

May 5, 1970

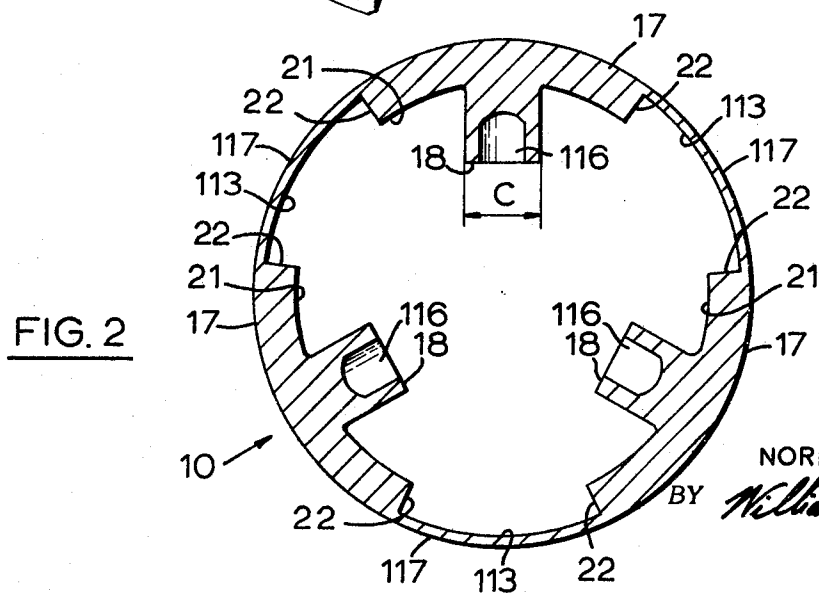
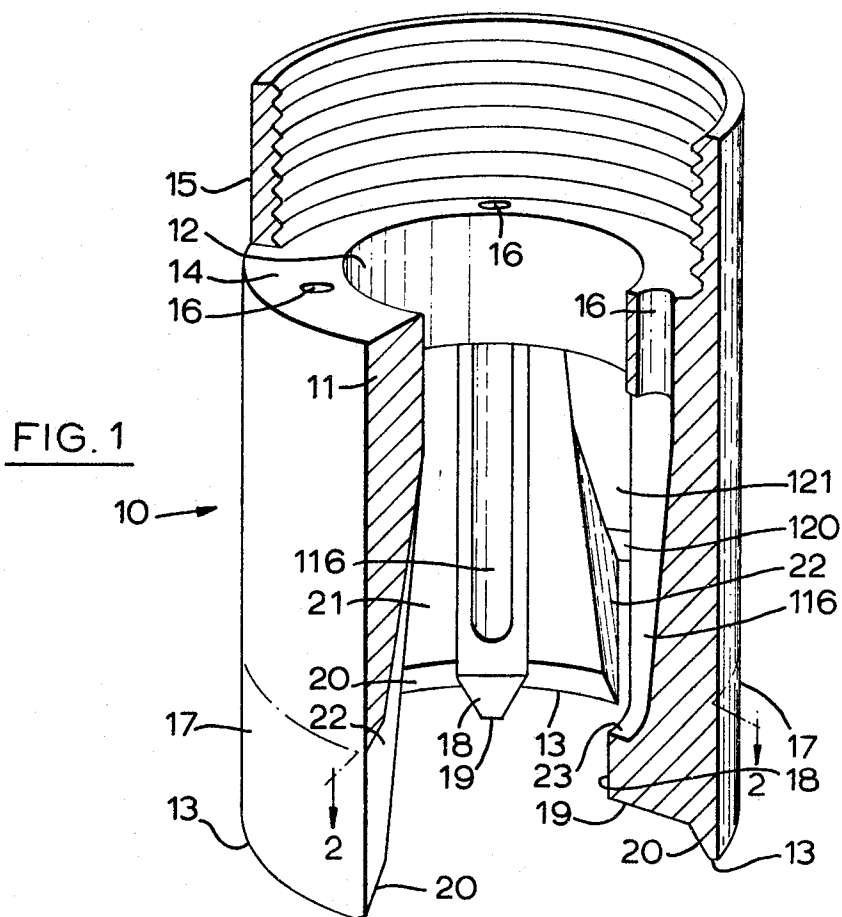
N. D. BECKER

3,509,953

SPADE BIT

Filed May 7, 1968

3 Sheets-Sheet 1



INVENTOR.
NORMAN D. BECKER

BY *William G. Hooley*

May 5, 1970

N. D. BECKER

3,509,953

SPADE BIT

Filed May 7, 1968

3 Sheets-Sheet 2

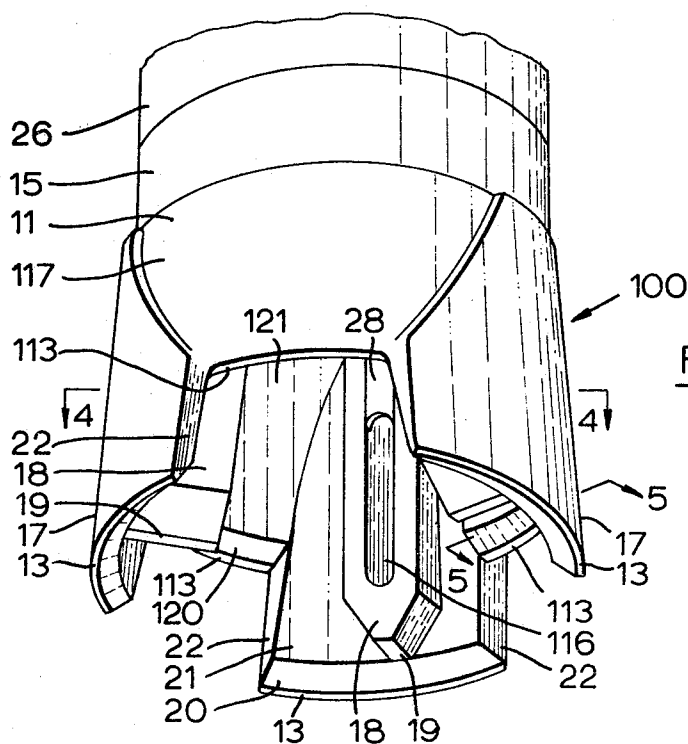


FIG. 3

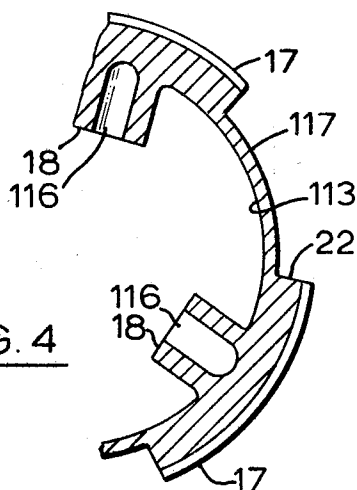


FIG. 4

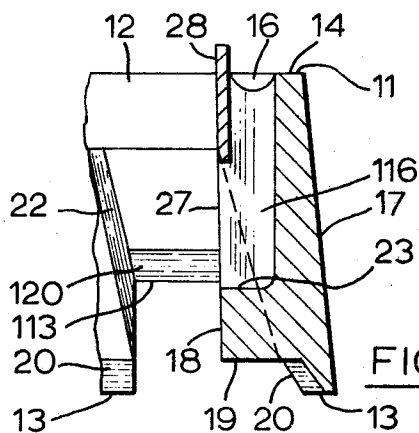


FIG. 5

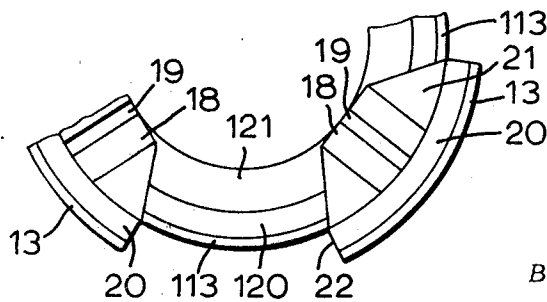


FIG. 6

INVENTOR.

NORMAN D. BECKER

BY

William G. Hopley

1

3,509,953
SPADE BIT

Norman Donald Becker, Calgary, Alberta, Canada, assignor to Becker Drilling (Alberta) Limited, Calgary, Alberta, Canada, a Canadian company
Filed May 7, 1968, Ser. No. 727,209
Int. Cl. E21c 13/02

U.S. Cl. 175—405

11 Claims

ABSTRACT OF THE DISCLOSURE

An annular bit for percussion drilling of earth formations having fluid guiding passages. Sectoral portions of the depending wall of the bit body are elongated downwardly and spaced equiangularly about the body and terminating in lower bevelled cutting margins. Intermediate sectoral portions of the bit body terminate in bevelled cutting margins which are axially spaced above the lower cutting margins. The sectoral portions of the body have inclined surfaces and are tapered in radial thickness from the central passage to the bevelled cutting margins. Each elongated sectoral portion has an upright projecting tooth extending inwardly from the inclined surfaces and has a chisel edge at the lower end, which is above the lower cutting margin but below the cutting margin of the intermediate sectoral portion. The teeth have fluid guiding passages opening inwardly and communicating with the fluid guiding passages in the body.

This invention relates to percussion earth drilling and in particular concerns improved annular bits having radially-set teeth integrally centered on sectoral cutting edges, and which are capable of penetrating relatively non-plastic formations.

The novel bit forms according to the invention extend the method of impact drilling described in U.S. Pat. No. 3,280,925 to the sinking of boreholes in soils and formations impenetrable to or difficultly penetrable by the annular drill bits disclosed therein. In the aforesaid patent, forms of drill bit lacking the spade-like edge elements of the present invention have been described, wherein an annular body carries depending radially-set teeth terminating in chisel edges and the lower portion of the annulus is conic and terminates in a sectorally-interrupted cutting margin lying above the tooth edges; the cutting margin is disposed either at the inner diameter or outer diameter of the annulus as decided by the nature of the formation, to displace fragments mainly outwardly into the formation or mainly inwardly into a central passage.

While the bit forms of the prior patent have proven efficacious for penetrating most of the overburden deposits encountered in the field where the soils or formations exhibit a degree of plasticity, it has been found that a number of earth materials are resistant to penetration. The problem arises wherever the earth formation in the highly stressed zones in contact with the tooth edges and with the cutting margins is not sufficiently susceptible of displacement either laterally or also downwardly into the surrounding ground. The problem also occurs wherever the bit may be partly in contact with a solid body such as a stone which is embedded in a non-plastic matrix. As a result the tooth edges and cutting margins may be driven only far enough into the ground to shape complementary recesses, in the nature of a mold, the surfaces of which closely engage the tooth edges and conic faces of the bit body without effecting fragmentation or plastic yielding of the intensely stressed material. Despite the application of massive amounts of impact and axial energy, the entire input of pressure and energy appears to be absorbed in a sort of seismic mass movement re-

2

sulting from the effective coupling of the bit with the earth material compacted under it. The penetration achieved is very small and in many cases nil. Inspection of the "seat" molded in the bottom of the borehole shows that the earth material has become densely compacted under repeated impact blows.

The failure to achieve zonal crumbling and lateral and/or downward displacement of the material under the bit has been observed in drilling cemented or densely compacted soils, such as certain dry glacial till deposits, very dry "young" clays, soft sandstones, dry silica silts, calcareous gravels of graded sizes having a strong set, and dry lateritic deposits such as bauxite. These materials, although being relatively weak and having brittleness sufficient to promise penetrability by the prior art bits, can only be drilled by chipping tools such as star percussion drill bits. It has been inferred that the high resistance to slip or failure to yield by plastic deformation results from lack of a plasticizing matrix component in the earth material such as would cause the more highly stressed zones to be deformed and thereby to continuously re-distribute stress on the more brittle portions adjacent the bit face. Although the mechanism of fragmentation of the formation under impact is not known, the successful penetration of typical overburden by the prior bit form can be fairly ascribed to the joint properties of plasticity of matrix compounds such as clays, and brittleness of occluded solid bodies such as stones.

In attempts to solve the problem by concentrating the axial load and impact energy delivered to the bit on a shorter radial length of tooth edges, their number was drastically reduced from eight to three and the tooth shape was modified as well as the shape of the cutting margins to provide a smaller contained angle. When a sufficient input of impact energy was delivered to effect penetration of a resistant formation by the teeth, the extremely high stresses developed in the tooth material caused failures repeatedly by fracture.

Attempts were also made to lengthen the tooth shanks and to enlarge their cross-sections and to concentrate the impact energy by employing bit forms with two teeth and three teeth having chisel edges shaped to a more acute angle. Although an increase in tooth strength was achieved, penetration was not enhanced and failures again resulted by shank fracture. It was concluded that re-design of the radial tooth form could not effect a practical solution of the problem.

It has now been discovered that greatly enhanced penetration and strength results from a modification that does not involve radical re-design of the radial tooth form of the prior bit, if the circular cutting margin is relocated below the chisel tooth edges. Despite the fact that the length of the circular margin is considerably increased by this modification, it has become clear that when alternate arcuate portions of the cutting margin are axially offset below the radial tooth edges and intervening arcuate portions lie above the tooth edges, an optimum increase in penetration is achieved. When each radial tooth shank is centered on the arcuate portion extending below the tooth edge, to form an integral web of T section therewith, and by axially offsetting the intervening cutting margins upwardly so that the T sections resemble spades disposed about the bit periphery, a bit form is realized which is effective in all soils and formations previously penetrable to the prior bit form, while resistant or impenetrable ground may be drilled.

The bit form described in the aforesaid patent disposed the sectoral cutting margins between the radial tooth shanks and well above the tooth edges. Moreover, the cutting margin of the prior art bit is interrupted, and all of the sectoral portions lie in a common transverse

plane. The novel construction of the bit forms of the present invention, providing webbed sectors alternating with non-webbed shorter sectors, and providing further that the breadth of channels formed between adjacent non-webbed sectors is constant, achieves improved freedom for upward movement of fragments.

According to the invention, therefore, an improved annular toothed percussion bit for impact drilling of relatively non-plastic brittle soils and grounds essentially consists in a thick-walled annular body having a central axial passage and an upper apertured impact-receiving face, portions of the body tapering downwardly and terminating in sectoral cutting margins, these portions having integral vertical teeth fixed as webs centered on the sectors and having chisel edges set radially and disposed axially above the cutting margins, and intervening tapering portions terminating in sectoral arcuate margins lying in a plane spaced axially above the other margins and also above the tooth edges. The teeth are preferably formed with vertical passages opening into the axial passage and communicating with the face apertures, for conveying a fluid for entrainment and transport of fragments, provision being made in preferred embodiments for fluid cleaning to prevent clogging by plastic sticky materials such as wet clays.

In carrying the invention into effect, an improved annular percussion bit is realized as a unitary cast or forged alloy steel body of cylindrical annular form and having a wall height in excess of its diameter, the wall thickness tapering downwardly to provide a contained angle at each sectoral cutting margin of not more than about 18 degrees, the sectoral cutting margins being three in number and equidistant from the axis and each subtending an angle of about 67 degrees, and the exterior surface tapering and enlarging in diameter downwardly to provide clearance with respect to the borehole. Each tooth has constant chordal width and constant radial width and projects from the inner conic surface of the sector carrying the lower cutting margins. The chisel edge of each tooth terminates above the plane of the associated cutting margin. The upper sectoral margins are axially offset upwardly such distance as to ensure a contained angle in any axial radial plane of not more than about 42 degrees and preferably as small as possible.

Due to the resemblance of each sectoral margin to a spade, which is stiffened and strengthened by the centered tooth shank acting as a web of an angle section, the bit has aptly been called a "spade bit," and its action in plastic soils is very like the action of a group of three peripherally-arranged spades.

The invention may be more readily comprehended as to its concepts and mode of putting into effect, by studying the following description of its preferred embodiments in conjunction with the accompanying figures of the drawing, wherein:

FIG. 1 is a partly cut-away perspective view of one form of three-tooth spade bit according to the invention, having a threaded connecting flange;

FIG. 2 is a transverse section taken on a plane designated 2—2 in FIG. 1;

FIG. 3 is a perspective view of a modified bit according to the invention, looking into it from underneath;

FIG. 4 is a partial transverse section taken on a plane designated 4—4 in FIG. 3;

FIG. 5 is a partial section viewed in elevation, taken on a radial plane through the bit of FIG. 3 along line 5—5;

FIG. 6 is a partial plan view looking from the underside of the bit of FIG. 3;

FIG. 7 is a side elevation view partly in diametral axial section of another form of bit according to the invention;

FIG. 8 is a partial transverse section taken on line 8—8 of FIG. 7, looking upward to the central passage;

FIG. 9 shows a plan view of part of the upper surface of the bit of FIG. 7 showing porting and channeling for

distributing fluid to the teeth and into the central space of the bit.

With reference to the drawing, a bit generally designated 10 has the form of a hollow cylinder, the annular upper end portion 11 of which is thickened inwardly and defines the upper opening of a central passage 12, and the lower end of which terminates in three sectoral bevelled cutting margins 13 disposed in a common transverse plane, these margins alternating about the circumference of the bit with the three intermediate sectoral margins 113. The latter are disposed in another common transverse plane spaced uniformly above the margins 13.

The upper end of the bit is provided with a flat impact-receiving face 14, the outer zone of this surface being integrally joined with a taper-threaded connector flange 15. Fluid-injection passages 16 spaced about and opening upwardly into the annular face 14 extend axially within each sectoral spade-like portion 17, communicating with the trough-like channels 116 recessed into the sides of teeth 18. The openings in the face 14 communicate with a space within a bit-connector (not shown) to receive a supply of high pressure fluid such as air delivered thereto by way of the annular passage of a double-walled drill pipe, as described in the aforesaid patent.

Teeth 18 are centered on the respective arcs spanned by the spade-like sectoral portions 17, and are formed integrally therewith as inward web flanges of T angle sections. The lower end of each tooth terminates in a radially-aligned chisel edge 19 offset above the sector lower margin 13, and the upper portion merges into the annulus 11. Each tooth has a substantially constant chordal dimension C as measured between opposite sides of the shank above the chisel edge, and the radial dimension of the tooth, as measured from the inward vertical face 27 to the exterior of the bit body, is constant and equal to the breadth of the annular face 14.

The intermediate spade-like sectoral portions 117 of the bit body which are integrally joined with the portions 17 to form a cylindrical wall, carry no teeth when the bit diameter is less than about eight inches. However, in larger sizes, such portions may also carry teeth similar to the teeth 18.

Each of the lower cutting margins 13 and 113 of the bit is formed by the bevelling of conic faces 20 and 120, respectively, which taper inwardly and upwardly from the margins to form a contained angle of about 42 degrees; it is not however intended that the margin should be sharp-edged, and since it is inevitable that after a few minutes of operation in stony ground the cutting margins will become somewhat blunted, the bevelled faces 20 and 120 are manufactured to leave a flat end face of about $\frac{3}{16}$ inch radial width.

The inward surfaces 21 and 121 of the spade-like sectoral portions 17 and 117 are sloped inwardly and upwardly above the bevelled faces 20 and 120, the contained angles of the respective spade portions being less than the contained angle of the margins, the angle of the shorter spade portions being the greater. Each sloping portion merges with the central passage 12 at the lower extremity thereof. The side faces of the longer spade portions 17 lie in vertical diametral planes, thereby allowing earth materials contiguous to the sloped surfaces 121 to move relatively unobstructedly upwards to the central passage.

The vertical spacing between cutting margins 13 and 113 may be as much as two inches or more, for a typical bit of external diameter about 5 inches to 10 inches. For a three-tooth space form bit any increase in the vertical spacing improves the movement of non-plastic fragments, although the bit strength is adversely affected as the spacing becomes large. In general, margin 113 will be positioned to lie intermediate the axial distance between margin 13 and the lower end of passage 12.

The lower ends of the channels 116 terminate short of the chisel edges 19, and the bottom wall 23 of the

5

channel is preferably curved about a horizontal radial axis, to deflect the air or fluid stream laterally toward loosened materials in the space adjacent the inner surfaces of teeth 18. The action of the laterally deflected jets of high-velocity fluid issuing from the tooth channels 116, when impinging ascending material, is to break up such material, this action being enhanced by the conjoint jetting from all channel openings, and possibly also being assisted by the fact that each jet is directed toward the earth formation exposed under cutting edges 113, where the cutting action of the margin has not yet effected cracking of the zone. Consequently as any fragment breaks, an upward component of the jet immediately entrains and clears it from the bit interior.

In the event that earth materials which are of a plastic or gummy character are encountered, such as moist clays, these may be so cohesive as to resist the fragmentation of air blasts issuing from the channel openings. As a result such material may be driven as a coherent wad or plug anchored to the formation below, and the plug may extend nearly the full height of such openings, causing a restriction of ascending flow. However the upper portion of the plug will be increasingly subjected to scouring blasts as the openings decrease in area, tending to break it up when sufficient pressure is applied.

Where the nature of the formation to be traversed requires cutting a borehole having a diameter appreciably larger than the drill pipe diameter to permit the pipe to move freely in the hole, the bit 100 of FIGS. 3 to 6, is preferred. The bit is formed with a tapered body, flaring downwardly and outwardly to cut a borehole providing clearance with respect to the bit connector 26. Each of the toothed sectoral spade-like portions 17 is thickened outwardly with respect to the intermediate sectoral portions 117, the latter being either cylindrical segments, or preferably also being shaped with a small taper for clearance between the borehole wall and the segments above margins 113. The connector flange 15, secured as by welding on the outer zone of the face area 14 of annulus 11, has an outside diameter no larger than the diameter of the upper ends of the sectoral portions 117, so that the widened parts of the annulus, i.e. the upper ends of sectoral portions 17, form shoulders. The bit form differs further from that of FIG. 1 in that the radial side walls 22 of spade sectors 17 project outwardly as well as inwardly. As a consequence the walls of the borehole cut by this bit form are cylindrical fluted surfaces, three flutes of larger diameter being generated by margins 113 and three intervening flutes being generated by margins 113. The earth materials passing upward toward passage 12 inside the annulus 11 are assisted to move upward by the shaping of the side faces 22 on the inside, these having constant chordal width. The faces 22 on each spade sector, as viewed in elevation from the axis of the bit, are sloped upwardly toward the tooth 18, as the junction thereof with annulus 11.

Due to the widening of the bit downwardly and also to the fact that each tooth has its inside face 27 shaped parallel with the bit axis, the chisel edges 19 are relatively longer and the lower end of each spade-like portion 17 is consequently strongly reinforced; the stiffness of the spade is improved as the radial dimension of the web increases.

Channels 116 are shielding from the earth fragments within the bit by inserts 28 welded to cover the upper ends of the grooves which are initially cast in the bit body. These inserts make necessary drilling into the face 14 and also provide a larger cross-sectional area of the fluid-injection passages 16. Where the bit body is extremely hard the use of inserts avoids the costly drilling operation. In affixing the inserts, as by welding or brazing, it is located so that no portion projects appreciably within the plan projection area of the central passage 12. The

6

radial width of the insert is moreover so chosen that the lower end of the bit connector 26, shown in dashed outline, engages the threaded flange 15 by its threaded exterior and the interior surface of the connector is spaced outwardly from the insert to provide a gap 128 therebetween. As a fluid such as air passes down the supply passages of the bit connector and distributes along a peripheral recess in the lower face, it finds its way into the passages 16. The entry portions of the passages communicate with an arcuate groove 30 recessed into the face 14, at a radial position such that groove 30 registers with the recess of the bit connector.

It will be apparent that some flow will be shunted upwardly by way of the gaps 128, and that such shunted flow serves to assist upward transport of fragments. This effect is particularly useful when boring gravel formations having lenses of wet clay, as a sudden penetration of the clay may force a plug through the central passage 12 while fragments are moving up the drill pipe. If the flow were abruptly cut off, by plugging of all channels 116, the drill pipe would probably become blocked and a withdrawal of the string would be necessary. It has been found that the shunted flow, in conjunction with the widening of the bit connector's internal passage, serves to break up plugs as their upper portions move above the inserts 28, so that only short wads are discharged.

Some improvement in spade strength may be obtained by adopting the cylindrical bit form of FIGS. 7-9, wherein the external diameter is substantially constant or where the taper is extremely small to minimize the volume of fragments which may lodge between the bit and the wall of borehole. The radial width of teeth 18 in this embodiment is constant and equal to the thickness of annulus 11. Due to the larger bulk of the bit body the annulus portion 11 may be kept quite short, and the spade lengths may be increased to reduce the slope angles of the conic surfaces 21 and 121, thereby gaining improved penetration in many resistive formations.

In the bit form of FIGS. 7-9 the channels 116 and the supply passages 16 are further protected from blockage by ascending earth masses such as sticky clays, by virtue of the radially-outward extension of the upper ends of the supply passages. The radial offset of the groove 30 permits air to enter the passage without being constricted as to flow cross-section. Consequently, the gap 128 may be made larger and the supply passage in the bit-connector may be located further from the axis.

The bits described hereinabove have proven to be durable and to be effective in percussion drilling of boreholes in ground lacking plasticity such as would either greatly impede or else seat a prior toothed percussion bit immovably in an impression enfolding the tooth edges and cutting margin edges. While a bit form having three spade-like tooth-carrying sectoral portions has been specifically illustrated, it is to be understood that the invention is in no way limited to the form shown, and that as few as two opposed tooth-carrying spade sectors may be provided, particularly for the smaller boreholes. In a very large diameter size, e.g. above 8 inches, more than three teeth may be provided, and teeth may be carried by alternate sectors or by all of them as described hereinabove.

While the embodiments described in the foregoing description are highly effective to advance a borehole into non-plastic or resistive ground, it is to be understood that such ground is highly likely to jam a bit when the drill string is pulled upward, since detritus surrounding the drill pipe may wedge between the borehole and the drill pipe. Therefore, it is contemplated that the bit forms of the present invention will be carried by bit connectors providing adequate selective venting to remove the fragments, such as are described in a copending application.

I claim:

1. A hollow bit for percussion drilling of overburden, comprising a bit body having a central passage, a thick-

7

ened upper end of said body having an impact-receiving annular face, fluid-guiding passages opening into said face, a depending wall portion having sectoral portions thereof elongated downwardly and spaced equiangularly about said body and terminating in bevelled lower cutting margins, and having intermediate sectoral portions terminating in bevelled cutting margins disposed in a plane spaced axially above said lower cutting margins, said sectoral portions having inclined inner surfaces and tapering in radial thickness from said central passage to said bevelled cutting margins, at least each elongate sectoral portion having an upright tooth integrally formed as a projection of and extending inwardly from said inclined surface, and having a chisel edge formed at the lower end and disposed above said lower cutting margins but below the cutting margins of said intermediate sectoral portions, and fluid-guiding channels extending along said teeth and opening inwardly thereof and communicating with said fluid-guiding passages.

2. A bit as claimed in claim 1 wherein said elongate sectoral portions have an external diameter larger than the external diameter of said intermediate sectoral portions.

3. A bit as claimed in claim 2 wherein said bit body has an integral connecting flange secured to said impact-receiving face and said flange has a diameter not larger than the diameter of said intermediate sectors.

4. A bit as claimed in claim 3 wherein said central passage is a cylindric bore and said teeth have a radial width subsequently equal to the radial width of said impact receiving face.

5. A bit as claimed in claim 4 wherein said wall portion has an exterior taper to provide clearance for said bit body above said bevelled margins.

6. A bit as claimed in claim 4 wherein said lower cut-

8

ting margins and said intermediate cutting margins lie in respective transverse planes and lie also on a common cylindric surface, and said elongate wall portion having side walls lying in axial diametral planes.

7. A bit as claimed in claim 6 wherein said channels open inwardly along said teeth and terminate above the lower cutting margins and wherein said channels are closed adjacent said central passage by shields.

8. A bit as claimed in claim 7 wherein said shields project above said impact-receiving face and slightly below said central passage.

9. A bit as claimed in claim 8 wherein said impact receiving face is arcuately grooved concentrically with the bit axis and said grooves are offset outwardly of said fluid-guiding passages and the upper end portions of said passages are widened to communicate with said grooves.

10. A bit as claimed in claim 9 wherein said channels have lower end walls which are cylindrical surfaces, the axis of the cylinders lying along radii of said bit body.

11. A bit as claimed in claim 10 wherein said elongate sectoral portions have chordal dimensions narrowing upwardly on both the inside and outside of said bit body.

References Cited

UNITED STATES PATENTS

1,213,652	1/1917	Johnson	175—405
2,334,453	11/1943	Swofford	175—405
2,358,052	9/1944	Brown	175—418
3,047,082	7/1962	Brown	175—415

DAVID H. BROWN, Primary Examiner

U.S. Cl. X.R.

175—418