-type for drilling a bore hole into a subterranean formation, as by the rotary-percussion method, wherein the bit is so constructed as to facilitate drilling of the outer diameter of the bore hole to maintain the gauge thereof.

The drilling of bore holes by the rotary-percussion method has long been known in the art. In such a method, a bit, having one or more cutting surfaces at its lower end, while being rotated is subjected to a succession of vertical impacts from the impact member of a percussion tool. The rotation of the bit causes the cutting surfaces to index about the bit's longitudinal axis between each impact, so that substantially the entire bottom surface of the bore hole will be chipped away. The chips or cuttings are customarily carried to the surface by a flushing fluid, such as air, which is passed down a hollow drill stem, through passages in the bit, and thence up the annulus between the drill stem and bore hole wall.

To prevent excessive wear of the bit's cutting elements and to improve the cutting action, these elements are usually made of a hard, tough, wear-resistant material such as tungsten carbide. This material may be embodied in the bit body in the form of button-like inserts.

One problem that the percussion drilling industry has long faced is that, during drilling, the wear-resistant inserts, which, being located nearest to the periphery of the bottom surface of the bit, must do a greater proportion of the work and are subjected to greater forces than those inserts which are closer to the center of the bit's bottom surface, subjecting the outer inserts to rapid wear and to cracking or other failure. While it may be postulated that this problem could be solved merely by utilizing a greater number of inserts near the outer edge, such a solution is impractical in practice because the amount of bit body metal surrounding the inserts becomes insufficient to adequately support them. Also, because the percussion tool can only impart a given amount of energy to the bit with each impact, the amount of energy transmitted through each insert will become insufficient to cause desirable rock fracture, and will in turn decrease the drilling rate.

It is also important to prevent reduction of the gauge or diameter of the bit body during drilling. If inserts are not positioned to engage the wall of the bore hole, the

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wall will contact and wear away the relatively soft metal of the peripheral surface of the body and cause a reduction in the diameter of the hole and bit as drilling progresses.

It is, accordingly, an object of the invention to provide a bit adapted to prevent excessive loading and wear on the portions thereof which cut the bottom of the bore hole nearest the side wall.

It is a further object of the invention to provide a bit adapted to prevent wear on the peripheral surface of the bit body and having means for reducing the loading and wear on the portion of the bit which cuts the bottom of the bore hole nearest the side wall.

According to the present invention, action of the bit is improved by disposition of its outermost cutting inserts so as to impact against the upper and inner side surfaces of a "shelf" or shoulder-like protrusion formed by the same inserts at the intersection of the bottom and the side wall of the bore hole. These outermost inserts are formed in a first annular row projecting below the bottom surface, but are spaced inwardly of the side surface, and a second annular row projecting outwardly beyond the side surface, and with its cutting extremities spaced substantially above and outwardly of the cutting extremities of the first row. The mentioned shoulder-like protrusion at the periphery of the hole bottom forms in the cutter free space between these rows.

It has been found that the formation of such a shoulder substantially reduces the work which must be performed by the outermost inserts, in that such a shoulder may be more easily fractured and broken off, especially in friable formations, than if the outermost inserts were to impact directly upon the bottom of the bore hole.

Other objects and advantages of the invention will further become apparent upon consideration of the following detailed description and the accompanying drawings, in which:

FIGURE 1 is a plan view of the bottom surface of one embodiment of the bit of my invention;

FIGURE 2 is a sectional view of the lower portion of the bit, taken on line 2—2 of FIGURE 1;

FIGURE 3 is a sectional view of the lower portion of the bit, taken on line 3—3 of FIGURE 1 and with all of the inserts except inserts 7 omitted for clarity; and

FIGURE 4 is an enlarged fragmental sectional view taken on line 4—4 of FIGURE 1, with inserts 10 omitted for clarity.

Referring now to the drawings, there is illustrated a preferred form of one embodiment of the bit of the invention, consisting of a body 1 of steel or other suitable material. Body 1 is preferably forged or otherwise formed from a single piece of material.

The upper end of the body is not shown in the drawings, as the structure thereof is entirely conventional and will depend upon the particular type of rotary-percussion tool to which the bit is to be attached. The upper end of the body may, for example, be a pin or female box joint, but in the preferred form of the invention it is formed as shown in U.S. Patent No. 3,105,559. As shown and described in that patent, the integral anvil-bit is slidably but non-rotatably attached to a drilling tool by means of a splined connection, and a hammer in the tool acts upon the upper end of the anvil bit to drive the latter vertically against the bottom of the bore hole by repeated impacts. Such tool also provides for supplying fluid from the interior of the hollow drill stem to a central bore in the bit.

The bit body 1 illustrated in the drawings is of substantially circular horizontal cross-section about its longitudinal axis and throughout its length. Below its upper end, the diameter of the body increases in stepwise fashion, having an intermediate portion 2 and a larger diameter portion 3 therebelow. The outer peripheral sur-

face 4 of the lower portion 3 may be cylindrical, as shown, or may taper slightly downwardly and outwardly.

The bottom surface 5 of the bit is, as shown, a generally flat, transverse plane perpendicular to the longitudinal axis of the bit. The central portion of the bottom surface is elevated to form a cylindrical cavity or pocket 6 (drop center) provided with downwardly-projecting wear-resistant inserts 7 of the type to be hereinafter described. At the intersection of the side wall of pocket 6 and bottom surface 5 is an annular chamfer 8 (FIG. 4), with downwardly and inwardly inclined, wear-resistant inserts 9 circumferentially spaced therearound and protruding therefrom. Alternatively, pocket 6 may be omitted, if desired, and the bit may simply be provided with a flat bottom surface containing inserts arranged in circular rows (similar to inserts 10) or in some other pattern.

In order to chip and cut away the bottom surface of the bore hole, there are provided intermediately in the bit bottom surface one or more sets of wear-resistant inserts 10. These inserts 10 protrude through surface 5 with their longitudinal axes normal thereto and are arranged in a circle concentric about the longitudinal axis of the bit body. The number of circular sets of inserts used will be dependent on the size of the inserts used and the bit diameter, but in most cases the inserts will be so arranged that their protruding (free) ends lie in a plane parallel to bottom surface 5.

In the region of the intersection of the bit bottom surface 5 with the outer peripheral surface 4, there are provided first and second concentric annular chamfers 12 and 13, outer chamfer 12 being tapered upwardly and outwardly to a greater degree than inner surface 13. As is more clearly shown in FIGURE 4, the rows of circumferentially-spaced, wear-resistant inserts 14, 11 protrude respectively through each of these chamfers with their longitudinal axes substantially normal to the respective chamfer. Thus, the longitudinal axis of each insert 14, 11 will extend at an acute angle to the longitudinal axis of the bit body with the angle of inserts 14 being greater than that of inserts 11. As will be hereinafter described, this inclination of inserts 14, 11 is an important feature of the invention.

It will be observed from FIGURE 4 that the protruding or free ends of outer inserts 14 do not lie in the same horizontal plane as the free ends of inner inserts 11, but are spaced thereabove by a distance D. As shown in FIGURE 4, this spacing causes a shoulder-like shelf or protrusion S to be formed in the formation substantially at the intersection of the side wall and bottom of the bore hole during drilling, likewise an important feature of the invention. Furthermore, the free ends of outer inserts 14 extend beyond the outer peripheral surface 4 of the bit body to cut the side wall and prevent the same from contacting surface 4, wearing away surface 4, and reducing the diameter of the bit body.

As used herein, the term "wear-resistant insert" refers to a discrete insert made of tungsten carbide or other relatively hard and wear-resistant material, of a hardness considerably greater than that of the bit body. The inserts shown in the drawing are generally cylindrical in form and preferably have free or protruding ends of hemispherical shape, although inserts having free ends of various other shapes may be used, if desired. The inserts are located in the bit body by inserting them into suitable holes drilled or otherwise formed in the body, and are secured therein by press fitting, brazing, or other means.

The bit shown is provided with a flushing fluid passage system consisting of central bore 16 and two pairs of passages 17, 18 leading therefrom to discharge fluid adjacent the lower end of the bit. Passages 17 discharge fluid into central cavity 6 to pick up the cuttings formed therein and carry them outwardly and upwardly, radial channels 19, 20 and body flutes 21, 22 facilitating this movement. Chamfers 12 and 13 also facilitate this flow.

In operation, the bit of my invention is rotated at a suitable speed (e.g., 13 to 16 r.p.m.), while being subjected to a succession of vertical impacts. The rotation causes the bit to index about its longitudinal axis between successive impacts.

As drilling progresses, inserts 9, 10 will cut or chip off pieces of the formation from the bottom of the bore hole. If the bit is of the type having a pocket 6, the portion of the bore hole bottom adjacent the pocket will not be immediately attacked and a cylindrical plug or core of material will rise in the pocket as the bit penetrates the formation. When the top of this plug is finally contacted by central inserts 7, it may be relatively easily broken up by their impacts, in cooperation with the action of inclined inserts 9, into relatively large pieces, as it is not supported at its sides by any surrounding subterranean material and consequently presents less resistance than the material around this core.

During drilling, inserts 14 and 11 will likewise be impacted against the formation and, because the free ends of inserts 14 are spaced vertically and radially from inserts 11 and the space between these inserts is free of cutting elements, the shoulder-like shelf or protrusion S, whose depth is approximately equal to D, will be formed at the intersection of the side wall and bottom of the bore hole. Inserts 14 protrude beyond the peripheral surface 4 of the bit body to maintain the gauge of the hole and protect the bit body.

The positioning and orientation of inserts 14 and 11 to cause the formation of shoulder S has been found to result in a substantial decrease in the vertical force which must be exerted by inserts 14 to cut away the peripheral portion of the hole. As previously discussed, the inserts in a percussion bit which cut and remove that portion of the bore hole bottom nearest the side wall are subject to the greatest abrasive forces and stresses, but I have found that if the inserts are arranged in the manner shown to form the shoulder-like protrusion S beneath the outermost inserts 14, the vertical force which must be exerted by these latter inserts is substantially reduced.

This reduction in force arises from the fact that the material forming shoulder protrusion S is unconfined by other formation material at its inner face, and thus may be fractured upon applying an impact force to the top of the protrusion. When the protrusion is of the configuration shown in FIGURE 4, for example, the impact of inserts 14 upon its upper surface will cause the shoulder to fracture approximately along or parallel to fracture plane F, and the protrusion will break off in relatively large pieces of material. The force which insert 14 must exert on the protrusion to fracture it is, moreover, substantially less than that which would be required for an insert, located at the same distance from the longitudinal axis of the bit body 1 as insert 14, to cut or chip material from the bottom surface of a non-shouldered hole, and, further, the volume of the piece of material formed by fracturing shoulder S is substantially larger. Thus, by arranging inserts 11 to form protrusion S in the formation, the vertical force which must be exerted by inserts 14 is substantially reduced and a larger chip results, diminishing the wear on inserts 14 and the danger of their breaking or failing prematurely. It may be considered that inserts 11 in effect "prepare" the portion of the formation upon which inserts 14 must act by reducing the force necessary to remove it.

A feature of importance to the successful performance of my invention is the downward and outward inclination of inserts 11 with their longitudinal axes at small, acute angles with the longitudinal axis of the bit. The nature of tungsten carbide and other hard, wear-resistant materials used for bit inserts in such that while they have great compressive strength they are relatively brittle and weak in tension, and thus will crack, break, or

otherwise fail under the influence of a substantial lateral (or bending) force. It will be evident from FIGURE 4 that if insert 11 were aligned with its longitudinal axis parallel to the longitudinal axis of the bit, the upstanding side of protrusion S would exert a substantial lateral force on insert 11 as the bit is driven downwardly. Similarly, if insert 11 were inclined at too great an angle to the vertical (e.g., at greater than about 45 degrees), the resistance of the material forming the bottom of the bore hole would impart an excessive lateral force to the insert. Therefore, it is important that the longitudinal axis of insert 11 be inclined so that the resultant of the vertical and horizontal forces acting on the insert at impact is more nearly parallel to the insert's longitudinal axis, reducing the tensile or bending forces on the insert and causing it to be subjected almost entirely to compression. Other advantages resulting from such an orientation are that the inserts 11 are surrounded by a substantial amount of body metal on all sides, reducing the possibility of their being torn or cracked out of their sockets and that surface 13 may be tapered to allow the flushing fluid to freely pass the inserts. While the angle of inclination of insert 11 will vary depending on the size of the bit, impact force, and many other factors, I have found that satisfactory results are obtained if this angle is set at about 25 degrees.

Upon impact, insert 14 is likewise subjected to both vertical and horizontal forces, but in this case these forces are necessarily greater than those acting on insert 11. The body metal surrounding inserts located in the position of insert 14, i.e., in a position to act both upon the side wall and bottom of the hole, is particularly subject to cracking and wear, and it is desirable to so orient these inserts that as much body metal as possible surrounds them. However, in bits which do not form protrusion S in the formation, if the insert 14 is oriented to resist in compression the larger vertical force normally exerted by the bottom of the hole, the desirable amount of surrounding body metal cannot generally be used, and, conversely, if the insert is oriented to allow a large amount of body metal on all sides, it is subjected to excessive lateral forces in a vertical direction.

By contrast, the formation of protrusion S caused by the operation of the bit of this invention reduces the vertical reactive forces received by insert 14. Consequently, the resultant of the vertical and horizontal reactive forces on insert 14 is both diminished and acts along a line at a greater acute angle to the longitudinal axis of the bit, allowing insert 14 itself to be oriented at an angle approaching this greater angle and thus to be surrounded by a greater amount of body metal. While the angle of inclination of insert 14 will also vary depending upon several factors, it has been found that in most cases the angle of inclination of inserts 14 should be at least as large as that of inserts 11. Gauge-holding inserts 14 may be of greater diameter than the inner inserts for greater resistance to lateral forces.

Another factor to be considered is the "shelf angle" A, which may be defined as the angle which a line T, drawn at a tangent to the free ends of inserts 14 and 11 (both rotated into the same plane), makes with a line perpendicular to the longitudinal axis of the bit. The shelf angle, which is of course partially dependent upon the angles of inclination of inserts 14 and 11, is so chosen that protrusion S will fracture under the impact of insert 14 while preventing an excessive lateral load on insert 11. If this angle is too great, protrusion S will not break off. For drilling in friable materials such as granite or hard limestone, it has been found that a shelf angle on the order of 35 degrees is satisfactory.

The depth D of the shelf is selected to be several times the depth of a single chip made by the impact of a vertically oriented insert (such as inserts 10). As a practical

matter, the minimum depth for economical operation should be about $\frac{1}{8}$ inch, which, when protrusion S fractures, yields a chip of considerably greater volume than those formed by the other inserts in the bottom surface 5. The radial distance between the free ends of inserts 14 and 11 depends on the depth D and shelf angle A, and is limited only in that if it is too great, insert 14 will merely chip the upper surface of shelf S rather than fracturing it.

It will be noted that inserts 9 adjacent cavity 6 are also inclined to more nearly cause the resultant of the vertical and lateral impact forces thereon to act along their longitudinal axes. However, since the forces on these inserts are not as great as those on the outermost inserts 14, it is generally unnecessary to employ a shelf-forming row of inserts in conjunction with them.

After protrusion S has fractured and the chip formed thereby has broken off, continued drilling will cause a new peripheral protrusion to form, which shelf will in turn be fractured by the impact of inserts 11 and 14, and so on. As the vertical force necessary to fracture these shelves is than that which would be required to cut directly upon the formation at the bottom of the hole, it is apparent that the outermost inserts 14 of the bit are subject to less strain and wear than those of conventional bits, and the danger of their breaking or failing is substantially reduced.

As used in the appended claims, the terms "cut" and "cutting" are used in a broad sense, and include the chipping action customarily associated with the percussive impact of a wear-resistant insert upon the material being drilled. The terms "fracture" and "fracturing" are used to denote the breaking of the drilled material along a substantially weak plane. Thus, as has been described above, the protrusion S fractures substantially along the line F.

While but one embodiment of the invention has been described herein, it will be understood that this embodiment is illustrative only, and that the invention may be modified in various respects as will occur to those skilled in the art and the exclusive use of all modifications as come within the scope of the appended claims is contemplated.

I claim:

1. A percussion bit comprising a body having a transverse bottom surface and a side surface, first cutting inserts protruding from said bottom surface and spaced inwardly from said side surface, and second cutting inserts projecting from said body in the general area of intersection of said bottom and side surfaces, the extremities of said second inserts extending radially beyond said side surface for maintaining the gauge of the hole being drilled and being spaced substantially upwardly and outwardly from the cutting extremities of said first inserts, there being a substantial annular space between said first and second inserts free of cutting elements for leaving a shoulder-like intrusion of material at the periphery of the hole bottom to facilitate chipping of said periphery by said inserts.

2. A percussion bit as described in claim 1 in which said second inserts are disposed with their axes inclined at an acute angle to the longitudinal axis of said body and are located wholly above a plane not substantially below said bottom surface.

3. A percussion drill bit comprising a body having a transverse bottom surface, a generally cylindrical side surface, a radially sequential pair of chamfers of outwardly increasing inclination at the intersection of said surfaces, first cutting inserts protruding downwardly from said bottom surface and spaced inwardly from said side surface, second cutting inserts protruding from the inner of said chamfers at an acute angle to the longitudinal axis of said body, and third inserts protruding from the outer of said chamfers at an acute angle to said second inserts and with their extremities spaced above and outwardly of the extremities of said second inserts and termi-

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nating at least in circumferential alignment with said side surface for maintaining the gauge of the hole being drilled, the annular space between said second and third inserts being free of cutters so as to form a shoulder-like protrusion at the periphery of the hole bottom to facilitate chipping away of said periphery by said inclined second and third cutter inserts.

4. A percussion drill bit comprising a side surface and a transverse bottom surface having an elevated central portion forming a pocket, first cutting inserts protruding from said bottom surface including inner and outer annular rows, the inserts of said inner row projecting at an inward acute angle to the longitudinal axis of said body and into said pocket for chipping the core formed in said pocket, said outer row being wholly spaced inwardly of said side surface, and a third annular row of cutting inserts projecting from the region of intersection of said bottom and outer surfaces outwardly at an acute angle to said body axis beyond said body side wall and positioned wholly upwardly from the plane of the extremities of said second row of inserts, the cutter free spacing of

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said second and third rows of inserts causing the formation of a shoulder-like protrusion of formation material at the intersection of the side and bottom walls of the hole to facilitate cutting of the periphery of said bottom wall by said third row of inserts.

5. A percussion bit as described in claim 4 including additional downwardly-protruding cutting inserts in the elevated part of said bottom wall and between said first and second rows of inserts.

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