

[54] **EXPLOSIVE DRILLING APPARATUS**

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- [52] U.S. Cl.....175/4.5, 175/4.6
- [51] Int. Cl.....E21b 7/00
- [58] Field of Search.....175/2, 3.5, 4.5, 4.54, 4.6

[56] **References Cited**

**UNITED STATES PATENTS**

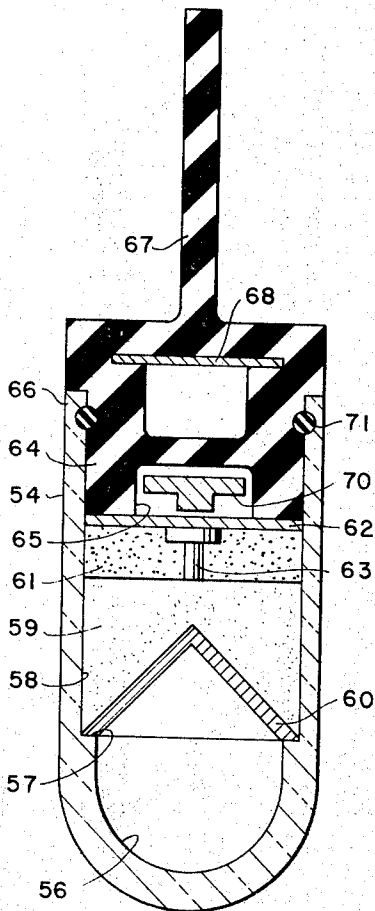
3,130,797	4/1964	Johnson.....	175/4.5
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3,566,979	3/1971	Bennett et al.....	175/2
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[57] **ABSTRACT**

The particular embodiment described herein as illustrative of one form of the invention utilizes an elongated housing having a shaped explosive charge in one end thereof, and a firing mechanism for detonating the explosive charge upon impact of the capsule with the lower end of the borehole. During borehole drilling operations, the capsule is released into a fluid stream and moved to the bottom of the hole with the fluid stream. The capsule then exits through the end of the drill stem and impacts the formation whereupon it is detonated to serve as an auxilliary means for drilling the borehole.

**8 Claims, 3 Drawing Figures**



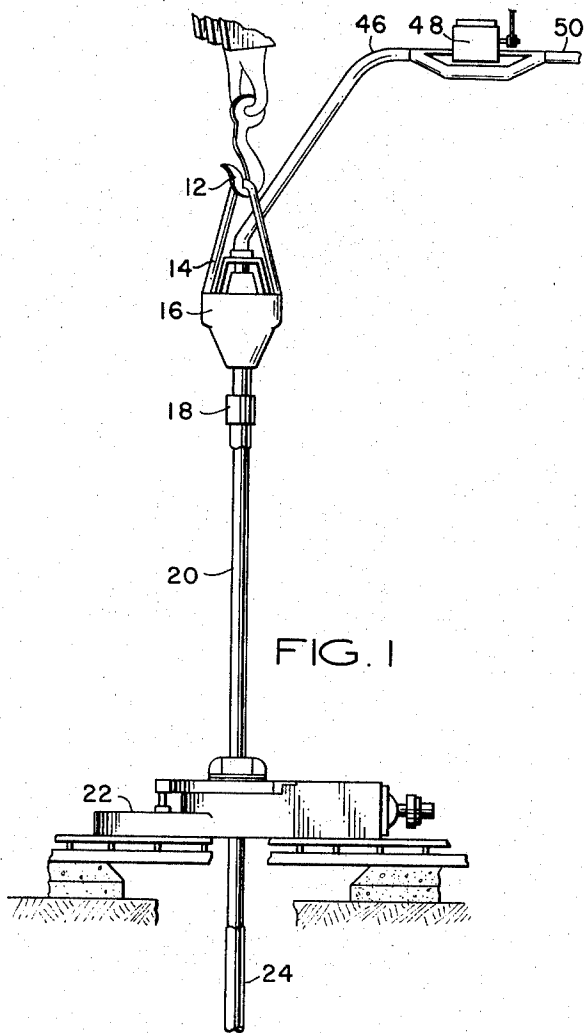


FIG. 1

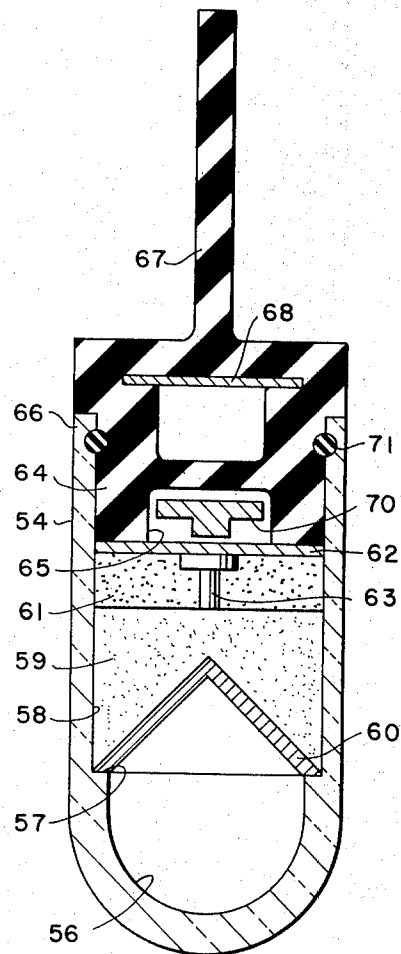


FIG. 3

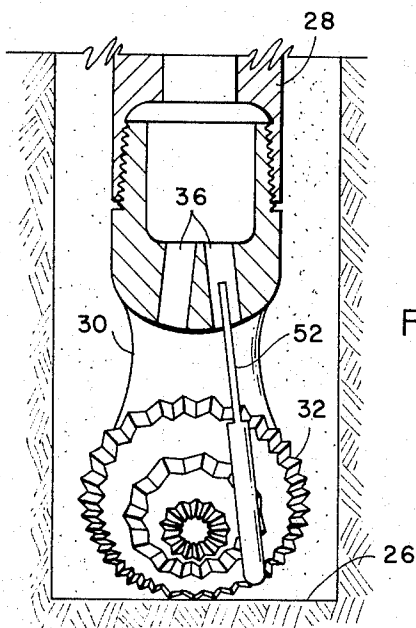


FIG. 2

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## EXPLOSIVE DRILLING APPARATUS

## BACKGROUND OF THE INVENTION

This invention relates to a new and improved method and apparatus for explosive assisted drilling and more particularly, to the use of a capsule which is moved through the eye of a conventional drill bit into impact with the formation to assist in the drilling operation.

As described in U.S. Pat. No. 3,130,797, issued to Ford L. Johnson, and dated Apr. 28, 1964, shaped charge devices may be dropped through a hollow drill stem and projected through the jet openings in conventional roller or other type bits to effect shattering of formations and thereby facilitate drilling. Prior to the use of such devices, it was found that the rate of drilling for example, by rotary tools, may vary greatly depending on the formation which is being drilled. In drilling through extremely hard rock, the progress may be slow and consequently costly because the costs of drilling are at least roughly proportional to time expended.

In accordance with the present invention, the explosive shaped charge is used as an adjunct to what is otherwise essentially conventional drilling procedure. Applied to rotary drilling by means of a bit driven through a hollow drill stem, the invention involves the utilization, as required, of explosive members which may be dropped or propelled through the hollow drill stem and guided into or through one or more passages in the bit, the unit members being exploded to shatter the formation at the bottom of the hole through which the drilling is proceeding. During this operation, the conventional drilling may be carried out with the circulation of the mud to remove the cuttings, which circulation also acts as a fluid to carry the explosive member into contact with the borehole at the bottom of the well. The use of such explosives in the drilling operation may be on an intermittent basis, such as when the progress of drilling is notably slowed down during the encountering of an extremely hard formation. In addition, it may be found that certain materials which constitute formations may be more susceptible to the use of explosives. Therefore, during the drilling of such formations, explosives may be routinely used.

If hard and unfractured rock is being drilled, there is a tendency for the drill to rotate on the surface of the rock, with a relatively low rate of rock removal despite heavy pressure exerted on the bit, the action then being largely one of abrasion. However, if the bit encounters rock which has been fractured, the cutting edges of the bit will enter openings due to fractures and tend to split the rock along with the production of impacts between the loosened portions of the rock, with the result that comminution is rapidly effected to produce rock segments of small size removable to the surface by the circulating mud. It is therefore evident that the use of explosives in accordance with this invention is not primarily for the purpose of having the explosive actually produce and shape the hole, rather the objective is to break up the rock so as to cause the bit to function more effectively. Nevertheless, there is advantage in using the shaped charge explosives which have generally as their objectives the production of holes.

In the present instance, the primary function of the charge is to produce violent shocks which will effect fracturing of the formation and such shocks are best obtained through the use of shaped charges. In addition, shaped charges give a greater depth of penetration, and will permit the pressure exerted by the hydrostatic mud column within the drill stem to be exerted to underlying portions of the formation below the face of the drill bit. This extension of the pressure into the formation effects a pressure equalization as opposed to a hold-down pressure of the mud which affords a greater rate of removal of the fractured formation. During a drilling operation, mud penetrates exposed interstices, or crevices of the formation, through which the cut is being made. This intrusion of mud which is in the form of a mud cake about the borehole wall, serves to hold formation pressure in check, and also prevents the walls of the bore from caving or breaking down. Such

mudding off' of the bore during drilling operations maintains the well in a dead condition throughout the drilling operation, with the mud cake and circulating pressure of the mud preventing the inflow of formation gas, oil, or other formation fluids. Normally, the weight or gravity of the mud is maintained at a level such that the hydrostatic head produced by the column of mud in the wellbore will be sufficient to maintain a positive differential back pressure over the expected downhole formation pressure.

It has been found by experiment that not only does the mud cake form about the borehole wall, but also at the bottom of the borehole which is being drilled by the drill bit. Normally, as the bit grinds into the earth formation, the mud is continuously being applied to the bottom of the hole, so that a positive back pressure is maintained against the formation being drilled at all times. Such a positive pressure on the formation at the bottom of the borehole is a direct deterrent to the removal and lifting of cuttings from the borehole, with the pressure tending to hold the cuttings down rather than permitting their removal to the surface with the mud column. Therefore, if by means of such holes made into the bottom of the formation by shaped charges, the mud pressure can be communicated into the formation, a balancing of the pressures will occur across the bottom face of the borehole which will neutralize the hold down pressure of the mud column.

The use of explosive charges has been shown to produce the desired effect in increasing the efficiency and rate of a conventional drilling operation. However, the devices such as those disclosed in U.S. Pat. Nos. 3,130,797, and 3,190,372, for use in such a drilling operation have had certain drawbacks which reduce the effectiveness of the drilling operation carried out thereby. For example, it has been found that due to the small diameter of the shaped charge capsule, which is released into the mud stream, the stability of the capsule is affected due to its length relative to the diameter of the borehole. For example, if the length is maintained short enough to permit passage of the capsule through surface equipment for introducing the capsule into the wellbore, it may become possible for the capsule to become inverted in the mud stream, thereby rendering it useless as an effective aid to the drilling operation. In addition, due to the movement of the capsule within various piping arrangements prior to its introduction into the drill stem, and its subsequent rapid descent into the drill pipe, it is possible that such apparatus may become prematurely detonated, thereby effecting not only damage to the drill string, but also a decrease in the effectiveness of the intended operation.

It is therefore an object of the present invention to provide a new and improved shaped explosive capsule for use in a rotary drilling operation.

## SUMMARY OF THE INVENTION

With this and other objects in view, the present invention contemplates an explosive device for use in a drilling operation and having means for stabilizing its passage and improving the safety of its operation. The device includes an elongated cylindrical housing having a shaped explosive charge positioned near one end thereof. A firing mechanism is positioned above the shaped charge, and is arranged to be detonated upon impact of the device with the lower end of the borehole. Provisions are made within the capsule to prevent premature detonation of the device due to accelerations and inadvertent impacts with the conveying equipment. A stabilizing device is also provided to prevent misorientation of the capsule within the conveying apparatus.

A complete understanding of this invention may be had by reference to the following detailed description, when read in conjunction with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of surface equipment utilized in the system for introducing explosive capsules into a drilling apparatus;

FIG. 2 is an enlarged view of a drill bit showing an explosive device projecting from the bit; and

FIG. 3 is a sectional view illustrating the construction of an explosive capsule in accordance with the present invention.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1 of the drawings, portions of a conventional drilling rig are shown for practicing the invention. There is illustrated at 12 a hook which is connected to the usual traveling block supported by cables and controlled by the draw works of a derrick (not shown). A bail 14 on the hook supports the conventional swivel 16, modified only to the extent that its drilling mud entrance opens upwardly and its interior is provided with means for guiding the explosive members as will be shown hereinafter. The swivel is joined at 18 with the usual kelly 20 passing through the rotary table 22 by which the kelly is driven and supporting the sectional drill stem 24 in conventional fashion. The drill stem terminates in the usual drill collar 28 (FIG. 2). Various conventional parts of the assembly are not indicated, but it will be understood that they are provided as in usual drilling practices. The drill collar 28 carries a bit 30, which is illustrated as of the multiple cone type, of which one of the cones is indicated at 32. Jet openings are provided between the cones of the bit at 36. The hole being drilled is indicated at 26. The mud flows to the swivel 16 through the flexible hose 46, the mud being supplied from the usual high pressure mud pumps which are not shown. The main flow takes place through a connection 50, but by-pass flow to carry the explosive members into the hose 46, swivel 16, and the hollow drill stem takes place through the feeding means for explosive members generally indicated at 48. Such feeding system is described in greater detail in the aforementioned U.S. Pat. No. 3,130,797.

A typical explosive member which may be used is designated generally at 52, and is shown in section in FIG. 3. In the particular form illustrated, the explosive member comprises an elongated cylindrical housing 54, preferably made of aluminum or the like, which has one end enclosed by a rounded portion thereof. The interior of the cylindrical housing is hollow with the lower end having a first diametered portion 56, which forms a stand-off space at the lower end of the capsule. A shoulder 57 is formed at the upper end of the first diameter portion. This shoulder supports a metallic liner 60 which in turn maintains the charge 59 in its shaped configuration. The charge 59 is positioned directly above the liner within a second diametered portion 58 of the housing. Positioned directly above the charge 59 in the portion 58 is a primer 61 having a detonator 63 molded therein. A cap 62 is positioned over the primer 61 and is arranged to be detonated upon impact of a hammer and firing pin assembly 70 with the cap.

A capsule end portion or end cap 64 is sized to fit within the second diametered portion 58 of the interior bore of the housing, and has a cylindrical portion extending downwardly therefrom into contact with the upper end of the charge and primer assembly positioned within such portion 58 of the housing. An O-ring seal 71 is provided between the outer cylindrical surface of the end cap 64 and the interior bore of the housing to provide a fluid tight seal therebetween. The lower end of the end portion has a hollow cylindrical portion 65 which provides a space for receiving the firing pin and hammer assembly 70, with such assembly being free to move within the hollow portion of the end cap. The end cap has an outwardly extending shoulder which rests upon the upper end 66 of the housing 54. Hydrostatic pressure of the fluid within the system provides a means for holding the end cap within the housing and maintain its assembly therewith. Extending upwardly from the upper end of the end cap is a tail section 67. The length of the tail section 67 is sufficient to render the overall length of the capsule greater than the internal diameter of the drill stem. The tail section 67 is made of a resilient material such as rubber, to facilitate its movement within curved or elbowed sections of piping at the surface of the

drilling apparatus. A strength insert 68 of a substantially rigid material such as aluminum is also provided within the end cap to prevent deformation of the end cap and breaking of the seal to thereby prevent exposure of the interior of the capsule to moisture within the drilling system.

In the operation of the apparatus described above, when it is desired for various reasons to aid the usual drilling operation so as to increase the rate thereof, an explosive member is introduced into the mud line by means of the device 48. During the period of introduction of the explosive member and during its descent to the bottom of the drill stem, the rotary drilling is normally continued, or of course can be interrupted as desired. Continuation of rotation has no adverse significance with respect to the explosive operation.

The explosive member passes downwardly within the mud stream as the pumping of mud is continued during the operation. When the member reaches the end of the drill stem, it is directed along with the flowing mud through one of the eyes of the bit whereupon it impacts the bottom of the borehole to be exploded. During its downward descent in the drill stem and also in flow lines at the surface, the downwardly extending cylindrical portion of the end cap 64 will prevent the charge 59 and firing device from moving upwardly within the housing of the explosive apparatus, so that the explosive members are not inadvertently moved into contact with the firing pin and hammer assembly during acceleration of the device within the drill stem or upon the even greater acceleration due to propulsion through the eye of the drill bit. Thus, premature detonation is prevented by this arrangement of parts. Thereafter, when the explosive member strikes the bottom of the borehole, the firing pin and hammer mechanism 70 is free to continue its downward movement within the space 65, whereupon the inertia of its movement ruptures the firing cap 62 and initiates the detonator 63 within the primer 61 to cause detonation of the jet charge 59. The stand-off distance which is provided by the space between the lower end of the capsule and the jet charge 59 permits the charge to form into a shape which is conducive to maximum penetration of the wellbore therebelow. This usual stand-off space which is provided has been recognized as desirable in the use of shaped charges. Such an explosion will result, in all probability, in a shattering or penetration of the formation in the wellbore beneath the rotary bit. For the various reasons described above, this will effect an increase in the drilling rate. While moving through the flow lines and the drill stem, the capsule which is provided with an elongated tail member is prevented from overturning within the system because of the added length provided by such tail. If the overall length of the apparatus is made greater than that of the diameter of the flow lines and drill stem through which it moves, overturning of the device is virtually impossible. In addition, the tail may be made of a flexible material which will permit its passage more readily through restricted portions of the system such as those that may occur at the surface in the form of elbows or bends in the flow lines.

While a particular embodiment of the present invention has been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects, and therefore, the aim in the above description is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. An explosive apparatus for use in drilling wellbores comprising: an elongated cylindrical housing shorter in length than the diameter of said wellbore; an explosive charge positioned within said housing; explosive initiating means positioned adjacent said explosive charge and reactive to sudden deceleration of said housing; and flexible stabilizer means extending from the upper end of said housing whose length when added with the length of the housing exceeds the diameter of said wellbore.

2. The apparatus of claim 1 wherein the explosive initiating means includes a primer; a detonator located in said primer; impacting means free to move in response to acceleration and

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deceleration of said housing; and firing cap means interposed between and adjacent to said impacting means and said detonator means.

3. The apparatus of claim 1 wherein said flexible stabilizer means is made of a resilient material and has means for absorbing compressive forces encountered in said wellbore.

4. The apparatus of claim 1 wherein said housing has an opening in its upper end and wherein the lower portion of said flexible stabilizer means fills the opening in the upper portion of said housing and wherein the upper portion of said stabilizer is a cylindrical tail member of a smaller diameter than said housing.

5. The apparatus of claim 1 wherein said explosive charge comprises a shaped charge which is spaced from the lower end of said housing and wherein said housing is substantially smaller in diameter than the diameter of said wellbore.

6. In an explosive apparatus passable through drill pipe for

use in drilling wellbores, having contained in an elongated cylindrical housing, an explosive and means for initiating the explosive which is responsive to deceleration of the housing, the improvement comprising: flexible stabilizer means attached to the upper end of said housing wherein the overall length of the stabilizer means together with said housing exceeds the diameter of said wellbore.

7. The apparatus of claim 6 wherein the stabilizer means has an elongated cylindrical upper portion having a diameter substantially smaller than the diameter of said housing.

8. The apparatus of claim 7 including seal means positioned between the housing and the stabilizer means so that the pressure differential developed across the attachment between the housing and the stabilizer means will tend to maintain the attachment when the explosive apparatus is subjected to pressure in the drill pipe.

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