HOLLOW CROWN DIAMOND BIT

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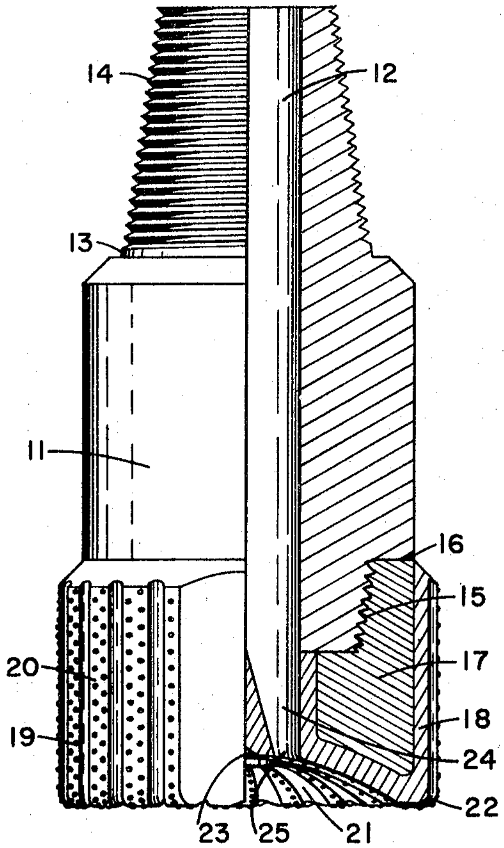

FIG. 1

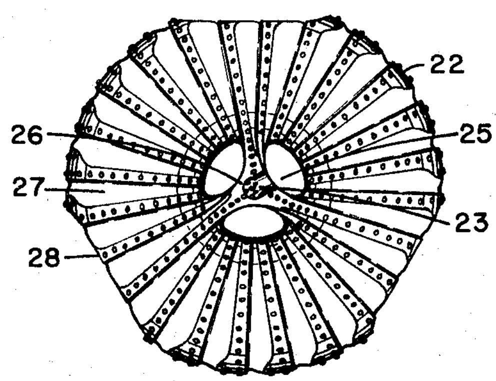

FIG. 2

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HOLLOW CROWN DIAMOND BIT

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The present invention relates to rotary bits for drilling boreholes in the earth and is particularly concerned with diamond bits for drilling oil wells, gas wells and similar boreholes.

The typical diamond drilling bit employed in the petroleum industry has a steel body and a crown composed at least in part of a matrix in which the diamond cutting elements are embedded. The crown generally has a convex configuration but includes a shallow concavity surrounding the bit axis. This configuration produces a short cone-shaped core which extends upwardly from the formation beneath the bit and tends to center the tool in the borehole. Studies have shown that much of the diamond wear on such a bit is due to wobbling of the tool in response to eccentric motion of the drill collars above it. The diamonds on one side of the bit tend to be forced into the formation as the tool wobbles; while those on the other side tend to be lifted away. The resulting variations in the effective weight on the individual diamonds often lead to overstressing of the diamonds and are in part responsible for diamond losses. This problem can be alleviated to some extent through the use of stabilizers or a shock isolator above the bit but has not been eliminated.

It is therefore an object of the present invention to provide improved diamond bits for drilling oil wells, gas wells and similar boreholes in the earth. Another object is to provide diamond drilling bits which can be used for longer periods without serious diamond losses than bits available in the past. A further object is to provide bits which tend to compensate for eccentric motion of the drill collars and thus reduce variations in the effective weight applied to the individual diamonds. Still other objects will become apparent as the invention is described in greater detail hereafter.

The improved diamond bits of this invention are characterized by crowns having concave spherical lower surfaces. Studies have shown that such crowns permit movement of the bit over the underlying formation in response to eccentric movement of the drill collars without substantial variations in the effective weight acting on the individual diamonds near the center of the tool. The variations which do take place are limited largely to the stones near the bit periphery where diamond wear is normally least severe and diamond losses are least likely to occur. This results in longer bit life and better performance than can ordinarily be obtained with conventional diamond drilling bits having flat or conically concave lower surfaces.

The nature and objects of the invention can best be understood by referring to the following detailed description of a diamond bit embodying it and to the accompanying drawing in which:

FIGURE 1 is a vertical elevation, partially in section, of a diamond drilling bit provided with a crown having a concave lower surface constructed in accordance with the invention; and,

FIGURE 2 is a bottom view of the bit of FIGURE 1.

The bit depicted in the drawing includes a tubular body member **11** containing an axial passageway **12** for transmitting drilling fluid through the tool. The body member is provided with an upper shank **13** having external threads **14** by means of which the tool may be connected to the lower end of a rotary drill string or to the outer

end of a drilling rod. For bits to be used in the petroleum industry, the dimensions of the shank and thread size are preferably chosen so that they conform to the standards for an API tool joint pin. Similar standards are available for tools to be employed in the mining industry. In lieu of the pin shown, the bit may be provided with a tool joint box or other connecting means. The lower end of the body member is provided with threads **15** to facilitate attachment of the crown before it is finally welded in place. The welded joint between the body member and crown is indicated by reference numeral **16**.

The crown of the bit shown in the drawing includes a crown blank **17**, a metallic matrix **18**, and diamond cutting elements **19**. The crown blank is a generally cylindrical member of steel or similar metal provided with internal threads by means of which it is attached to the lower end of the body member as pointed out above. The matrix is composed of finely divided tungsten carbide or a similar refractory hardmetal and a metallic binder and is bonded to the inner and outer surfaces of the crown blank. These surfaces may be roughened or indented to promote better adhesion of the matrix if desired. The diamond cutting elements are embedded in the outer surface of the matrix and protrude therefrom for contact with the formation to be drilled. The crown normally extends laterally beyond the body member as shown to provide a gage surface **20** which serves to maintain the required borehole diameter and stabilize the bit within the borehole. The upper part of the crown above the gage surface will normally be tapered at an angle of about 45° as shown.

The crown of the bit of the invention may be fabricated by an infiltration technique. This normally involves the placement of diamonds in shallow depressions in the wall of a refractory mold of carbon or similar material, the placement of the crown blank in the mold in the required position, and the packing of powdered tungsten carbide or a similar refractory hardmetal powder in the mold cavity around the blank. The mold is then placed in a furnace and heated to an infiltration temperature on the order of about 1650° F. to about 2600° F. After the mold and its contents have reached the required temperature, a molten binder metal is infiltrated into the interstice between the crown blank, the carbide granules, and the mold wall. The molten binder metal may be supplied from an upper section of the mold above the other elements or from a separate vessel heated to the infiltration temperature. The binder metal employed will normally be a copper-nickel alloy or similar metal having a melting point in the range between about 1500° F. and about 2500° F. and in the molten state having the ability to wet the carbide granules. As the metal solidifies following infiltration, it forms a metallurgical bond between the steel and carbide. The diamonds are held in place in the outer surface of the matrix by the binder metal and carbide granules. After the mold has cooled, the crown can be removed, sand blasted to eliminate surface irregularities, and thereafter attached to the body member. In lieu of the fabrication procedure thus described, the crown may be fabricated by the liquid phase sintering of an intimate mixture of powdered carbide and binder metal at high pressure and elevated temperature. These and other fabrication techniques, suitable hardmetals, and binder compositions are described in greater detail in the "Diamond Drill Handbook," 1956 edition by J. D. Cumming, published by J. K. Smit & Sons of Canada, Limited, Toronto, Ontario, Canada.

The bit illustrated in the drawing includes a crown having a concave spherical surface **21** for contacting the formation to be drilled. This spherical surface forms the center section of the lower face of the bit and converges with a convex rim **22** near the crown periphery to form a continuous surface. Considering a vertical cross-section through the tool along a plane extending radially through the longitudinal axis, the radius of curvature of the rim surface at points between gage surface **20** and spherical surface **21** will generally range between about 10% and about 30% of the crown radius. The radius of the crown is the horizontal distance between the longitudinal axis of the tool and the gage surface. A rim with a radius of curvature between about 10% and about 20% of the crown radius is preferred. Referring to the same vertical cross-section, the radius of curvature of spherical section **21** at points inside the rim will normally be from about 50% to about 250%, preferably about 80 to about 150%, of the crown radius. The use of a spherical center section having a radius of curvature equal to the crown radius is particularly effective. The spherical surface may be interrupted by a shallow conical cavity **23** at the longitudinal axis of the bit if desired. Such a cavity improves the performance of the diamonds in the immediate vicinity of the bit axis and does not seriously interfere with movement of the spherical surface on the underlying formation. Since the core is unsupported, it will readily break off in response to any lateral force exerted by the bit.

The crown of the bit contains an internal passageway **24** which communicates with axial passageway **12** in the bit body and extends to a discharge port **25** in the lower surface adjacent the bit axis. The tool will normally be provided with a crows-foot **26** which extends across the discharge port to the bit axis to permit drilling out of the entire formation beneath the tool. The conical cavity **23**, referred to earlier, will ordinarily be located in the crows-foot as shown. Water courses **27** extend radially from the discharge port to the bit periphery. The periphery may include one or more junk slots **28** to facilitate the removal of solids from beneath the bit and permit fluid to move around the tool during trips into and out of the borehole. The waterways extend upwardly on the gage surface to the upper edge of the crown. The diamond cutting elements **19** are embedded in the matrix surface between the waterways. It will be understood that the arrangement of the waterways and the diamond pattern employed is not necessarily limited to that shown in the drawing. The arrangement of the diamonds and waterways will depend in part on the particular service for which the bit is intended and may be varied.

During a drilling operation carried out with the bit of the invention, drilling fluid is circulated through the drill string or rod into axial passageway **14** in the bit body. This fluid flows through crown passageway **24** and is discharged through port **25** into the space between the formation and the lower face of the bit. Fluid and entrained cuttings are carried outwardly through waterways **27** and enter the annular space surrounding the body above the crown as the bit is rotated. Eccentric motion of the drill collars above the bit during the operation will change the forces acting upon the tool. The weight will tend to increase on one side and decrease on the other. In response to this change, the spherical center surface

on the lower face of the bit will tend to move laterally on the spherical surface of the underlying formation. This movement reduces variations in the weight acting upon the individual diamonds near the center of the tool where diamond wear is normally most severe. The stones near the periphery may wear slightly more than on most conventional bits. By thus reducing the wear at points inside the periphery, more uniform diamond life and a reduction in diamond losses are obtained. This generally results in better bit performance and savings in overall drilling costs.

Numerous modifications in the bit structure shown in the drawing can be made without departing from the invention. Changes which may be made in the diamond pattern, the arrangement of the watercourses, the configuration of the junk slots and similar modifications will be apparent to those skilled in the art.

What is claimed is:

1. A diamond drill bit comprising:

(a) a body member containing an axial passageway for transmitting drilling fluid through said member;

(b) a crown attached to the lower end of said body member, said crown including (i) a concave lower surface having a convex rim with a radius of curvature between about 10 percent and about 30 percent of the crown radius and a concave spherical center section converging with said convex rim, said center section having a radius of curvature between about 50 percent and about 250 percent of the crown radius; (ii) a conical cavity in said center section at the longitudinal axis of the crown; (iii) a fluid passageway communicating with said passageway in said body member and terminating in a discharge port in said lower surface near the longitudinal axis of said crown; and (iv) a plurality of waterways in said lower surface, said waterways extending from said discharge port to the crown periphery; and

(c) a plurality of particulate cutting elements embedded in said lower surface and protruding therefrom between said waterways.

2. A bit as defined by claim **1** wherein said rim has an external radius of curvature between about 10 percent and about 20 percent of the crown radius and said center section has an external radius of curvature between about 80 percent and about 150 percent of the crown radius.

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