ROTARY DRILL BIT WITH IMPROVED CUTTER AND METHOD OF MANUFACTURING SAME

This application is a divisional application of U.S. application Ser. No. 08/221,371, filed Mar. 31, 1994 and entitled "Rotary Drill Bit with Improved Cutter" (as amended), now U.S. Pat. No. 5,429,200.

RELATED APPLICATION

This application is related to copending application entitled Rotary Drill Bit with Improved Cutter and Seal Protection, Ser. No. 08,221,841, filed Mar. 31, 1994.

TECHNICAL FIELD OF THE INVENTION

This invention relates in general to rotary cone drill bits used in drilling a borehole in the earth and in particular to composite cone cutters with enhanced downhole performance.

BACKGROUND OF THE INVENTION

One type of drill used in forming a borehole in the earth is a roller cone bit. A typical roller cone bit comprises a body with an upper end adapted for connection to a drill string. Depending from the lower end portion of the body are a plurality of arms, typically three, each with a spindle protruding radially inward and downward with respect to a projected rotational axis of the body. A cone cutter is mounted on each spindle and supported rotatably on bearings acting between the spindle and the inside of a spindle-receiving cavity in the cutter. On the underside of the body and radially inward of the arms are one or more nozzles. These nozzles are positioned to direct drilling fluid passing downwardly from the drill string toward the bottom of the borehole being formed. The drilling fluid washes away the material removed from the bottom of the borehole and cleanses the cutters, carrying the cuttings radially outward and then upward within the annulus defined between the bit body and the wall of the borehole.

Protection of the bearings which allow rotation of the respective roller cone cutters can lengthen the useful service life of the bit. Once drilling debris is allowed to infiltrate between the bearing surfaces of the cone and spindle, failure of the bearing and the drill bit will follow shortly. Various mechanisms have been employed to help keep debris from entering between the bearing surfaces. A typical approach is to utilize an elastomeric seal across the gap between the bearing surfaces of the rotating cone cutter and its support on the bit. However, once the seal fails, it again is not long before drilling debris contaminates the bearing surfaces via the gap between the rotating cutter and the spindle. Thus, it is important that the seal be fully protected against wear caused by debris in the borehole.

At least two prior art approaches have been employed to protect the seal from debris in the well. One approach is to provide hardfacing and wear buttons on opposite sides of the gap between the spindle support arm and cutter, respectively, where the gap opens to the outside of the bit and is exposed to debris-carrying well fluid. These buttons slow the erosion of the metal adjacent the gap, and thus prolong the time before the seal is exposed to borehole debris. Another approach is to construct the inner-fitting parts of the cutter and the spindle support arm so as to produce in the gap a tortuous path to the seal that is difficult for debris to follow. An example of this latter arrangement is disclosed in U.S. Pat. No. 4,037,673.

An example of the first approach is used in a conventional tri-cone drill bit wherein the base of each cone cutter at the juncture of the respective spindle and support arm is defined at least in part by a substantially frustoconical surface, termed the cone backface. This cone backface is slanted in the opposite direction as the conical surface of the shell or tip of the cutter and includes a plurality of hard metal buttons or surface compacts. The latter are designed to reduce the wear of the frustoconical portion of the backface on the cone side of the gap. On the other side of the gap, the tip of the arm is protected by a hardfacing material. For definitional purposes, that portion of the arm which is on the outside of the bit and below the nozzle is referred to as a shirttail surface or simply shirttail. More specifically, in referring to prior art bits, radially outward of the juncture of the spindle with the arm, and toward the outer side of the bit, the lower pointed portion of the shirttail is referred to as the tip of the shirttail or shirttail tip.

During drilling with rotary bits of the foregoing character, debris often collects between the backface of the cone cutters and the wall of the borehole generally within the area where the respective gaps associated with each cone cutter open to the borehole annulus. As a result, the underside of the edge of the shirttail tips which lead in the direction of rotation of the bit during drilling, i.e., the leading edge, can become eroded. As this erosion progresses, the hardfacing covering the shirttail tips eventually chips off. This chipping exposes underlying softer metal to erosion and thereby shortens the path that debris may take through the gap to the seal. This path shortening ultimately exposes the seal to borehole debris and thereby causes seal failure.

SUMMARY OF THE INVENTION

The present invention contemplates an improved rotary cone drill bit by novel construction of the interfitting relationship between the associated cone cutters and their respective support arms to better protect against erosion at the clearance gap between each cone cutter and its respective arm and, thereby, better protect seals disposed in the gap associated with each cone cutter. The present invention also includes a composite cone cutter with improved wearing surfaces and enhanced service life.

In one aspect of the invention, a support arm and cone cutter assembly of a rotary rock bit having a body provides superior erosion protection. The assembly includes an arm integrally formed with the body and having an inner surface, a shirttail surface, and a bottom edge. The inner surface and the shirttail surface are contiguous at the bottom edge. A spindle is attached to the inner surface and is angled downwardly with respect to the arm. A portion of the spindle defines an inner sealing surface. The assembly also includes a cutter that defines a cavity with an opening for receiving the spindle. A portion of the cavity defines an outer sealing surface that is concentric with the inner sealing surface. The assembly further includes a seal for forming a fluid barrier between the inner and outer sealing surfaces. A gap associated with each support arm and cone cutter assembly includes a portion formed between the respective cavity and spindle, and has an opening contiguous with the bottom edge of the respective support arm.

In another aspect of the invention, a composite cone cutter is provided with the backface of the cone having a hard metal covering such as hardfacing. Alternatively, a portion of the composite cone including the backface may itself be made of hard metal so that the base of the composite cone adjacent the gap is highly resistant to both erosion and wear.