

Oct. 25, 1966

J. W. GRAHAM ETAL

3,280,926

BIT FOR DRILLING EARTH FORMATIONS

Original Filed May 13, 1959

2 Sheets-Sheet 1

FIG. 1.

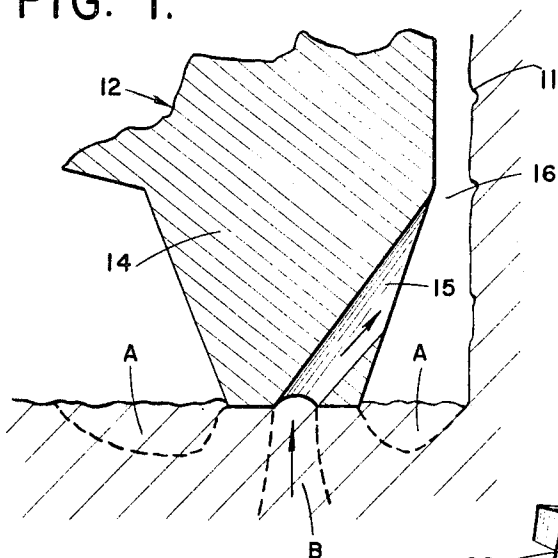


FIG. 2.

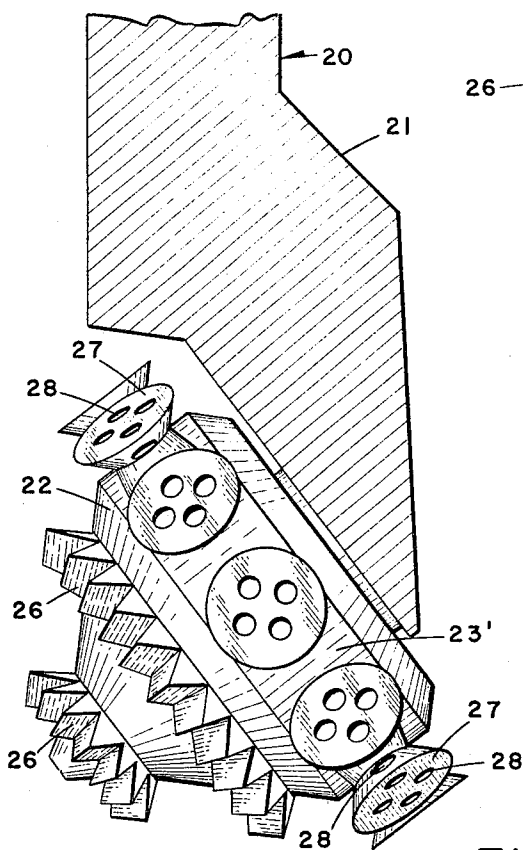
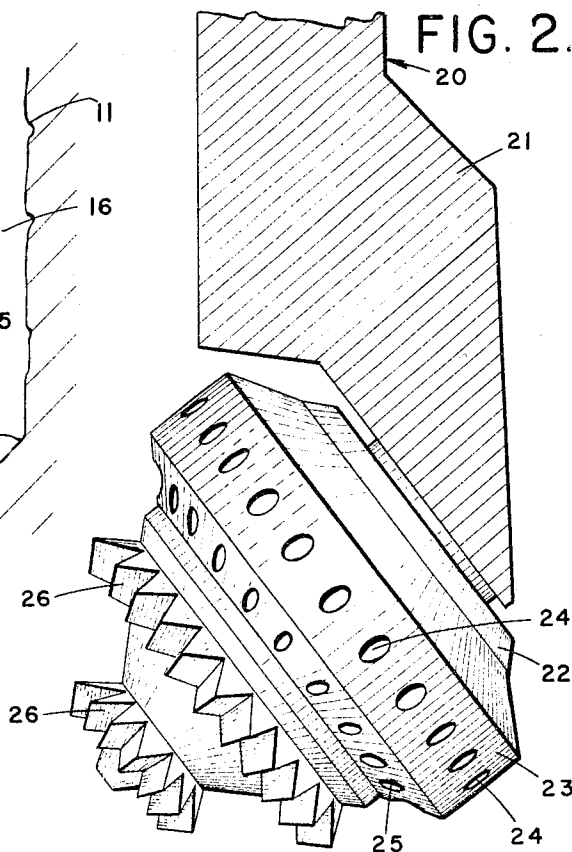


FIG. 2a.

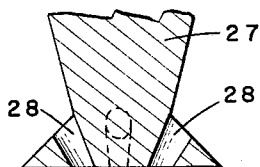
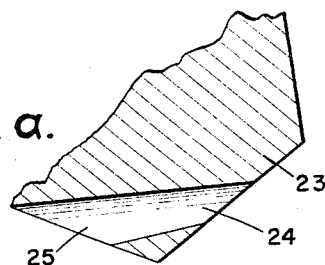


FIG. 3a.

FIG. 3.

INVENTORS,
JOHN W. GRAHAM,
BY LEON H. ROBINSON, JR.,

Thomas B. McQuinn
ATTORNEY.

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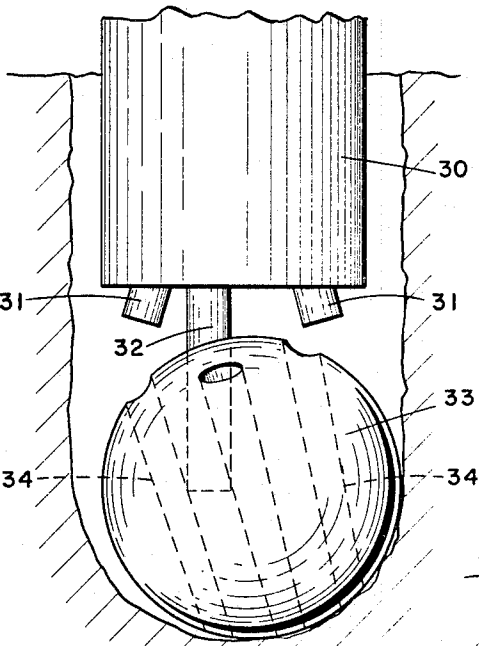


FIG. 4.

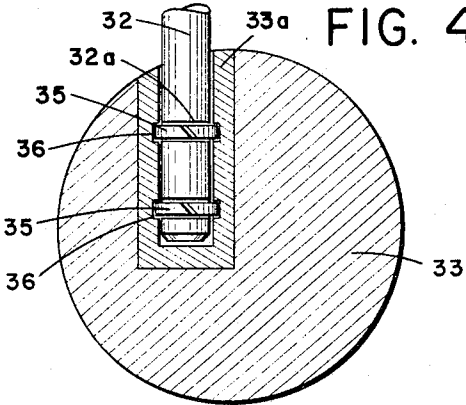


FIG. 4a.

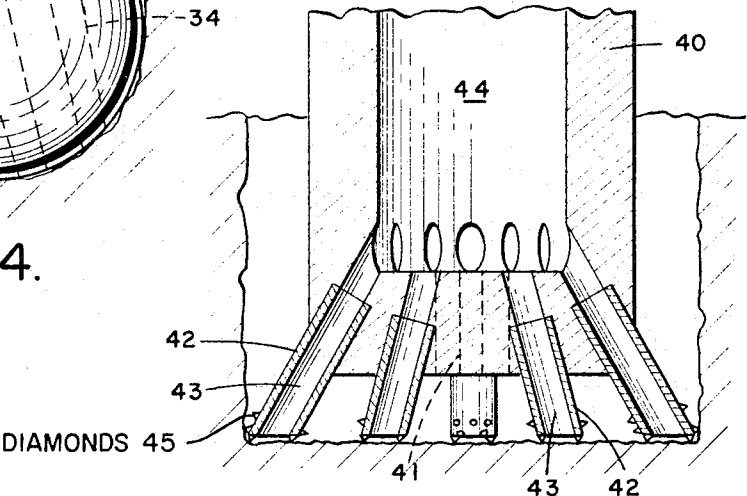


FIG. 5.

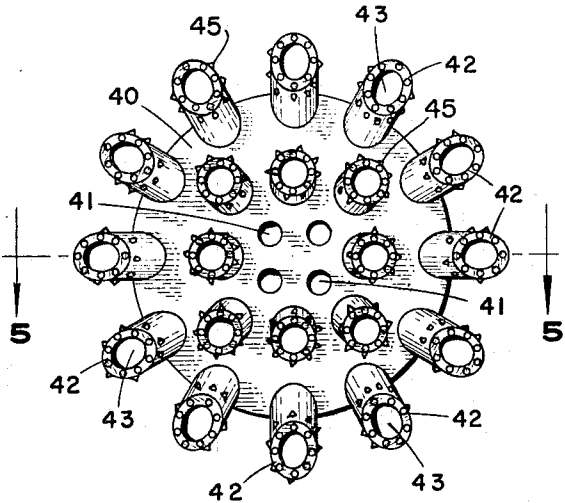


FIG. 5a.

INVENTORS.
JOHN W. GRAHAM,
LEON H. ROBINSON, JR.,
BY
Thomas B. McQuinn
ATTORNEY.

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3,280,926

BIT FOR DRILLING EARTH FORMATIONS

John W. Graham, Bellaire, and Leon H. Robinson, Jr.,
Houston, Tex., assignors, by mesne assignments, to Esso
Production Research Company, Houston, Tex., a corpo-
ration of Delaware

Application May 25, 1962, Ser. No. 197,674, now Patent
No. 3,163,242, dated Dec. 29, 1964, which is a division
of application Ser. No. 812,864, May 13, 1959, now
Patent No. 3,078,934. Divided and this application
Feb. 24, 1964, Ser. No. 346,660
4 Claims. (Cl. 175—330)

The present invention is directed to a drill bit. More particularly, the invention is concerned with drilling a well in which increased drilling rates are obtained. In its more specific aspects, the invention is concerned with an improved drill bit and method for a drilling well.

This application is a division of Serial No. 197,674, filed May 25, 1962, for John W. Graham and Leon H. Robinson, Jr., entitled "Drill Bit," which in turn is a division of Serial No. 812,864, filed May 13, 1959, now Patent No. 3,078,934, for John W. Graham and Leon H. Robinson, Jr., entitled "Drilling of Earth Formations by Extrusion."

The present invention may be briefly described as a drill bit for drilling a well in which a body member attached to a hollow drill string has a drill member mounted on the body member for contacting earth formations. The drill member is formed to provide a plurality of open-ended passageways with at least one of the ends of each of the passageways being formed to contact the earth formation peripherally in drilling of the well. Each of the passageways discharge into the well or into the circulating drilling fluid which in turn is discharged into the well whereby a portion of the earth formation is extruded through each of the passageways in contact with the earth formation.

The drill member may be rotatably or rigidly mounted on the body member and the drill member may be substantially a sphere or the drill member may be a toothed roller with the passageways being formed in the teeth or in a band in the outer edge of the tooth roller. The drill member may be cone-shaped and the band may be on the base of the cone with the passageways discharging below the band adjacent the teeth.

In drilling of wells, it is believed that the stress distribution within the rock is in part responsible for the slow drilling which is frequently encountered. The rock may be tectonically relaxed in a particular area of interest and, thus, the principal stresses within the rock may be equal. However, if a hole is drilled through this area, the hole will create discontinuities and stresses, particularly at or near the bottom of the hole. For example, the outer edge of the borehole may be under considerable compression because of the discontinuity caused by the presence of the hole. Moreover, the greater the sharpness of the corners (that is, the smaller the radius of the curvature), the greater will be the compressional stresses around the periphery of the hole. Stresses that are superimposed over the stress of the rock are those created by hydrostatic pressure of the fluid in the borehole, the overburden pressure caused by the weight of the formation, and the fluid pressure in the pores of the formation.

In areas where the subsurface rock fails malleably while drilling, an ideal situation would make full use of the compressional stresses existing at the bottom of the borehole. The drill bits employed in the art, however, do not take advantage of the stresses created by the borehole. It is, therefore, a feature of the present invention not only to exploit the stresses in existence, which will increase drilling rates. This is done by im-

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but also to generate additional stresses within the rock posing pressure on the earth formation pierced by the well at a plurality of spaced-apart points and extruding a portion of the formation from the bottom of the well through the drill bit at a plurality of points within the periphery of each of said plurality of points where the pressure is imposed.

This may be accomplished in a number of ways and, therefore, the invention will be further described by reference to the drawings in which:

FIG. 1 is a sectional view of a bit tooth of a preferred embodiment of the present invention in contact with the bottom of a well;

FIG. 2 is a view of a modified drill bit in accordance with FIG. 1 of the present invention;

FIG. 2a is a fragmentary sectional view of the band of FIG. 2;

FIG. 3 is a further modification of the device of FIG. 2; FIG. 3a is a sectional view of the elephant foot teeth of the device of FIG. 3;

FIG. 4 illustrates a bit embodying the present invention;

FIG. 4a is a partial sectional view of FIG. 4;

FIG. 5 is a still further modification of the present invention; and

FIG. 5a is a bottom view of the device of FIG. 5.

Referring now to the drawing and particularly to FIG. 1, numeral 11 designates the wall of a well drilled from the earth's surface, not shown, and having a drill bit 12 carried on the lower end of a drill string, not shown, contacting the bottom 13 of the well with the tooth 14, which is provided with a tapered passageway 15 drilled through the tooth and opening into the well. These holes 15 may be from 1/8 to 1/4 inch in diameter and may be arranged in the outer ring of teeth on each cone of a hard rock bit. When the tooth 14 contacts the formation and begins to destroy the formation immediately below the bit 12, a portion of the formation is extruded into and ultimately passes through the passageway 15 and discharges into the annulus 16 and then is removed from the well with the drilling fluid. As the tooth continues its journey, the extruded rock removed from the region B in the bottom of the well 13 leaves a small hole below the zone of the destruction normally produced by the bit. This small hole produces stresses in the rock because of the discontinuity of the bottom of the hole just as the discontinuity produced by the borehole 11 induces compressional stresses around the periphery of the borehole. Accordingly, destruction of the rock is increased immediately surrounding the region B from which the rock is extruded, and, therefore, increased drilling rates are obtained.

In ordinary drilling operations, the solid bit teeth of conventional bits cause regions A surrounding each tooth to fail by brittleness and, thus, small rock chips are created therein. No advantage is taken of the tremendous malleability existing immediately below each bit tooth. The improved bit and method of drilling with the passageway 15 in the bit tooth 14 allows the rock to deform malleably through the tooth and, hence, is removed permanently from region B.

In FIG. 2, a modified bit 20 having a body 21 has a plurality of roller cutters 22 rotatably mounted on the body 21. In the improved bit 20 of the present invention, the cone-shaped roller 22 has a band 23 on the outer edge of each of the cones provided with a plurality of open-ended passageways 24 tapering to a larger opening 25 immediately above the teeth 26 which are adjacent the apex of the cone. The holes 24 are suitably placed in the center of the band and are tapered with the smaller opening on the side of the band which contacts the bottom

of the well, as shown in FIG. 2a. It is considered that, in the practice of the present invention, the teeth 26 may also be provided with passageways which allow rock to be extruded therethrough.

Referring now to FIG. 3 which shows a modification of FIG. 2, the band 23' is provided with a plurality of teeth 27 shaped like an elephant's foot and formed with a plurality of open-ended passageways 28. These teeth have a large bearing surface and may be provided with a plurality of the tapered holes 28 as shown in FIG. 3a. As shown in the drawing, the bearing is flat. As a modification of FIG. 3, all of the teeth of the device of FIG. 3 may be of the elephant foot type.

As a further modification of the present invention, a body member 30 in FIG. 4, which suitably may be a drill collar attached to a drill string, is provided with a plurality of mud ports 31 for circulation of drill fluid and has a spindle 32 rigidly attached thereto on which is rotatably mounted a sphere 33 provided with a plurality of open-ended passageways 34 which are tapered. As shown in FIG. 4a, the spindle 32 is arranged in a sleeve bearing 33a which makes a press fit in a recess in sphere 33 designed to receive the sleeve bearing 33a. Split rings 35 are urged into split ring groove 32a on spindle 32 and into split ring groove 36 in sleeve bearing 33a, thus making a connection between the sphere 33 and spindle 32. In drilling with the device of FIG. 4 and FIG. 4a, the sphere 33 by virtue of its eccentric arrangement on the spindle 32 revolves off-center around the spindle 32 and the rock is extruded into and passes through the passageways 34 and carried up the hole with the drilling fluid. Also, rotation of the sphere 33 causes abrasion of the bottom and wall of the hole, thus advancing the bit through the formation being drilled.

As a still further modification of the present invention, as shown in FIGS. 5 and 5a, a body member such as 40 provided with mud ports 41 has formed thereon a plurality of spikes 42, each of which has an open-ended passageway 43 terminating at the bottom of the spike and discharging within the cavity 44 which, in turn, discharges into the well through mud ports 41. The spikes 42 have flat bottom faces, as shown in FIGS. 5 and 5a, and are mounted on body member 40 such that the flat bottom faces are all in the same plane. The spikes 42 may be constructed of tungsten carbide and may also have diamonds 45 mounted on the periphery of the spikes 42 such that when the improved device 40 is rotated and reciprocated, a scratching or churning action accompanies the extrusion action of the rock through the passageways 43. The spikes 42 in contacting the bottom of the well form channels with concentric shells of formation material between the channels. The shells are crushed as the bit penetrates the formation and the crushed, as well as the extruded, material is carried upwardly with the drilling fluid. The cavity 44 communicates fluidly with the drill string and the extruded material passes through the passageways 43 into the cavity 44 and thence downwardly with the drilling fluid through ports 41 and upwardly therewith to the earth's surface between the drill string and the wall of the well.

The present invention is quite advantageous and useful in that by imposing pressure on the rock, it becomes malleable and is caused to be extruded, creating additional stresses within the rock being drilled and thus contributing to improved drilling operations.

The invention will be further described by reference to the following operation in which water-saturated carthage marble was subjected to a confining pressure of 10,000 p.s.i. A tubular member having a $\frac{3}{8}$ inch opening next

to its face compressed the confined marble about 0.25 inch. The marble yielded and deformed malleably which caused it to extrude into the opening.

In practicing the invention, the malleable state occurs when the confining pressure is greater than the pore pressure of the rock by an amount in the range from about 2500 to about 5000 p.s.i., which may occur in wells at depths from about 5000 to about 10,000 feet.

The nature and objects of the present invention having been completely described and illustrated, what we wish to claim as new and useful and secure by Letters Patent is:

1. A drill bit adapted to be connected to a hollow drill string for drilling a well which comprises a body member having a cavity therein adapted to communicate fluidly with said drill string and provided with ports for discharge of drilling fluid, a plurality of tungsten carbide spikes rigidly mounted on said body member for contacting an earth formation having diamonds mounted on the periphery of the free end thereof, said spikes being formed to provide a plurality of open-ended passageways, the free end of each of said spikes being adapted to contact said earth formation peripherally of each of said passageways in drilling of said well and the other end of each of said passageways discharging into said cavity, said spikes having flat bottom faces on the free end thereof and being mounted on said body member such that the flat bottom faces are all in the same plane, whereby a portion of said earth formation is extruded into and passes through each of said passageways in contact with said earth formation into said cavity and is discharged through said ports with the drilling fluid.

2. A drill bit adapted to be connected to a hollow drill string for drilling a well which comprises a body member having a cavity therein adapted to communicate fluidly with said drill string and provided with ports for discharge of drilling fluid, a plurality of outwardly extending tungsten carbide members mounted on said body member for contacting an earth formation having diamonds mounted on the periphery of the free end thereof, said outwardly extending members being formed to provide a plurality of open-ended passageways, the free end of each of said outwardly extending members being adapted to contact said earth formation peripherally of each of said passageways in drilling of said well and the other end of each of said passageways discharging into said cavity, said outwardly extending members having flat bottom faces on the free end thereof and being mounted on said body member such that the flat bottom faces are all in the same plane, whereby a portion of said earth formation is extruded into and passes through each of said passageways in contact with said earth formation into said cavity and is discharged through said ports with the drilling fluid.

3. A drill bit in accordance with claim 2 in which the outwardly extending members are tubular.

4. A drill bit in accordance with claim 1 in which the spikes are tubular.

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CHARLES E. O'CONNELL, *Primary Examiner.*

JACOB L. NACKENOFF, *Examiner.*

N. C. BYERS, *Assistant Examiner.*