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3,058,535

ROTARY DRILL BIT

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Fig. 1.

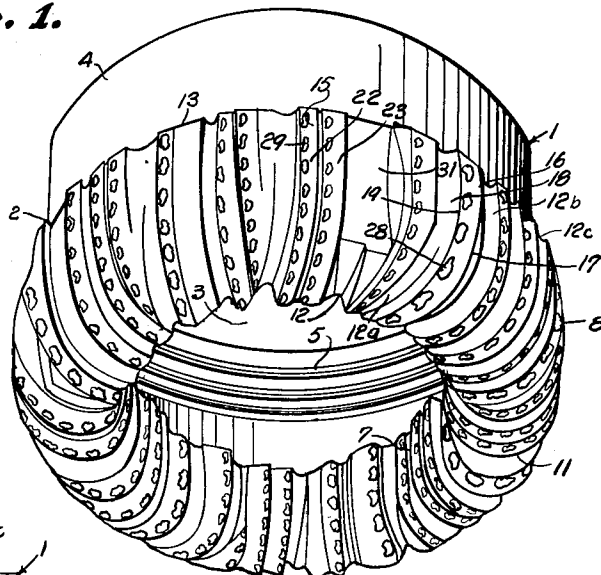


Fig. 3.

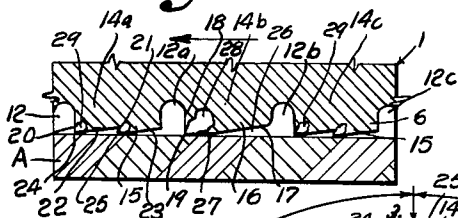
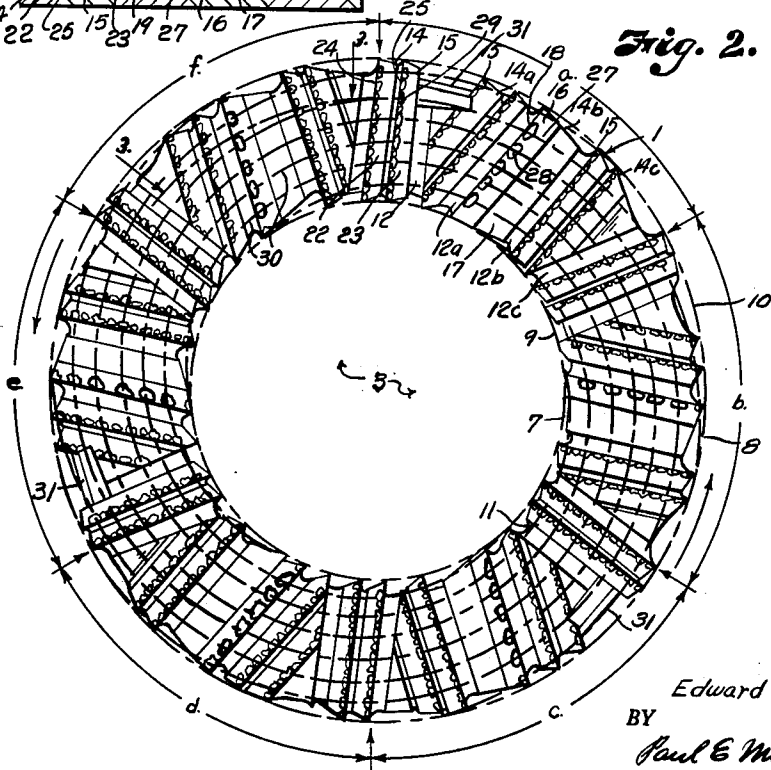


Fig. 2.



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3,058,535

ROTARY DRILL BIT

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4 Claims. (Cl. 175-330)

This invention relates to drill bits for rotary drilling of earth formations to substantial depths, and particularly to bits of the diamond type for drilling relatively hard formations such as limestone interbedded with shale or limestones containing soft streaks.

Previous to the present invention, it has been the practice when drilling such formations to use a drill bit having cutting elements best adapted for drilling the hard formations, and no consideration was given to the softer streaks and weak bonded formations that are usually gummy or sticky, consequently, it has been difficult to maintain a constant penetration rate under different drilling conditions, particularly when passing into the softer streaks. Also, little consideration has been given to protection of the relatively small cutting elements for cutting hard formations under increasing weight of the drill pipe as the bore hole deepens.

Therefore, the principal objects of the present invention are to provide a bit with an arrangement of cutting elements and cutting relief angles therefor to maintain substantially constant penetration rate when passing from the hard formations into the softer streaks, and also to provide for protection of the small cutting elements from overcutting and damage under crushing weight of the drill pipe.

A further object of the invention is to provide a bit of the diamond type for more efficient cuts of the relatively small size cutting elements that are necessary in making the number and size of cuts to cover the area to be removed when drilling hard formations.

A further object of the invention is to provide a bit with grooving to assure ample volume flow of the drilling fluid to maintain a clean bit and clean condition of the bore hole.

In accomplishing these and other objects of the invention, as hereinafter pointed out, I have provided an improved structure, the preferred form of which is illustrated in the accompanying drawing, wherein:

FIG. 1 is a perspective view of a core bit constructed in accordance with the present invention.

FIG. 2 is an underneath plan view of the bit.

FIG. 3 is an enlarged fragmentary section through a portion of the bit, taken on the line 3-3 of FIG. 2 and showing a portion of the formation being cut by the bit when in use.

Referring more in detail to the drawing:

While the invention is adapted to various types of diamond bits, I have particularly illustrated and described the invention incorporated into a core bit generally designated by the numeral 1, and which includes a substantially circular or ring shaped body 2 that is formed of a material capable of withstanding drilling strains and to carry a matrix metal for seating and backing of the cutting elements later to be described. The body 2 has an axial bore 3 to pass a core into a core barrel (not shown) when the bit is in operation. The upper portion of the

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body has a reduced external diameter to provide a collar portion 4 having internal threads 5 to connect the bit with the core barrel, and which in turn is attached to the lower end of the drill pipe, also not shown, since the present invention resides in the drill bit per se. The matrix metal 6 is suitably bonded to an inner and outer lower portion of the body 2 in a manner well known to those skilled in the construction of diamond type core bits.

The inner and outer circumferential surfaces 7 and 8 of the matrix metal are generally circular, as indicated by the dot and dash lines 9 and 10, FIG. 2, and produce the diameter of the core and the gauge of the bore hole to be drilled. The generally circumferential faces 7 and 8 are connected by a generally rounding end face 11 which corresponds with the bottom contour of the bore hole in the formation "A" to be drilled by the bit.

In carrying out the invention, the faces 7, 8 and 11 are divided into sectors, there being six sectors illustrated in the drawings and designated "a," "b," "c," "d," "e," and "f," respectively, in FIG. 2. Each sector has a plurality of main grooves 12, 12a, 12b and 12c. Each groove extends downwardly of the face 7, across the end face 11, and upwardly of the exterior face 8, to terminate through the annular shoulder 13 that encircles the collar portion 4, to provide a plurality of spaced apart courses for flow of drilling fluid. It will be noted that the grooves 12 and 12c extend across the end face 11 at a slight angle to radial planes extending through the axis of rotation of the bit, and that the grooves 12a and 12b are at a different angle. The grooves provide therebetween ridges 14, 14a, 14b and 14c having shaped bottom faces forming secondary teeth (FIG. 2). The secondary teeth 15 on the ridges 14, 14a and 14c are in pairs, while the ridge 14b has only a single and much larger primary tooth 16 than the secondary teeth 15 of the pairs of teeth on the other ridges. The primary tooth 16 of each sector has an inclined bottom face 17 merging into the groove 12b on the trailing side of the tooth, and the front or advance face 18 is substantially perpendicular and registers with the side of the groove 12a. The faces 17 and 18 join in an advance edge 19. The secondary teeth 15 which are arranged in pairs on the ridges 14, 14a and 14c are of similar shape and have perpendicular front faces 20 and 21 and inclined bottom faces 22 and 23 of smaller size than the corresponding faces of the tooth 16 to provide advance edges 24 and 25.

When the bit is in use in drilling a bore hole in a formation, the edges 24-25 of the pairs of secondary teeth and the edges 19 of the primary teeth 16 of the respective sectors are in contact with the formation and the bottom faces 17, 22 and 23 slope from the formation to provide relief spaces 26, as shown in FIG. 3. The relief angles of the primary teeth 16 have a slightly flatter angle at the forward portions 27 thereof, to provide ample width and metal for bedding and backing relatively large size or major cutting elements such as diamonds 28, which are arranged in spaced apart relation along the face portions 27 near the forward edge 18 of each primary tooth 16. The teeth 15 which are arranged in pairs have imbedded in the metal thereof relatively smaller and closer spaced cutting elements, such as diamonds 29, capable of cutting the harder formations and providing the many small cuts that are necessary when cutting relatively hard material of the formation "A." This is important because dia-

monds make relatively small scratches on hard formations and if all the diamonds were of large size, such as the diamonds 28, there would not be space enough to accommodate all of the diamonds that would be necessary, but by using the smaller diamonds 29, a sufficient number can be arranged along the teeth 15 to make the required number of cuts on the hard formation and still accommodate a sufficient number of large diamonds 28 to support the load on the bit and prevent crushing of the small diamonds 29. In order to obtain maximum coverage, the diamonds in one tooth are staggered relatively to the diamonds in the following teeth in the direction of rotation, so that each diamond is effective in making its individual cut. To this end, the diamonds are arranged in a generally overall spiral pattern, as indicated by the dot and dash lines 30 in FIG. 3. For the sake of clarity in the illustration, only the spiral lines 30 are shown that pass through the larger diamonds 28. The spiral arrangement locates each diamond at a different distance from the center of bit rotation, consequently, the desired coverage can be made with a minimum total of diamonds. The diamonds are all set in the matrix metal to a substantially perfect contour, that is, the leading points of any one of the diamonds is neither high nor low with respect to the leading edges of the teeth, so that they all make cuts of like depth.

Small diamonds 29 obviously make cuts of less width than large diamonds, and the smaller diamonds in themselves do not cut satisfactorily when soft streaks or softer formations are encountered, but with the larger diamonds 28 in combination therewith and the larger teeth 16, the bit makes satisfactory progress through such formations.

The arrangement of the teeth of each sector in the above described manner and the angular relationship of the teeth as shown in FIG. 2, are important in facilitating circulation of the drilling fluid over the bottom of the bore hole and producing better clearance and more rapid removal of the cuttings. In order to further provide the bit with upwardly directed jets of the drilling fluid, the outer periphery of the bit has certain of the portions of the grooves in the exterior face 8 enlarged as indicated at 31 to provide a more free flow of fluid and thereby aid in the upward flow of the cuttings made by the bit. The enlarged passageways 31 may be provided in the sectors "a," "c" and "e," as shown in FIG. 2.

In using the bit, it is applied to a core barrel on the lower end of a drilling string and rotated in the conventional manner, so that in hard formations the larger diamonds 21 support the load and meter the cuts produced by the smaller diamonds under the load of the drill pipe. The larger diamonds also have an additional function of producing the bigger cuts that are desirable when the bit encounters the softer formations. Even in the harder formations the cuts produced by the larger diamonds result in a more effective cutting action of the points of the smaller diamonds, as the larger scratches or cuts produced by the larger diamonds start the cutting action and make it easier for the smaller diamonds to complete removal of the material between the larger cuts.

While the overall size of the ridges 14, 14a, 14b and 14c is substantially the same, a greater amount of matrix metal is allowable on the ridges 14b and is utilized in backing and imbedding the larger diamonds, and this added material provides for more effective support of the bit under the load of the drill pipe, to avoid damage or displacement of the diamonds.

The cutting relief angle predetermined by the size of the diamonds results in the relief spaces 26 through which the cuttings are moved from each row of diamonds for discharge into the fluid grooves. The cutting relief angles are also effective in adding capacity to supplement the main grooves in accordance with the cutting range of the teeth in the particular formations on which the size of diamonds are most effective.

It is also obvious that the large diamonds prevent over-cutting of the smaller diamonds when cutting the harder formations.

While I have referred to the cutting elements as diamonds, the cutting elements may comprise bortz particles, or other crystals or fragments sufficiently hard to cut the earth formations.

What I claim and desire to secure by Letters Patent is:

1. A drill bit for rotary drilling of bore holes through earth formations, said drill bit including a body member having an end face providing the general bottom hole contour of the bore hole to be drilled by the bit, said end face being composed of a plurality of substantially like sectors arranged in a circular series about the axis of the bit, each sector having a series of transverse ridges with transverse watercourses between the transverse ridges, one of said ridges of each sector providing a major transverse tooth and the other ridges of each sector being divided into substantially smaller transverse teeth, small cutting elements inset in the smaller transverse teeth to make substantially circumferential cuts covering the bottom contour of the hole, and larger cutting elements inset into the major transverse tooth in each sector for metering the cuts of the smaller cutting elements.

2. A drill bit for rotary drilling of bore holes through earth formations, said drill bit including a body member having an end face providing the general bottom hole contour of the bore hole to be drilled by the bit, said end face being composed of a plurality of substantially like sectors arranged in a circular series about the axis of the bit, each sector having a series of transverse ridges with transverse watercourses between the respective transverse ridges, one of said transverse ridges of each sector providing a major transverse tooth and the other transverse ridges of each sector being divided into substantially smaller secondary transverse teeth, small cutting elements inset in the secondary teeth to make substantially circumferential cuts covering the bottom contour of the hole, and larger cutting elements inset into the major transverse tooth in each sector for metering the cuts of the smaller cutting elements when the bit is in use, said ridges having sloping faces for providing relief of cuttings into the immediately following watercourses.

3. A drill bit for rotary drilling of bore holes through earth formations, said drill bit including a body member having an end face providing the general bottom hole contour of the bore hole to be drilled by the bit, said end face being composed of a plurality of substantially like sectors arranged in a circular series about the axis of the bit, each sector having a series of circumferentially transverse ridges with transverse watercourses between the transverse ridges, one of said transverse ridges of each sector providing a major transverse tooth and the other transverse ridges of each sector being divided into substantially smaller secondary transverse teeth, small cutting elements inset in the secondary teeth and having cutting points to make substantially circumferential cuts covering the contour of the bottom of the hole, and larger cutting elements inset into the major tooth in each sector and having cutting points for metering the cuts of the smaller cutting elements, said points of the small and larger cutting elements of the sectors being arranged in said ridges for producing substantially equal depth cuts on the bottom contour of the bore hole when the drill bit is in use.

4. A drill bit for rotary drilling of bore holes through earth formations, said drill bit including a body member having an end trailing face having the general shape of the bottom hole contour of the bore hole to be drilled by the bit, said end face being composed of a plurality of sectors arranged in a circular series about the axis of the bit, each sector having a series of spaced apart transverse ridges with the trailing ridge of each series substantially radial of the rotary axis of the bit and the for-

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ward ridges of each series substantially parallel to each other and located at an angle to the radial ridge, one of said parallel ridges of each sector providing a major transverse tooth and the other transverse ridges of each sector having smaller transverse teeth, small cutting elements inset in the secondary transverse teeth and having cutting points to make substantially circumferential cuts covering the bottom contour of the bottom of the hole, larger cutting elements inset into the major transverse tooth in each sector for metering the cuts of the smaller cutting elements, said cutting points of the large and small

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cutting elements being arranged in said teeth to provide substantially equal depth cuts on the bottom contour of the bore hole when the bit is in use.

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