Aug. 25, 1964 H. C. BRIDWELL ETAL 3,145,790

DRAG BIT

Filed June 10, 1963

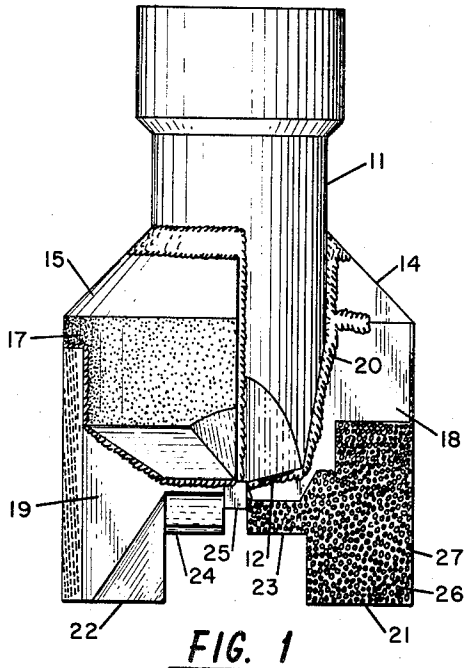


FIG. 1

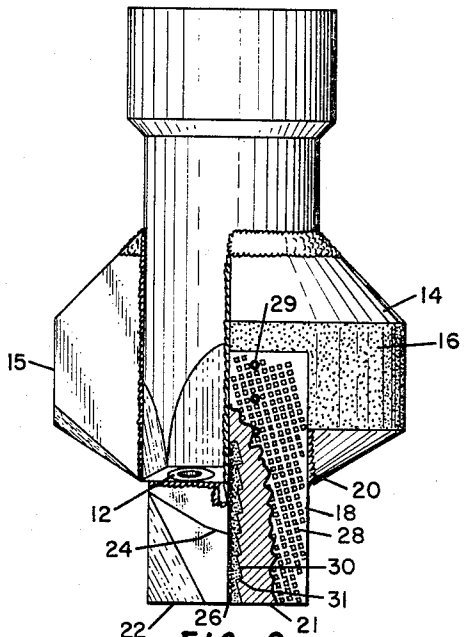


FIG. 2

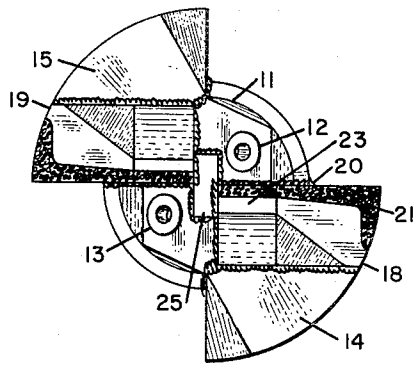


FIG. 3

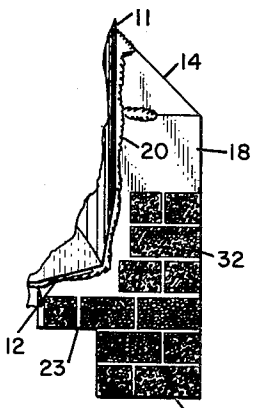


FIG. 4

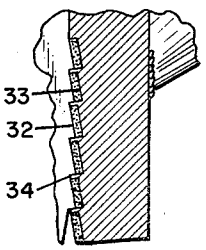


FIG. 5

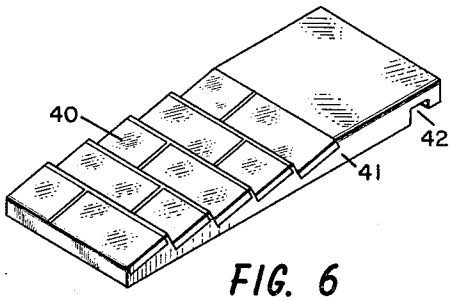


FIG. 6

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DRAG BIT

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The present invention relates to rotary drill bits and is particularly concerned with drag bits useful for drilling oil wells, gas wells and similar boreholes.

The blades of drag bits used in the petroleum industry are normally hard surfaced with tungsten carbide or a similar abrasion-resistant material. Experience has shown that the bonding of such a material to the face and gage edge of each blade improves performance but that such bits generally last only a short time. The high longitudinal and torsional impact loadings to which the blades are subjected cause fractures near the bond line between the hard surfacing material and the softer supporting metal, resulting in rapid loss of much of the hard metal from the face of each blade. Once this happens, the softer metal wears away quickly and the bit must be discarded. Efforts to avoid this and related problems by changing the composition of the hard surfacing material and the method used to bond it in place have been largely unsuccessful. As a result, drag bits are normally used only in soft formations where impact loadings are generally low and blade wear is less severe.

It is therefore an object of the present invention to provide an improved drag bit having blades hard surfaced with tungsten carbide or a similar abrasion-resistant material which will wear longer and permit higher drilling rates than have generally been obtained with drag bits available in the past.

Another object of the invention is to provide an improved drag bit blade structure which is stronger and better able to resist high longitudinal and torsional impact loadings than conventional blades hard surfaced with tungsten carbide or a similar material.

A further object of the invention is to provide an improved method for the mounting of tungsten carbide or a similar hardmetal on the face of a drag bit blade to avoid fracturing at the bond line between the hardmetal and the softer supporting metal under conditions normally encountered in drag bit drilling operations.

Other objects of the invention will be readily apparent from the following detailed description of a drag bit including several blade embodiments and the accompanying drawing, in which:

FIGURE 1 is a vertical elevation of a fixed blade drag bit fitted with blades constructed in accordance with the invention;

FIGURE 2 is a vertical elevation, partially in section, of the bit shown in FIGURE 1 rotated through an angle of 90° to illustrate construction of the blade;

FIGURE 3 is a bottom view of the bit shown in FIGURES 1 and 2;

FIGURE 4 is a fragmentary view of a bit similar to that shown in FIGURES 1 through 3 illustrating an alternate blade structure;

FIGURE 5 is a vertical section through the blade depicted in FIGURE 4; and

FIGURE 6 shows a drag bit blade constructed in accordance with the invention for use on an extensible blade drag bit.

The fixed blade drag bit shown in FIGURE 1 of the drawing includes a hollow steel body **11** of conventional design. A standard A.P.I. tool joint box or similar means is provided near the upper end of the body to permit attachment of the bit to the lower end of a drill collar or other drill string component. Nozzles **12** and **13**, only

one of which appears in FIGURE 1, are installed near the lower end of the body for the discharge of drilling fluid from within the hollow body against the formation at the bottom of the borehole. The nozzles will normally be made of tungsten carbide or a similar erosion-resistant material and may be welded to the body or held in place by snap rings or the like. Each nozzle is oriented so that the drilling fluid discharged beneath the bit will impinge against the formation between the center of the hole and the borehole wall at a point a short distance in front of the blade. The nozzles are preferably arranged so that the fluid can be discharged at high velocity. The nozzle arrangement is shown more clearly in FIGURE 3 of the drawing.

Abrasion-resistant pads **14** and **15** are mounted on the body of the bit shown in FIGURE 1 near the lower end thereof. Each pad is cast or machined from steel or similar metal and is hard surfaced with a matrix containing tunsten carbide particles or a similar hard surfacing material indicated by reference numerals **16** and **17**. In lieu of such a hard surfacing material, inserts of tungsten carbide or the like may be embedded in holes drilled in the outer surface of each pad. The pads shown are welded in place. Each pad extends about the body circumference through an angle of from about 45 to about 120° and projects outwardly to substantially the gage diameter of the bit. The diameter through the pads will preferably be about 1/64 to about 1/4 inch less than gage diameter and should never be greater than the diameter through the blades of the tool. Each of the pads extends vertically from a point near the bottom of the body to an intermediate point on the outer surface of the body above the blades. The pads reduce the annular space through which drilling fluid may pass upwardly about the bit and thus assist in controlling the flow pattern of the fluid. They also serve to stabilize the bit in the borehole and reduce wear of the blades at the gage surfaces. The bit shown in the drawing has two pads and two blades and is thus referred to as a "two-way" bit. It will be understood, however, that the invention is equally applicable to bits having more than two blades.

Blades **18** and **19** of steel or other metal are attached to the body of the bit shown in FIGURE 1 and extend downwardly below it in spaced relationship to the nozzles and pads. Each blade as shown is cast or machined to fit closely against the side and bottom of the body within a recess in the forward portion of a pad and is welded in place. The weld metal is indicated by reference numeral **20**. The blades shown are stepped across the bottom and are thus provided with lower edges **21** and **22** which drill the outer portion of the hole and with upper edges **23** and **24** which drill the inner portion of the hole. This results in the formation of a short core which assists in centering the bit in the hole and generally promotes smoother operation. The blades may be tapered on the back side to reduce the contact area at both the upper and the lower steps. Each blade extends laterally beyond the body to a point adjacent the outer surface of the corresponding pad and preferably projects a short distance beyond the pad, thus providing a gage surface which serves to ream the borehole during a drilling operation. A short filler **25** is welded in place between the blades and the body in order to secure the inner section of the blades. In the two-way bit shown in FIGURES 1 through 3, the blades are located on opposite sides of a line extending through the axis of the bit. On a three-way, four-way or similar bit, the blades will normally be located at equal intervals around the body periphery.

The construction of the blades employed on the bit shown in FIGURE 1 is depicted more clearly in FIGURES 2 and 3 of the drawing. The face and gage edge of each blade are hard surfaced with a matrix **26** con-

taining particles of tungsten carbide, a tungsten carbide alloy or a similar abrasion-resistant material having a Rockwell A hardness in excess of about 85. A variety of matrix metals may be used, including copper-nickel alloys, copper-nickel-tin alloys, copper-nickel-manganese alloys, iron-nickel-manganese alloys, iron-carbon alloys, S-Monel and the like. Powdered tungsten carbide or a similar abrasion-resistant powder may be incorporated within the matrix metal in order to increase its strength and resistance to erosion and abrasion. The carbide particles 27 on the faces of the blades are irregularly shaped particles or chips of tungsten carbide ranging from about ⅛ and 3/16 inch in size. The particles 28 on the gage surfaces are tungsten carbide cubes from about ⅛ to about ⅜ inch along each edge. Chips or cubes of tunsten carbide or a like material may be used on both the face of the blades and the gage edges if desired. Hard surfacing materials including a matrix metal and embedded particles of tungsten carbide or a similar hard metal may be produced by powder metallurgy techniques. A preferred process for the manufacture of such materials is described in co-pending application S.N. 136,308 filed in the name of Harold C. Bridwell and David S. Rowley on September 6, 1961. It will be understood, however, that the invention is not limited to the use of blades hard surfaced in this manner and that pads or inserts of tungsten carbide or a similar hard surfacing material may be bonded to the blade surfaces by other techniques. The blades shown include diamonds 29, about ⅛ carat in size, embedded in the gage surfaces to further increase the abrasion resistance of the bit.

As can be seen from FIGURE 2, the hard surfacing material employed on the face of each blade is bonded to the steel supporting structure along vertically-spaced surfaces 30 inclined at negative angles to the longitudinal axis of the blade. Studies have shown that the fracture problem encountered with conventional blades is due in part to the way in which the hardmetal is mounted on the face of the blade. The tungsten carbide or similar material is much more resistant to wear and abrasion than the steel used in the body of the blade. As a result, the hardmetal normally extends slightly below the rest of the blade, forming a small clearance angle between the blade and the formation. Because of this clearance angle, higher vertical compressive stresses are set up in hardmetal than in the adjacent steel when weight is applied to the bit. This creates shear stresses across the bond betwen the steel and hardmetal. The generation of additional shear as the bit rotates, due to unequal weight distribution or impact of the bit against the formation for example, may cause fractures in the hardmetal or at the bond line between the two materials. Once the fracture is initiated, it acts as a stress riser and may result in the loss of much of the hardmetal initially present. By bonding the hardmetal to the steel along surfaces inclined to the blade axis at negative angles, a part of the longitudinal stress in the hardmetal can be transmitted across the bond line to the steel as a compressive stress. This reduces the tendency of the hardmetal to fracture during operation of the bit and thus minimizes the loss of hardmetal under severe conditions.

The surfaces 30 to which the tungsten carbide or similar abrasion-resistant material is bonded are inclined with respect to the longitudinal axis of the blade. The included angle which the projected surfaces make with the longitudinal axis may range from about 5° to about 30° and will preferably fall between about 5° and about 15°. This angle is referred to as a negative angle because the inclined surfaces slope downwardly away from the face of the blade toward the trailing edge. Each inclined surface is separated from the adjacent inclined surface by an intervening surface 31 which in the bit shown extends in a substantially horizontal direction. This gives the face of the blade, prior to application of the hard surfacing material, a serrated or sawtooth profile. The recesses between the inclined and intervening surfaces may be machined in the face of the blade or may be produced by casting the blade in a suitable mold. The outer surface of the hard surfacing material on the bit shown in FIGURES 1 through 3 extends substantially parallel to the longitudinal axis of the blade.

FIGURES 4 and 5 of the drawing depict an alternate blade structure which utilizes a plurality of vertically spaced inserts in lieu of the continuous facing or single insert described above. Here individual inserts 32 prepared from chips of sintered tungsten carbide or a similar material, carbide powder and a metallic binder are bonded to inclined surfaces 33 and intervening surfaces 34 in a vertically-spaced relationship. The individual inserts may extend across the entire blade or may extend only part way as shown. The outer face of each insert may be parallel to the bonded surfaces or parallel to the longitudinal axis of the blade. Fabrication techniques similar to that referred to earlier or other methods may be utilized. This use of a plurality of vertically-spaced inserts bonded to surfaces inclined at negative angles to the longitudinal axis of the blade is advantageous in that multiple inserts restrict the distance through which any fracture is propagated vertically in the hardmetal and thus further reduce the likelihood that significant quantities of hardmetal will be lost from the face of the blade.

A drag bit blade intended for use on an extensible drag bit is shown in FIGURE 6 of the drawing. This blade is similar to those described earlier in that it comprises a plurality of vertically-spaced abrasion-resistant inserts 40 bonded to the face of a steel supporting structure 41 along surfaces inclined at negative angles to the longitudinal axis of the supporting member. Each of the inserts shown is a rectangular plate of sintered tungsten carbide or similar material. The inserts are set in vertically-spaced notches or grooves in the face of the blade. Each is separated from the adjacent inserts in order to limit the propagation of any cracks or fractures that may develop during drilling. Hardmetal and diamonds may be provided on the gage edge of the blade to reduce blade wear. The blade includes a groove 42 at its upper end for attaching it to an extensible blade drag bit. Other means for mounting the blades may be employed, the means selected depending upon the characteristics of the particular bit for which the blade is intended. Several embodiments of such a bit are disclosed in U.S. Patent 3,066,749, issued on December 4, 1962.

The advantages of the blade construction described above over conventional blades can be seen by considering the results of drilling tests carried out with drag bits under field conditions. In a first set of tests, two drag bits were employed. The blades on both bits were provided with inserts generally similar to those on the blade depicted in FIGURE 4 of the drawing. Except for the fact that the inserts on one set of blades were set at a negative angle of 10° with respect to the longitudinal axis of the blade and those on the other set of blades were vertically-oriented and thus were not set at a negative angle, the two sets of blades were essentially identical. Identical materials and techniques were employed in their fabrication. Both bits were tested in the same formation using a Mayhew drilling rig and conventional auxiliary equipment. A bit weight of 15,000 pounds and a rotary speed of 60 revolutions per minute were used in the test. Examination of the bits at the conclusion of the drilling operation showed that matrix fractures had occurred on the bit having vertically-oriented inserts. The fractures extended across almost the entire leading edges of the blades and at points large pieces of the inserts had been lost. There was no evidence of fracturing on the bit having inserts set at a negative angle. This indicates that the mounting of the inserts at a negative angle on the faces of the blades reduces insert fracturing and resulted in a strong more dependable blade structure.

A second series of tests was carried out in a commercial

well in the South Texas area. In these tests an extensible blade drag bit was used. Two blades having 10° negative angle inserts generally similar to those shown in FIGURE 6 of the drawing was first used to drill through an interval of 2,605 feet. The inserts used on these blades contained tungsten carbide particles ranging in size between about 0.1 inch and about 0.15 inch. The particles were embedded in a matrix containing powdered tungsten carbide, powdered nickel and a copper-nickel alloy. Each insert was ¾ inch high. The blades wore ⅞ inch in drilling the 2,605 feet. No fracturing of the inserts occurred. No unusual or detrimental effects were detected when the blades wore down past the first inserts and the second vertically-spaced inserts came into operation. A second set of blades constructed of the same basic materials and fabricated in the same manner as the first set, except that the inserts were not set at a negative angle to the blade axis, were then tested. It was found that this second set of blades had fractured after drilling 1,004 feet under the same loading conditions as were used with the first blades. Comparable drilling rates were obtained with the two sets of blades, indicating no substantial differences in the hardness and abrasive characteristics of the strata drilled. It can thus be seen that the bonding of the hard metal to the face of the blade along vertically-spaced surfaces inclined at a negative angle to the blade axis has definite advantages over bonding the material to the face of the blade in the conventional manner.

It will be understood that the improved drag bit blades of the invention are not limited to the specific features represented in the drawing. The blades of the invention may be constructed of either cast or sintered metal and may be provided with a continuous hard facing of tungsten carbide or a similar material or with a series of vertically-spaced inserts. In either case, the hard metal is bonded to the face of the blade along vertically-spaced surfaces inclined at negative angles to the longitudinal axis of the blade. The blades of the invention may be employed on bits having two, three, four or more blades and are applicable to both core bits and drilling bits. These and similar modifications will be readily apparent to those skilled in the art.

This application is a continuation-in-part of S.N. 41,999, filed on July 11, 1960, now abandoned.

What is claimed is:

1. A drag bit cutting element comprising a metallic blade having a hard facing material bonded to the face thereof, said hard facing material being bonded in place along vertically-spaced surfaces sloping downwardly toward the trailing edge of said blade at an angle of from about 5° to about 30° to the longitudinal axis of the blade.

2. A cutting element as defined by claim 1 wherein said hard facing material comprises particles of tungsten carbide embedded within a metallic matrix.

3. A cutting element as defined by claim 1 wherein said hard facing material is bonded to said blade along a plurality of vertically-spaced surfaces which slope downwardly toward the trailing edge of the blade at an angle of from about 5° to about 15° to the longitudinal axis of said blade.

4. A cutting element for a drag bit comprising a metallic blade having a plurality of vertically-spaced surfaces on the face thereof, said surfaces being inclined to the longitudinal axis of said blade at a negative angle of from about 5° to about 30°, and an abrasion-resistant composition composed at least in part of a material having a Rockwell A hardness in excess of about 85 bonded to said surfaces on said blade.

5. A cutting element for use on a drag bit which comprises a blade and a plurality of vertically-spaced abrasion-resistant inserts bonded to the face of said blade along planes extending at negative angles of from about 5° to about 30° to the longitudinal axis of said blade, said inserts comprising a refractory hard facing material having a Rockwell A hardness in excess of about 85.

6. A cutting element as defined by claim 5 including means near the upper end of said blade for attaching the same to an extensible blade drag bit.

7. A drag bit comprising a body member provided with means near the upper end thereof for attaching said member to the lower end of a rotary drill string; a plurality of blades connected to and depending from said body member, each of said blades including a plurality of vertically-spaced surfaces sloping at negative angles of from about 5° to about 30° from the leading face toward the trailing edge thereof; and a refractory hard metal having a Rockwell A hardness in excess of about 85 bonded to the face of each blade along said sloping surfaces.

8. A bit as defined by claim 7 wherein said hard metal comprises a metallic matrix and a plurality of tungsten carbide particles dispersed within said matrix.

9. A bit as defined by claim 7 wherein said hard facing material comprises sintered tungsten carbide.

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