Oct. 15, 1963 F. L. CHRISTENSEN 3,106,973

ROTARY DRILL BITS

Filed Sept. 26, 1960

FIG. 1.

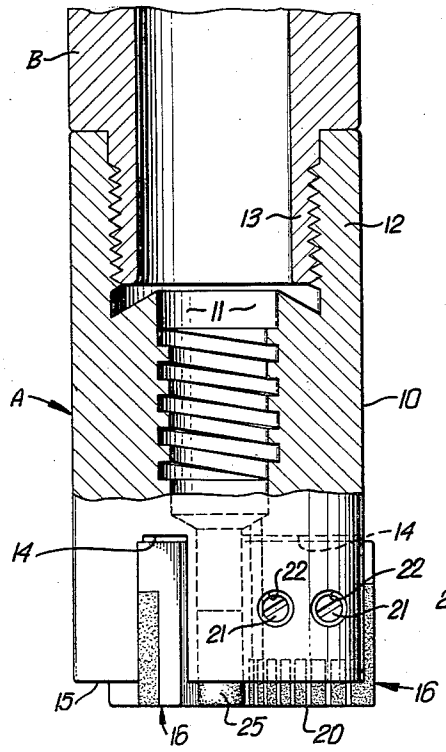


FIG. 3.

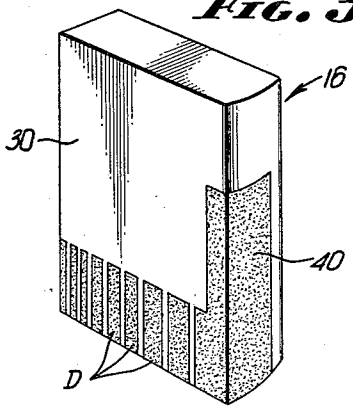


FIG. 4.

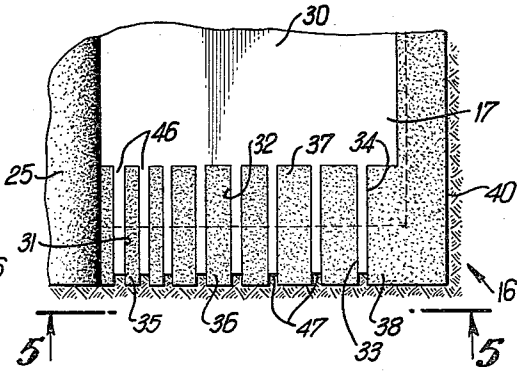


FIG. 2.

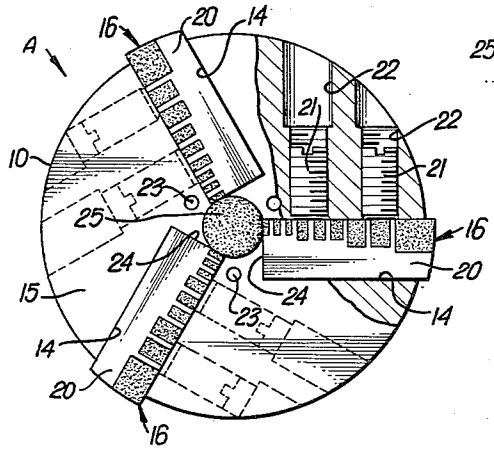
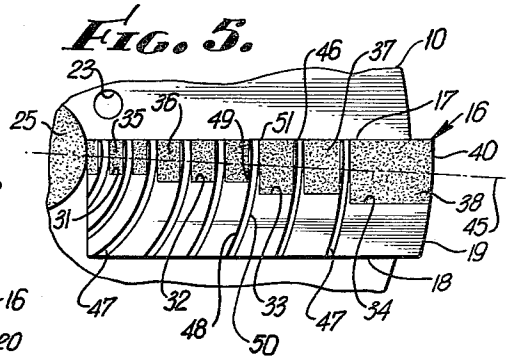


FIG. 5.



INVENTOR.

FRANK L. CHRISTENSEN

BY

Bernard Kriegel

ATTORNEY.

United States Patent Office 3,106,973 Patented Oct. 15, 1963

3,106,973

ROTARY DRILL BITS

Frank L. Christensen, Salt Lake City, Utah, assignor to Christensen Diamond Products Company, Salt Lake City, Utah, a corporation of Utah

Filed Sept. 26, 1960, Ser. No. 58,489
10 Claims. (Cl. 175—413)

The present invention relates to drill bits especially useful in the drilling or coring of bore holes, such as mining holes and well bores.

An object of the invention is to provide an improved drill bit having a longer useful drilling life than bits heretofore available.

Another object of the invention is to provide a drill bit embodying diamond and diamond-like cutting elements disposed over the cutting face of the bit, in which the cutting elements are so arranged as to obtain approximately uniform wear of the bit over the radial extent of its cutting face.

A further object of the invention is to provide an improved drill bit that centers and stabilizes itself in the hole which it is producing, and which runs smoothly as drilling of the hole progresses.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings.

FIGURE 1 is a longitudinal section through a drill bit embodying the invention, with the lower portion thereof shown in side elevation;

FIG. 2 is a bottom plan view of the bit shown in FIG. 1, with a portion thereof shown in section;

FIG. 3 is an isometric projection, on an enlarged scale, of one of the cutter blades forming part of the drill bit;

FIG. 4 is an enlarged section, with its cutter blade shown in front elevation, of the drill bit drilling a bore hole;

FIG. 5 is a bottom plan view of the drill bit, as seen along the line 5—5 in FIG. 4.

The drill bit A specifically disclosed in the drawings is adapted to be rotated by a drilling string B, such as a string of drill pipe, that extended to the top of the hole being drilled. As shown, the bit employs diamonds D as primary cutting elements for operation upon the formation, and is of the drag type.

The drill bit A includes a main body or shank 10 having a central fluid passage 11 and an upper threaded box 12 by means of which the body is threadedly secured to the lower pin end 13 of the string of drill pipe B. The body has a plurality of circumferentially spaced and generally radial sockets or grooves 14 extending upwardly from its lower end 15, these grooves opening outwardly through the periphery of the body. A cutter blade 16 is mounted in each of these grooves, making a snug fit therewithin.

Each cutter blade has a leading cutting face 17 contiguous one side of the groove 14 and a trailing face 18 contiguous the other side of the groove. The blade extends laterally inwardly within the groove 14 to the extent desired, depending upon the use to which the bit is to be put, and the outer end 19 of the blade preferably extends outwardly beyond the periphery of the body 10

of the bit, at least to a small extent. Each groove 14 has a substantial length, and each cutter blade also has a substantial length, each blade being movable longitudinally in the body groove so that its lower end face 20 projects outwardly beyond the lower end 15 of the body. Each blade is secured to the bit body 10, in the position to which it has been adjusted within the body groove 14, in any suitable manner, as by lock screws 21 threaded in companion bores 22 in the body and bearing against one face 17 of the blade. All of the blades 16 will be adjusted within the body 10 of the tool, so that their lower end faces 20 extend axially beyond the lower end 15 of the bit body to the same extent, whereupon their respective lock screws 21 are tightened against the blades to firmly secure them in place.

Rotation of the drill pipe B and bit A attached thereto, with the proper drilling weight imposed on the bit, will cause the blades 16 to operate upon the formation and cut the same. The cuttings are flushed from the bottom of the hole by circulating drilling fluid down through the drill pipe B, which will flow downwardly through the central passage 11 of the body, and then through suitable nozzles or fluid channels 23 in the body communicating with the central passage 11, and preferably opening through the lower end 15 of the bit body in advance of the leading faces of the blades, so that the drilling fluid discharging from the nozzles will flush the cuttings from the drilling region, and will also maintain the blades free from cuttings and effect their cooling. The cuttings are carried by the drilling fluid upwardly around the exterior of the body 10 of the bit and the string of drill pipe B to the top of the hole, in a known manner.

The drill bit A can be used to drill the entire cross-sectional area of the hole, the inner end 24 of each blade being spaced from the axis of the hole, and the central portion of the hole being removed by a suitable plug 25 mounted in the lower portion of the central passage 11 of the bit body and secured to the latter in any suitable manner, as by welding or brazing. The plug 25 may include diamond cutting elements embedded in a matrix, the diamonds and matrix being of an extended length so that diamonds are available for operation upon the formation as the central plug portion wears away. Thus, the blades 16 will cut the outer and main portion of the hole being drilled; whereas the central portion is removed by the diamond impregnated plug 25.

If the drill bit is to be used for securing a core, then the plug will be omitted so that the core passes upwardly into the central passage 11 of the bit. For that matter, the diameter of the core produced can be greatly increased by spacing the inner ends 24 of the blades 16 further away from the axis of the bit body, and by making the central opening 11 of the bit body of a correspondingly greater diameter.

Each cutter blade 16 is preferably elongated in character and has sections of diamonds impregnated matrices secured thereto in any suitable manner, as by brazing. As disclosed, each blade body 30 has a plurality of spaced longitudinal extending grooves 31, 32, 33, 34 opening outwardly through its forward or leading face 17, in which diamond impregnated sections 35, 36, 37, 38 are disposed. Each of the grooves extend from the lower end 20 of the blade body to a substantial extent, and each of the diamond impregnated sections disposed in its groove has a corresponding length. As shown, the sections 35—38 and the grooves 31—34 in which they are received are of varying widths and of varying depths, but preferably have substantially the same length so that all of the sections are available for operation upon the bottom of the hole during the entire useful

drilling life of a blade. Each section includes a matrix containing diamonds D of a suitable size or mesh, the diamonds preferably being substantially uniformly dispersed throughout the matrix. Matrix materials of any suitable type can be used. For example, the matrix may include tungsten carbide or tungsten powder held together by a suitable binder, such as cast iron, nickel, copper, or the like. Various matrix materials are well known in the art and, per se, form no part of the present invention.

The diamond impregnated sections 35—38 lie flush with the leading face 17 of the blade body, the outermost section 38 preferably having gauge stones 40 in its side face for insuring proper reaming action of the outer section upon the walls of the well bore and the maintenance of the bore hole to a proper gauge. The radially separated sections 35, 36, 37, 38 have different widths and depths. Thus, an inner section or sections 35 each have a width and depth which is less than the next adjacent section or sections 36; whereas the latter have a lesser depth and width than the section or sections 37 radially disposed outwardly thereof, which, in turn, have a lesser width and depth than the outermost section 38. Thus, the outermost section or sections 38 will have a greater diamond impregnated area operating upon the bottom of the hole than the section or sections 37 inwardly thereof, which, in turn, will have a greater diamond impregnated area for operation upon the bottom of the hole than the section or sections 36 adjacent thereto and inwardly thereof. The latter section or sections will also have a greater diamond impregnated area operating upon the bottom of the hole than the innermost section or sections 35.

The progressive increase in areas of the sections operating upon the bottom of the hole, as their distance from the axis increases, insures the approximately uniform wear of the sections 35—38, since the sections have progressively a greater cutting action to perform the further they are removed from the axis of rotation of the bit. The outermost section 38 operates upon a much greater hole area during each revolution of the bit than the sections 37 radially inwardly thereof, these latter sections, in turn, covering a much greater area for each revolution of the bit than the sections 36 inwardly thereof, and the latter sections operating upon a greater circumferential extent of hole than the sections 35. The bottom of the hole traversed during each revolution of the bit body by each section is progressively less as its distance from the axis of rotation of the drill bit decreases. Thus, more cutting elements D are presented for operation upon the bottom of the hole in the outer portions of each blade 16 than in the intermediate portions, which, in turn, present more cutting elements D for operation upon the bottom of the hole than the inner cutting segments. The result is a substantially uniform wear of the cutting segments 35—38 as the hole is being drilled. The lack of such approximately uniform wear would result in one or a plurality of segments being worn away more rapidly than other segments, with attendant lack of penetration of the entire cutter blade in the formation and its cessation of effective drilling, thereby requiring the entire drill bit to be removed from the hole prematurely and replaced with another bit, or with new cutter blades.

It is to be noted that the leading face 17 of each cutter blade 16 does not lie on a radial plane 45 of the bit body, but is disposed forwardly of such radial plane to a small extent. In fact, a radius 45 can be drawn from the axis of the drill bit through substantially the midportions of all of the impregnated diamond sections 35—38. In other words, the central portion of each diamond section will lie on a radial plane of the bit body, which results in a smoother operation of the drill bit than if the sections possessed a more predominant negative rake or a more predominant positive rake. The cutting action of each segment 35—38 on the bottom of the hole averages out to a substantially zero rake.

Stability in the operation of the drill bit and its maintenance in a centered condition in the bore hole are obtained by the spacing of the diamond impregnated sections 35—38 from one another generally radially of the axis of the drill bit. The spacing 46 is of such an extent that the sections do not collectively cover the entire radial extent of the hole being drilled by the blade. In fact, there are intermittent areas of the hole bottom that are not operated upon by any diamond impregnated sections. As represented in FIG. 5, annular areas of the hole bottom are not acted upon by the sections at all. As a result, during the operation of the cutter blades 16 on the bottom of the hole, the formation material is removed by them leaving annular or circular ribs 47 in the hole between adjacent diamond impregnated sections. These ribs assist in maintaining the drill bit in a centered condition in the hole so that the drill bit operates smoothly and with stability. The formation material, however, even when very hard, does not possess sufficient strength as to cause the radially separated impregnated sections to produce ribs 47 of any substantial length. During the drilling operation, the ribs or ridges 47 are only formed to a relatively short degree, whereupon they will break down or off by thmemselves, and be removed by the drilling fluid from the drilling region.

In insuring the formation of the centering ridges or ribs 47 in the bottom of the hole, the adjacent diamond sections must be spaced apart sufficiently such that a circle 48 drawn from the axis of the bit to a trailing corner 49 of one section is spaced from a circle 50 drawn from the axis of the bit through the leading corner 51 of an adjacent section, the radial distance between the two circles determining the thickness of the ridge 47 between the sections. Actually, such radial distance should be relatively small so that each rib is relatively thin, whereby it readily and automatically breaks down into pieces that are removable from the bottom of the hole by the drilling fluid.

The stabilizing ribs or ridges 47 could be formed by having the sections 35—38 made with arcuate sides, rather than straight sides. However, it is more economical to form each section with parallel straight sides, capable of fitting within grooves 31—34 in the blade body 30 that also have straight parallel sides. Each groove can be formed economically by use of a milling cutter having the proper width, and which will produce the groove of the desired depth extending inwardly from the leading face 17 of the blade body 30.

When the drilling bit A is first inserted in the hole, each cutter blade 16 projects beyond the end 15 of the bit body to the desired extent. After the end portions of the blades have worn to a substantial extent as the result of drilling the hole, the bit can be removed therefrom, the screws 21 loosened and the cutter blades 16 moved downwardly within the body pockets 14, so that the blades again project below the end 15 of the body to the desired extent, whereupon the lock screws 21 are again tightened against the blades to secure them firmly to the bit body 10. The drill bit is then run back into the hole for continued drilling action upon its bottom.

The blades 16 can be moved axially outwardly of the body 10 by loosening and then retightening the lock screws until substantially the entire length of the diamond impregnated sections 35—38 has been worn away, after which the blades are discarded and a new set mounted in the body in their place.

By virtue of the drill bit described above, no wear is encountered on the body 10 of the drill bit, inasmuch as the blades 16 project beyond its lower end 15, and also radially outwardly thereof to ream the hole to the desired and proper diameter. The blades have a long life inasmuch as the impregnated diamond sections 35—38 can have an extended length, if desired. The long life is

is also attributable to the fact that approximately uniform wear is secured by virtue of gradually increasing the widths and depths of the impregnated diamond sections as they are disposed at greater distances from the axis of rotation of the drill bit. Moreover, the spacing of the sections 35 to 38 from each other laterally of the bit, so that the sections produce the circular ridges 47 in the bottom of the hole, insures the automatic centering of the bit in the hole. The sections 35—38 need not extend downwardly beyond the blade body 30 for the ridges to be formed. Inasmuch as the blade body 30 is made of a suitable steel or other material that does not have as great resistance to wear as the diamond impregnated sections, the body material of the blade will wear away between the sections 35—38 leaving the sections exposed below the blade body 30. As the sections 35—38 wear away, the body material itself will also wear away to a further extent, resulting in the tooth-like extensions of the sections below the blade body 30, for effective operation upon the bottom of the hole.

I claim:

1. A cutter blade for a rotary drill bit adapted to be disposed in a bore hole, including a body having generally parallel longitudinal grooves in its leading face extending upwardly from its lower end and spaced from each other across said leading face; and diamond impregnated cutter sections in said grooves secured to said body and extending upwardly from the lower end of said body; the width and depth of each groove and cutter section therein progressively increasing in one direction across the face of said body.

2. A cutter blade for a rotary drill bit adapted to be disposed in a bore hole, including a body having generally parallel longitudinal grooves in its leading face extending upwardly from its lower end and spaced from each other across said leading face; and diamond impregnated cutter sections in said grooves secured to said body and extending upwardly from the lower end of said body, the width and depth of each of said grooves and cutter sections progressively increasing in one direction across the face of said body, the distance between adjacent sections being such that said sections are adapted to form intervening circumferential ridges in the bottom of the bore hole when rotated therein.

3. In a drill bit: a supporting meber adapted to be rotated in a bore hole; a cutter blade mounted on said supporting member and including a body; said body having grooves in its leading face extending upwardly from its lower end and spaced from each other generally radially of the axis of the supporting member; diamond impregnated cutter sections in said grooves secured to said body and extending upwardly from the lower end of said body, the width and depth of each groove and cutter section therein progressively increasing as the distance of said sections and grooves from the axis of the supporting member increases.

4. In a drill bit: a supporting member adapted to be rotated in a bore hole; a cutter blade mounted on said supporting member and including a body; said body having grooves in its leading face extending upwardly from its lower end and spaced from each other generally radially of the axis of the supporting member; diamond impregnated cutter sections in said grooves secured to said body and extending upwardly from the lower end of said body, the width and depth of each cutter section progressively increasing as the distance of said sections from the axis of the supporting member increases, the distance between adjacent sections being such that said sections form intervening circumferential ridges in the bottom of the bore hole.

5. In a rotary drill bit: a supporting member adapted to be rotated in a bore hole; a cutter blade mounted on and extending generally radially of said supporting member and including a body; said body having grooves in its leading face extending upwardly from its lower end and spaced from each other generally radially of the axis of the supporting member; cutter sections in said grooves secured to said body and extending upwardly from the lower end of said body, the width and depth of each groove and cutter section therein progressively increasing as the distance of said sections and grooves from the axis of the supporting member increases, whereby a greater circumferential extent of cutter section is operative upon the bottom of the bore hole the greater the cutter section is located from the axis of the supporting member.

6. In a rotary drill bit: a supporting member adapted to be rotated in a bore hole; a cutter blade mounted on and extending generally radially of said supporting member and including a body; said body having grooves in its leading face extending upwardly from its lower end and spaced from each other generally radially of the axis of the supporting member; cutter sections in said grooves secured to said body and extending upwardly from the lower end of said body, the width and depth of each groove and cutter section therein progressively increasing as the distance of said sections and grooves from the axis of the supporting member increases, whereby a greater circumferential extent of cutter section is operative upon the bottom of the bore hole the greater the cutter section is located from the axis of the supporting member, the generally radial distance between adjacent sections being such that said sections form intervening circumferential ridges in the bottom of the bore hole during rotation of the drill bit therewithin.

7. In a rotary drill bit: a supporting member adapted to be rotated in a bore hole; circumferentially spaced cutter blades mounted on and extending generally radially of said supporting member, each of said blades including a body having grooves in its leading face extending upwardly from its lower end and spaced from each other generally radially of the axis of the supporting member; cutter sections in said grooves secured to said body and extending upwardly from the lower end of said body, the width and depth of each groove and cutter section therein progressively increasing as the distance of said sections and grooves from the axis of the supporting member increases, whereby a greater circumferential extent of cutter section is operative upon the bottom of the bore hole the greater the cutter section is located from the axis of the supporting member; the cutter sections of said blades being circumferentially aligned and the generally radial distance between adjacent sections of each blade being such that said sections of said blades form intervening circumferential ridges in the bottom of the bore hole during rotation on the drill bit therewithin.

8. In a rotary drill bit: a supporting member adapted to be rotated in a bore hole; a cutter blade mounted on and extending generally radially of said supporting member and including a body; said body having grooves in its leading face extending upwardly from its lower end and spaced from each other generally radially of the axis of the supporting member; cutter sections in said grooves secured to said body and extending upwardly from the lower end of said body, the width and depth of each groove and cutter sections therein progressively increasing as the distance of said sections and grooves from the axis of the supporting member increases, whereby a greater circumferential extent of cutter section is operative upon the bottom of the bore hole the greater the cutter section is located from the axis of the supporting member, said sections being so disposed on said body that a radius drawn from the axis of said supporting member passes through substantially the mid-portions of all of said sections.

9. A cutter blade for a rotary drill bit adapted to be disposed in a bore hole, including a body having generally parallel longitudinal grooves in its leading face extending upwardly from its lower end and spaced from each other across said leading face; cutter sections in said grooves secured to said body and extending upwardly

from the lower end of said body, the width and depth of each groove and cutter section therein progressively increasing in one direction across the face of said body, whereby a greater thickness of cutter section is adapted to be operative upon the bottom of the bore hole the greater the cutter section is located from the axis of the bore hole when disposed therewithin.

10. A cutter blade for a rotary drill bit adapted to be disposed in a bore hole, including a body having generally parallel longitudinal grooves in its leading face extending upwardly from its lower end and spaced from each other across said leading face; cutter sections in said grooves secured to said body and extending upwardly from the lower end of said body, the width and depth of each groove and cutter section therein progressively increasing in one direction across the face of said body, whereby a greater thickness of cutter section is adapted to be operative upon the bottom of the bore hole the greater the cutter section is located from the axis of the bore hole when disposed therewithin; the distance between adjacent sections being such that said sections will form intervening circumferential ridges in the bottom of the bore hole when rotated therein.

References Cited in the file of this patent

UNITED STATES PATENTS

1,172,065	Sletten et al.	Feb. 15, 1916
2,648,524	Dionisotti	Aug. 11, 1953
2,693,938	Roberts	Nov. 9, 1954
2,729,427	Davis et al.	Jan. 3, 1956
2,740,651	Ortloff	Apr. 3, 1956

FOREIGN PATENTS

752,525	Great Britain	July 11, 1956