ROTARY DRILL BIT AND METHOD OF FORMING BORE HOLE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the boring of holes into earth material, such as which is typically involved in petroleum and natural gas exploration and mining, for example. More particularly, one aspect of the present invention relates to an earth boring rotary drill bit for cutting an axially advancing bore hole in the earth material. Even more specifically, the present invention relates to a rotary drill bit employing means for emitting a continuous jet of fluid or water to cut material from the bore hole drill face and also employing rotating rock breaking wheels for cooperatively removing the drill face material.

2. Brief Description of Prior Art

One prior art configuration of a rotary drill bit involves a plurality of conically-shaped rock cutting and breaking wheels positioned on a drill bit body and generally arranged as three equally spaced, conically-shaped configurations or cones. Cutting elements or teeth protrude from the wheels and contact the drill face material. The conically shaped wheels traverse circular paths at the drill face of the bore hole as the drill bit is rotated. When axial force is applied to the drill bit through the attached drill string, the teeth cut, break and spall the material of the drill face to axially advance the bore hole. Wash jets of the drill bit deliver a flow of fluid to the drill face for washing the particles of broken material away from the drill face to transport or conduct the broken material out of the bore hole to the surface of the earth, thereby establishing a circulation of wash fluid which removes material from the bore hole. Variations of this conventional drill bit configuration are used for a number of different earth boring applications as is well known in the art.

To achieve the best effectiveness, substantial axial force is required to engage the drill bit with the drill face and to spall the material therefrom. The axial force is transferred through the breaker wheels and applied, for the most part, as a compression force for fracturing and breaking particles from the drill face material. Since rock or earth material requires a relatively large force to fracture in compression, as compared to a substantially lower force which will fracture the earth or rock material in tension, the drill bit and its elements are required to withstand relatively large axial force during use. As a consequence, prior rotary drill bits have experienced relatively short lifetimes in use since the teeth or cutting elements of the breaker wheels are rapidly worn and get dull, or the bearings which allow rotation of the breaker wheels fail after a relatively short period of use. Upon drill bit failure, the lengths of attached pipe comprising the drill string must be removed from the bore hole one length at a time to replace the drill bit. Replacing the drill bit is a time consuming process which increases the cost of cutting the bore hole and lengthens the time required to cut the bore hole to its desired depth. It is not uncommon that cutting relatively deep bore holes through hard rock will require replacement of the rotary drill bit at least a dozen times before the bore hole is completely cut to its desired depth.

The substantial axial force supplied through the drill string can have the effect of creating downhole deviation as the bore hole is cut. Downhole deviation results when the bore hole which is actually cut, angles or deviates from the desired axis along which the bore hole is intended to be cut. Downhole deviation, once started, is difficult to correct. Downhole deviation may result in the bore hole missing or avoiding the geological formation or area which the objective of the drilling operation is to intersect.

The substantial axial force supplied through the drill string can also have the effect of creating slothing. Slothing occurs when the axial force fractures the rock formation surrounding the bore hole. Fractures in the surrounding earth material prevent the wash fluid from effectively conducting the material removed from the drill face up the bore hole and to the surface of the earth, resulting in loss of circulation. With loss of circulation the material removed from the drill face cannot be effectively transported out of the bore hole, which results in inhibiting or terminating the ability to further cut the bore hole.

Rotary drill bits with rotating breaker wheels are constructed differently depending upon the type and hardness of the earth material which is drilled. In drilling a typical bore hole, it is not uncommon that many different rock formations and earth materials will be encountered. Drilling through different earth materials may also require the changing of the drill bit which, of course, also increases the cost of and time for drilling the bore hole. Other disadvantages of prior rotary drill bits employing breaker wheels are also known and of significant consequence in utilizing drill bits of this type in cutting bore holes.

It is known that a concentrated jet of relatively high pressure or energy water or fluid will effectively cut rock, earth materials and the like. To a limited extent, high pressure fluid jets have been used in conjunction with rotary drill bits to cut bore holes. Publications relating to the use of fluid or water cutting jets with rotary drill bits include the following: *Novel Drilling Techniques* by William C. Maurer, Pergamon Press, 1968, Library of Congress Card No. 68-17738; "High Pressure Drilling", Journal of Petroleum Technology, July, 1973, pp. 851-859; "Cutting Rock With Water Jets", International Journal of Rock Mechanics, Mineral Science and Geomechanics Abstract, Vol. 11, pp. 343-358, 1974; "A Rotating Water Jet Device and Data on its Use for Slotting Berea Sandstone", International Journal of Rock Mechanics, Mineral Science and Geomechanics Abstract, Vol. 11, pp. 359-366, 1974; "Recent Advances in Rotary Drill Bits", Oil World, Mar. 9, 1977, pp. 52-56; and U.S. Pat. No. 3,838,742.

It is generally proposed by the present invention that the use of high energy water or fluid jets to cut bore holes will achieve an increase in cutting rate and a decrease in the time required for boring the hole. In addition, however, many disadvantages of the prior art rotary drill bit employing rotating breaker wheels may be avoided or overcome, and many advantages previously unobtainable with prior rotary drill bits can be obtained, as results of the present invention.

SUMMARY OF THE INVENTION

Objectives of the present invention are to provide a new and improved rotary drill bit and method of cutting an axially extending bore hole, which obtain the desirable characteristics of: increasing the speed by which the bore hole is cut or bored, decreasing the cost of drilling a typical bore hole, obtaining wide adaptabil-