DIAMOND CUTTER ROCK BIT WITH PENETRATION LIMITING

BACKGROUND

Two principal types of rotary drill bits are employed for rock drilling for oil wells, recovering core samples, and the like. One type uses rolling cone cutters mounted on the body of the drill bit so as to rotate as the drill bit is rotated. The angles of the cones and the bearing pins on which they are mounted are aligned so that the cones essentially roll on the bottom of the hole without gross slippage. Sometimes the cones are deliberately skewed to enhance gouging action in some rock types. One type of rolling cone cutter is an integral body of hardened steel with teeth formed on its periphery. Another type has a steel body with a plurality of tungsten carbide or similar inserts of high hardness that protrude from the surface of the body somewhat like small knobs. As the rolling cone cutters roll on the bottom of the hole being drilled, the teeth or carbide inserts apply a high compressive load to the rock and fracture it. The cutting action in rolling cone cutters is typically by a combination of crushing and chipping. The cuttings from a rolling cone cutter are typically a mixture of moderately large chips and fine particles.

Another basic type of rotary rock drill is a drag bit. Some of these have steel or hard faced teeth, but primarily they are set diamond drills. Typically in a set diamond drill the face is coated over much of its area with a hard material in which are embedded or "set" numerous diamonds. The diamonds protrude from the surface of the matrix a short distance (typically no more than a few hundredths of an inch in a new drill) and when the drill is used they rub on the rock, abrading shallow tracks and cutting primarily by a combination of compressive and shearing action. In most cases set diamonds, due to their small size, bear loads of about 100 to 200 pounds per diamond. In many set diamond bits, rounded diamonds are selected to give best resistance to compressive forces. The depth of penetration of the set diamonds is ordinarily determined by the weight on the bit, the quantity of diamonds on the bit and heat limitations.

Combinations of drag bits and rolling cone bits have been proposed. For example, U.S. Pat. No. 3,174,564 to E. A. Morlan for a "Combination Core Bit", has a cylindrical crown encrusted with set diamonds for cutting an annulus around a core. The set diamonds protrude from the matrix tiny distances in the conventional manner. A plurality of rolling cone cutters with carbide inserts are mounted in special recesses around the cylindrical crown for cutting an outer annulus of considerably greater area than the inner annulus cut by the diamonds. The set diamonds are used for their fine abrasive action in trimming the core and thereby minimizing breakage. Most of the cutting is done by the rolling cone cutters.

In conventional set diamond drills the depth of penetration of each diamond is only a few mils but rapid penetration rates can be obtained because of the large number of diamonds set on the face of the bit. Penetration rate is limited so that there is minimal wear of the matrix in which the diamonds are mounted. Rock drilling by set diamond drills is analogous to grinding with a grinding wheel made of small abrasive particles. The cuttings from a set diamond bit are in the form of extremely fine particles.

U.S. Pat. Nos. 1,731,262 to Phipps and 2,054,277 to Wright also have combinations of drag bits and rolling cone cutters. These bits have large steel drag teeth and steel rolling cone cutters hence are rather limited in application. Only very soft formations can be cut efficiently with such a design and they are impractical for deep wells where it is desirable to cut long distances before changing the rock bit.

Recently a new product has become available that permits a new type of rock bit. The product is a diamond cutter described in greater detail hereinafter. Broadly, the diamond cutter has a wafer or plate of diamond about 0.020 inch thick and 0.33 inch in diameter bonded to a tungsten carbide slug. This product was developed by General Electric and is commercially available under their trademark COMPAX. The slug can be inserted in a drill bit body so that the diamond plate protrudes therefrom at the proper angle for cutting rock. The cutting action by these diamond cutters is by shearing the rock much in the manner of conventional machining with cutting tools rather than the grinding-like action of conventional set diamond drills. Instead of finely ground material, much of the cut rock emerges from the drilled hole as appreciable size chips, somewhat like those from a rolling cone cutter.

A rock drill having such diamond cutters protruding from its face has been built by General Electric. Such bits have demonstrated good penetration rates in a variety of rocks and very long lifetime. Some problems have been noted under adverse conditions due to breakage of the diamond cutters. This appears to be a particular problem in interspersed formations where there are sudden changes between relatively soft and relatively hard types of rock, and most particularly when the dip of the interspersed formation is steep relative to the hole being drilled.

When a rotary rock bit is being used, a selected weight is applied to it by the weight of the drill string in the hole above it, as controlled by the drilling rig. The weight applied to the bit is adjusted depending upon the type of rock being drilled. Rapid drilling weight adjustment to account for differences in rock types in interspersed formations is not feasible. This means that penetration may be too much in one rock type or too little in the other. This problem is serious in ordinary set diamond drills but is not significant in rolling cone drills. It also can be significant in drills with diamond cutters where a limited number of cutters are engaging the rock during drilling.

Drills with diamond cutters appear particularly sensitive to overloading which can break the diamond cutters. Sudden changes in rock hardness may also apply an impact load on the diamond cutter and initiate failure. It may, therefore, be necessary in interspersed formations to use a drilling load that is appreciably less than optimum for best penetration to protect the bit with diamond cutters. It is desirable to provide a means for protecting the diamond cutters during drilling to inhibit damage to the diamond cutters so that maximum penetration rates can be achieved.

BRIEF SUMMARY OF THE INVENTION

There is, therefore, provided in practice of this invention according to a presently preferred embodiment, a rock bit having a bit body with a plurality of diamond cutters mounted thereon and protruding from the surface in positions that provide a cutting edge on each diamond cutter for shearing rock upon rotation of the