BIT BREAKERS, BITS, SYSTEMS, AND METHODS WITH IMPROVED MAKEUP/ BREAKOUT ENGAGEMENT

CROSS-REFERENCE TO OTHER APPLICATIONS

This application claims priority from U.S. provisional application 60/093,225 filed Jul. 17 1998, which is hereby incorporated by reference.

BACKGROUND AND SUMMARY OF THE INVENTION

The present application relates generally to drilling tools used in the drilling of oil and gas wells, or similar earth drilling operations, and in particular to disconnection of a threaded rock drill bit from a threaded drill string member.

Background: Drilling

Oil wells and gas wells are drilled by a process of rotary drilling. In a conventional drill rig, as seen in FIG. **5**, a drill bit **50** is mounted on the end of a drill string **52**. As drilling progresses, more sections of collar and pipe are screwed onto the drill string, which may be several miles long. Surface equipment **51** includes a rotary drive (rotary table or top drive) which turns the string, including the bit at the bottom of the hole, and powerful pumps which pump drilling fluid (or "mud") through the string. The elements of the drill string are connected together by large screw threads.

Roller-Cone and Fixed-Cutter Bits

In contemporary drilling practice, there are two basic categories of rock drill bits: roller-cone bits and fixed cutter bits. Within each of these classifications, a range of sizes and design configurations are available.

A general schematic of a conventional rotary cone bit is shown in FIG. **3**B. The most common roller cone bits have three independently rotating "cones" **336** (which may or be not be precisely conical) fitted on three bearings. The cones will have cutting elements **335** or "teeth" attached to, or integral with the cones. The bearings are mounted on "arms" **333** whose other ends are attached to a body **331**. There is a threaded drill string connection **334** on the junction of the arms at the upper end of the bit. A further example of this type of rock drill bit is disclosed in U.S. Pat. No. 5,644,956 by Blackman.

A general schematic of a conventional fixed cutter bit **230** is shown in FIG. **2**B. The most common fixed cutter bits have at one end a supporting structure referred to as the "bit head" **356**. Wear-resistant cutting elements **231** are strategically located on the outer and lower surfaces of the bit head. Slot **240** and an identical slot on the far side of the shank **235** of the bit are explained in conjunction with the bit breaker with which it is used. A further example of this type of rock drill bit is disclosed in U.S. Pat. No. 5,033,559 by Fischer.

Drill bits will need to be replaced for a number of reasons. The most common reason for changing a drill bit is that it wears out and stops drilling. Another reason for changing a drill bit is to utilize a drill bit specifically designed for drilling a formation with the physical properties being drilled or one designed to provide certain performance characteristics, such as directional drilling. Another reason is to utilize a drill bit sized to produce the desired well bore diameter. To achieve the desired drilling and performance characteristics, a wide variety of drill bit designs are available.

Makeup and Breakout

As noted, the elements of the drill string are connected together by heavy threads. When a drill bit wears out or needs to be replaced for other reasons, the drill bit must be removed from the drill string. The torque required for this can be very substantial; for example, for a 26-inch bit, the specified makeup torque can be more than 40,000 pound-feet. (By comparison, the lug nuts on a typical light truck wheel require less than 100 pound-feet or torque.) These very large values of torque are needed to assure that the joint is not only mechanically stable under the high applied forces seen while drilling, but also sealed tightly against the high pressures of mud flow. Once a mud leak begins, the fine abrasive particles entrained in the mud can cause rapid erosion along the leakage channel.

For most of the joints in the string, the piece below the joint can be held by "slips" which support the drill string, while the piece above the joint is turned by mechanical pipe tongs. However, this is more difficult when attaching the drill bit itself, since the drill bit cannot be held by the slips which hold drill pipe or collar.

To keep the drill bit from turning when torque is applied to the joint, a "bit breaker" plate is used. FIG. **2**A shows a bit breaker **200** used for fixed-cutter bits (such as shown in FIG. **2**B). Bit breaker **200** has a base **210** and two arms **205**, which mate with twin milled slots **240** on the shank **235** of the bit **230** to keep the bit from turning in relationship to the bit breaker. A latch **220** is normally included on the bit breaker plates, but this latch does not itself bear on the bit at all. In practice, this latch is often detached and discarded as soon as such a bit breaker plate is first used on the rig floor.

Fixed-cutter bits normally include a shank portion, into which the slots for a breaker tool are milled. Roller cone bits, however, normally do NOT normally include any such extended shank. There are several reasons for this, one of which is the undesirability of loss of mud pressure during passage through the interior of the bit. Another is the high rigidity required of the arm structures (since any bending in service can destroy the bit).

For roller-cone bits, a conventional bit breaker (as shown in FIG. **3**A) simply has a cutout in its middle, into which the bit (shown in FIG. **3**B) is lowered. The irregularities in this cutout engage the arms of the roller-cone bit, as shown in FIG. **3**C.

The bit breaker plate fits into the rotary table. The internal geometry of the bit breaker is shaped so as to engage the bit securely and transmit torque from the rotary table to the drill bit in either right-hand or left-hand rotation. If the rotary table is held fixed, the bit will also be held fixed.

Correct operation of the bit breaker is important during make-up as well as during break-out. Any defect in assembly may lurk undiscovered until the bit is at the bottom of the hole, necessitating an extra trip to replace the bit. Any unexpected trip is extremely undesirable.

The process of "tripping" is required to change the bit. A heavy hoist pulls the entire drill string out of the hole, in stages of (for example) about ninety feet at a time. After each stage of lifting, one "stand" of pipe is unscrewed and laid aside for reassembly (while the weight of the drill string is temporarily supported by another mechanism). Since the total weight of the drill string may be hundreds of tons, and the length of the drill string may be tens of thousands of feet, this is not a trivial job. One trip can require tens of hours and add significant expense in the drilling budget. To resume drilling the entire process must be reversed.

Disadvantages of Available Designs

The standard bit breaker for a three cone bit has a bottom plate, four vertical side plates, and a top plate with an opening configured to engage the drill bit arms above the