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3,420,099

APPARATUS FOR AND METHOD OF LOGGING EARTH FORMATIONS

Filed Oct. 4, 1965

Sheet 1 of 2

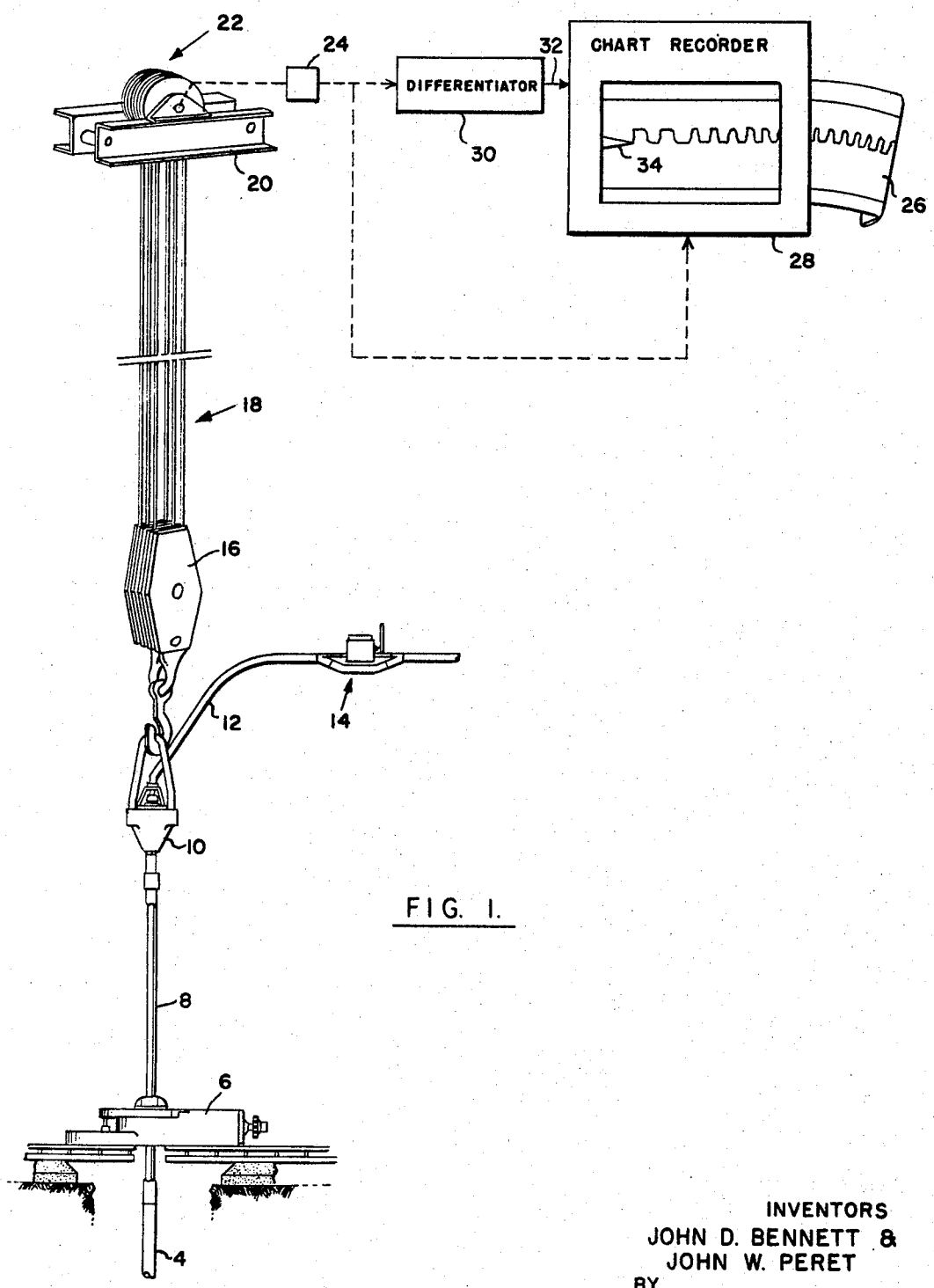


FIG. 1.

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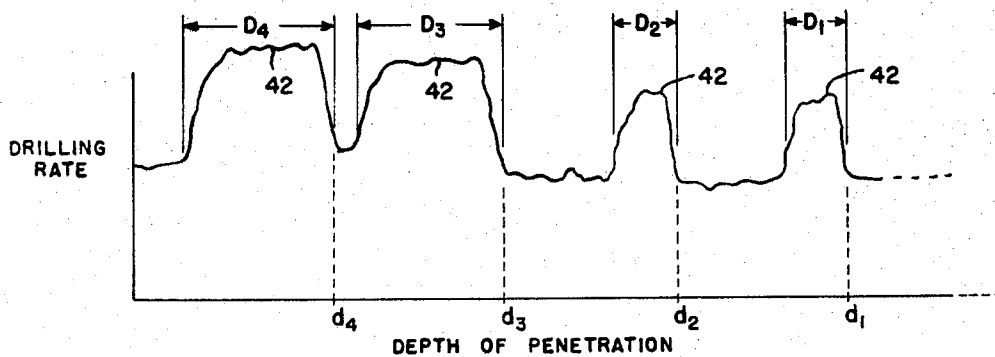


FIG. 3.

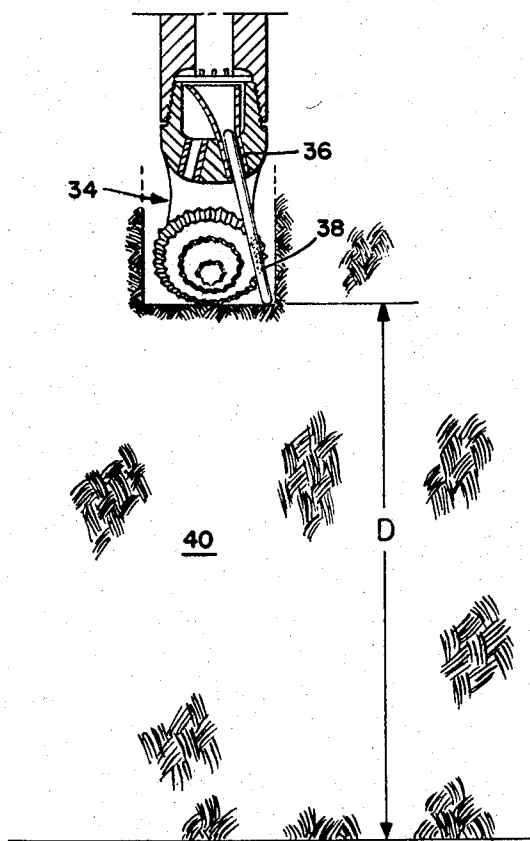


FIG. 2.

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APPARATUS FOR AND METHOD OF LOGGING EARTH FORMATIONS

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5 Claims

ABSTRACT OF THE DISCLOSURE

Characteristics of earth formations at various depths are determined by detonating standard explosive charges at various points at the bottom of a bore hole, and drilling through the fractured formation. The rate of drilling is measured, and recorded against depth, so that distances of relatively easy drilling can be determined. Since different formations are fractured to different depths, the record indicates the nature of the formation being drilled.

This invention relates to the identification of earth formations during the drilling of a well.

In drilling for oil, it is desirable to have information concerning the nature of the formation through which the bit is cutting in order to avoid drilling into lower strata carrying undesirable fluids. In order to avoid excessive depth of penetration, it is desirable to obtain the information concerning the nature of the formation immediately or very soon after it is encountered by the bit.

Prior methods of obtaining such information have been time consuming, and consequently uneconomical.

Different formations usually have different characteristics with regard to the ease of drilling; that is certain formations may require more drilling energy than others, or if a constant energy is supplied to the drill stem, the rate of penetration will be greater for some formations than for others. It is, however, very difficult to hold the energy expended for penetration at a constant, since it requires careful control of the weight on the bit, the rate of rotation of the bit, careful control of the circulating pressure discharged from the slush pumps, and some means of compensation for changes in the sharpness of the bit which necessarily occur during drilling. By maintaining all of the above factors constant it is theoretically possible to obtain information concerning the nature of formation being drilled by making relative comparisons between drilling rates at different times. The method is, however, inaccurate, and since there is no way of determining accurately the condition of the bit while it is being used, the theoretical method is unrealistic and impractical.

The present invention involves the use of explosive charges which are designed to produce standard depths of penetration in particular formations so that, if they are introduced through the drill stem to the bit periodically during drilling, they shatter the formation below the bit to a particular depth, and permit relatively easy drilling for a distance which may be measured. Stated in another way, if a more or less constant energy is applied to the bit for drilling, the drilling rate will increase for a period following an explosion and will decrease when the bit reaches the level below which no shattering took place. The depth through which the bit moves during the period of increased drilling rate is measured, and indicates the nature of the formation being drilled. With this information, the drilling rate does not have to be compared with a standard drilling rate since the only variable which is actually being measured is depth. The energy expended for penetration does not have to be held con-

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stant over long periods of time, and is not particularly critical since it can vary considerably even directly after an explosion takes place. The only requirement is that the drilling rate must not vary to such an extent that the overall changes in drilling rate cannot be identified.

The primary object of the present invention is therefore to provide an apparatus which provides continuous and accurate geological information during drilling, and which indicates the nature of the formation being penetrated at the time at which it is being encountered by the drill bit.

Other objects will become apparent from the following description when read in conjunction with the accompanying drawings in which:

FIGURE 1 is an elevation of the upper part of a drilling apparatus and includes a diagrammatic representation of an apparatus for retaining and recording geological information;

FIGURE 2 is a partial section of a conventional jet bit modified in accordance with the invention; and

FIGURE 3 is a diagram of a chart record obtained by the apparatus shown in FIGURE 1.

For a detailed description of the explosive torpedoes and the apparatus for introducing torpedoes into the drill stem, references should be made to United States Patent 3,130,797, issued Apr. 28, 1964. Except for the means for obtaining geological information from the drill apparatus, the apparatus is exactly similar to that described in the above-mentioned patent, and will not be described in detail.

Referring to FIGURE 1, a drill stem 4 is shown arranged to be rotated by a table 6 through a kelly 8. A swivel 10 is provided at the upper end of kelly 8 and is arranged to receive drilling mud and explosive torpedoes through pipe 12 from a torpedo introducing mechanism 14. Swivel 10 is supported by a traveling block 16, which, in turn, is supported by cable 18 from a crown block 20 including a plurality of independently rotatable sheaves 22.

It will be apparent that any one of sheaves 22 will rotate at a rate proportional to the rate of descent of drill stem 4, and that through a suitable transducer and servomechanism 24 the movement of the chart 26 of the chart recorder 28 can be made to correspond directly to the movement of drill stem 4. Thus the amount of chart movement is made to indicate the depth of the bit. A conventional differentiator 30 which may be of an electronic type is connected to receive an output from transducer 24, and deliver an output through line 32 to operate pen 34 of the chart recorder. The position of pin 34 corresponds to the rate of descent of the bit with respect to time. It will be apparent that differentiator 30 must be provided with suitable response characteristics in order to accommodate the relatively slow descent of the bit.

Referring to FIGURE 2, a jet bit 34 is shown having a guiding funnel 36 for the reception of explosive torpedo 38. Torpedo 38 is designed so that it explodes only when its nose strikes a surface directly. A contact with the wall of funnel 36 will therefore not detonate the explosive. Torpedo 38 is also desirably of a type having a shaped charge arranged to produce a relatively high degree of penetration in the downward direction, and may alternatively be of a multiple charge type such as that described in United States Patent No. 3,190,372, issued June 22, 1965, which shows a well torpedo having a shaped charge for producing a cavity below the bit and a blasting charge with means for propelling the blasting charge into the cavity formed by the shaped charge so that the extent of shattering of the formation is greatly increased.

For a given earth formation indicated at 40 in FIGURE 2, a typical depth throughout which the formation

is shattered is indicated at D. It is necessary that all of the torpedoes 38 used produce approximately the same depth of shattering in a given formation and different depths of shattering in different formations. In accordance with the present invention, different formations are shattered to different depths, and can therefore be distinguished from one another and identified by comparison of the measured depths of shattering with known standard depths.

FIGURE 3 shows diagrammatically a typical chart record obtained with the apparatus illustrated in FIGURES 1 and 2. The abscissa of the graph represents the depth of the bit which increases toward the left of the figure. The ordinate corresponds to the drilling rate. Depths d_1 , d_2 , d_3 and d_4 represent the depths at which explosive charges are detonated. After each detonation, a peak 42 is obtained in the chart record which indicates an increase in the drilling rate. The significance of these peaks is that the width varies for different formations. For example, in FIGURE 3, a pair of relatively narrow peaks having widths D_1 and D_2 are followed by successive peaks having considerably greater widths D_3 and D_4 . These widths correspond to the depth of shattering of the formation obtained by a standard explosive charge, and a change in the nature of the formation is clearly indicated as occurring between depths d_2 and d_3 . Lengths D_1 , D_2 , D_3 and D_4 can be compared with previously obtained data concerning shattering depths of different formations for the particular explosive charge used, and the formations at the different depths at which explosions have taken place can be identified.

It is impossible to supply a constant drilling energy to the bit, and consequently a smooth drilling rate curve cannot be obtained. In interpreting the curve obtained by the chart recorder minor variations in the curve must be ignored, and the overall changes are significant.

In summary, the advantage to be obtained by the present invention is that a change in the nature of the earth formation encountered by the bit is indicated practically immediately at the surface and the limitations in accuracy produced by changes in bit condition and by other causes are circumvented. It will be apparent that various other modifications can be made to the method and apparatus of the present invention without departing from its scope as defined in the following claims:

What is claimed is:

1. An apparatus for logging earth formations comprising, in combination, mechanical drilling means including a drill stem and a drill bit secured to the lower end of said drill stem, means for introducing an explosive charge into the bottom of a bore hole formed by said bit, means for effecting an explosion of said charge to cause shattering of the earth strata adjacent and below said bit, means supplying rotational power to said drill stem and drill bit, means providing a signal corresponding to the depth of said drill bit, means for providing a signal corresponding to rate of descent of said drill bit, and means receiving said signals and plotting one against the other.

2. An apparatus for logging earth formations com-

prising, in combination, mechanical drilling means including a drill stem and drill bit secured to the lower end of said drill stem, means for introducing an explosive charge into the bottom of a bore hole formed by said bit, means for effecting an explosion of said charge to cause shattering of the earth strata adjacent and below said bit, means supplying rotational power to said drill stem and drill bit, means providing a signal corresponding to the depth of said drill bit, means for providing a signal corresponding to the rate of drilling and means receiving said signals and plotting one against the other.

3. An apparatus for logging earth formation comprising in combination, mechanical drilling means including a hollow drill stem and a drill bit secured to the lower end of said drill stem, said bit having a passage leading from the interior of said drill stem to the exterior of said bit, means for introducing an explosive capsule into the bottom of a bore hole through said stem and said bit, means causing said capsule to explode causing shattering of the earth strata adjacent and below said bit, means supplying rotational power to said drill stem and said bit, means providing a signal corresponding to the depth of said bit, differentiating means receiving said signal and providing an output corresponding to the rate of descent of said bit, and recording means receiving both said signals simultaneously and providing a record from which the depths at which changes in rate of descent of the bit occur can be determined.

4. An apparatus for logging earth formations comprising in combination, mechanical drilling means, explosive means for shattering the earth strata below the bit of said drilling means, and means indicating depths of the bit at which mechanical drilling becomes relatively easy following an explosion, and indicating the depths of the bit at which relatively easy drilling ceases.

5. The method of identifying earth formations during the drilling of a well comprising the steps of effecting rotary drilling to a first depth, introducing an explosive charge into the hole formed by rotary drilling and detonating said explosive charge at said first depth to cause shattering of the earth formation throughout a distance below said first depth, effecting rotary drilling throughout said last mentioned distance, continuously measuring the rate of penetration of the drill, and measuring the depth below said first depth through which the rate of drilling is substantially increased.

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