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Allgood et al.

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[54] **STRESS WAVE DRILL**

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[52] **U.S. Cl.** **175/15**, 175/16, 175/17, 175/67

[51] **Int. Cl.** **E21b 7/00**

[58] **Field of Search** 175/15, 16, 17, 57, 65, 175/67

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[57] **ABSTRACT**

A method and apparatus for drilling a hole in rock. An open-ended, hardened, drilling head containing a means for creating high-intensity stress waves capable of spalling rock is utilized to drill the hole. A fluid is passed through the drilling head which removes the spalled rock from the drilling head.

7 Claims, 4 Drawing Figures

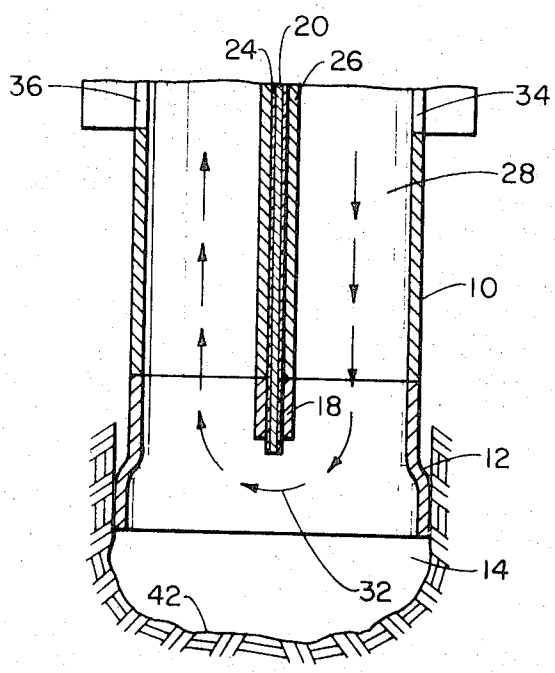


Fig. 1.

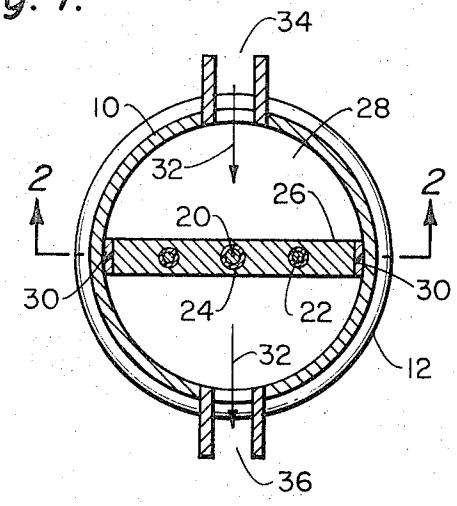


Fig. 3.

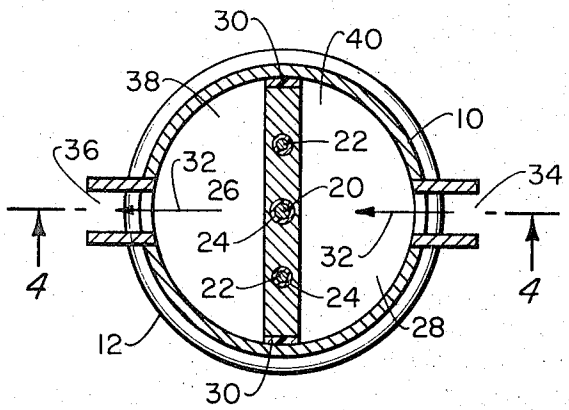


Fig. 2.

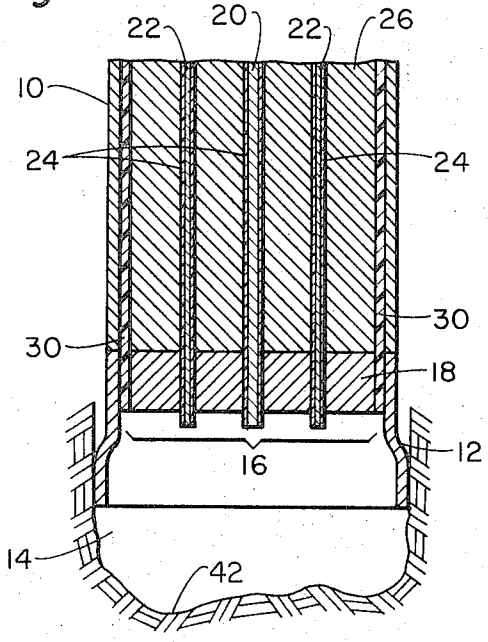
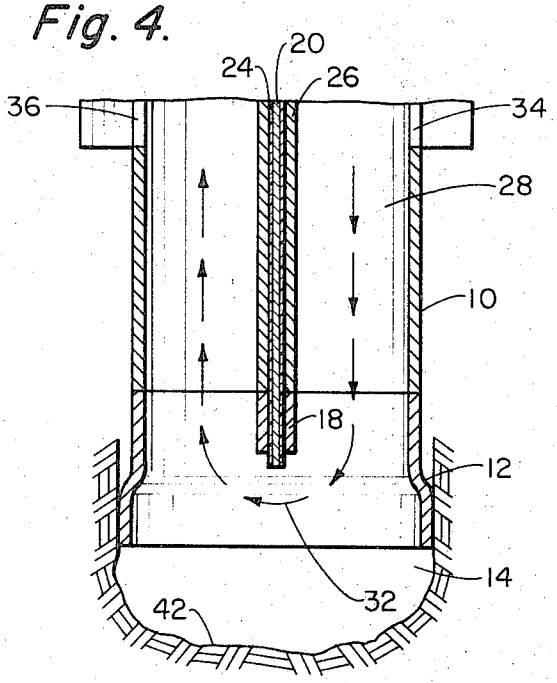


Fig. 4.



STRESS WAVE DRILL

BACKGROUND OF THE INVENTION

1. Field of the Invention.

This invention relates, generally, to drilling a hole in rock and, more specifically, to utilizing high intensity stress waves to drill a hole in rock.

2. Description of the Prior Art.

Some prior art drills utilize cavitational drilling techniques. Cavitation is a phenomenon whereby under certain conditions cavities form and violently collapse within a liquid. A shock wave results from the cavitation and may cause considerable mechanical damage to neighboring solid surfaces. Cavitation is induced in a drilling liquid by any suitable technique such as by the generation of acoustic energy. The cavitation threshold is a function of the physical properties of the liquid. The shock wave pressure is a function of the cavitation threshold. Hence, the shock wave pressure is not easily controlled or varied. Liquids having differing physical properties are necessary for creating different shock wave pressures. Since the shock wave pressure necessary to cause spalling of rock varies with the physical properties of the rock, the cavitation method may require different liquids for different rock in order to effect spalling. Also, the range of shock wave pressures achievable by cavitation is limited by the physical properties of the liquid. Thus, certain types of rock are incapable of being spalled by cavitation.

Currently most rock drilling is done by rotary drag bits or percussion bits. In both of these methods a bit made of hardened steel or other hard material scrapes or impacts against the rock until the rock material is disintegrated into a powder. The efficiency of such drills is very low. The rate of drilling and the cost increases greatly for hard formations and deep holes. In addition, the power lost in transmitting power to the rock reaches significant proportions.

The explosive drill, which is currently an operational alternative to rotary-percussion methods, is greatly restricted in application due to the high cost of explosive pellets.

SUMMARY OF THE INVENTION

The general purpose of this invention is to provide a stress wave drill for drilling rock whose shock wave pressure is easily controlled and varied, that does not require different liquids for different rock, whose shock wave pressure is not limited in range, that is highly efficient, and that is more economical to operate than prior art drills. To achieve these significant advantages, one embodiment of the present invention provides an open-ended, hardened, drilling head containing an electro-hydraulic pulser. The electrohydraulic pulser creates high-intensity stress waves capable of spalling the rock. These high-intensity stress waves are transmitted to the surface of the rock by a liquid which also serves as a carrier to remove spalled rock from the borehole.

Accordingly, one object of the present invention is to provide an easily controllable stress wave capable of spalling rock.

Another object of the present invention is to provide an easily variable stress wave capable of spalling rock.

Another object of the present invention is to provide a wide range of stress waves capable of spalling rock.

Another object of the present invention is to provide a highly efficient drill.

Another object of the present invention is to provide a highly economical drill.

Another object of the present invention is to provide a faster drilling rate.

Another object of the present invention is to provide drilling rates that are relatively independent of rock properties.

Another object of the present invention is to increase the percentage of total power of a drill that is transmitted to the rock.

Other objects and a more complete appreciation of the present invention and its many attendant advantages will develop as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which like reference numerals designate like parts throughout the figures thereof and wherein

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top view of a specific embodiment of the present invention.

FIG. **2** is a front elevation of the specific embodiment of FIG. **1.**

FIG. **3** is a top view of a specific embodiment of the present invention.

FIG. **4** is a front elevation of the specific embodiment of FIG. **3.**

DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning to FIGS. **1** and **2,** numeral **10** designates a drill stem. Attached to one end of drill stem **10** is an open-ended, hardened, drilling head **12.** Hardened drilling head **12** is flared slightly to prevent jamming of drill stem **10** in the borehole **14.** Hardened drill head **12** must be capable of withstanding the stress waves generated by electrohydraulic pulser **16** without cracking or breaking.

Electrohydraulic pulser **16** comprises a solid block of electrical Electrode material **18.** A high voltage electrode **20** extends through insulating material **18** and projects into the space inside drilling head **12.** Two ground electrodes **22,** located adjacent to high voltage electrode **20,** also extend through insulating material **18** and project into the space inside drilling head **12.** Solid block **18** prevents short circuiting of the discharge between electrodes **20** and **22.** Electrodes **20** and **22** are enclosed in electrical insulation **24** inside drill stem **10.** The description and operation of electrohydraulic pulser **16** is promulgated in detail in Browne, Allen and Schrom, Electrohydraulics, Science Journal, March 1968. ELECTRODE support material **26** supports and protects the electrodes **20** and **22** from impact with spalled rock being carried out of the borehole **14** by fluid **28.** Gasket **30** enables electro-hydraulic pulser **16** to rotate within drill stem **10** and drilling head **12.** Gasket **30** forms a fluid-tight seal between electrohydraulic pulser **16** and drill stem **10** and drilling head **12.**

Referring to FIGS. **3** and **4,** fluid **28** enters drill stem **10** via inlet port **34** and leaves drill stem **10** via outlet port **36.** The direction of flow of fluid **28** is indicated

by arrows **32.** Fluid **28** serves as a carrier for spalled rock. Loose rock spalled by electrohydraulic pulser **16** is carried from the bottom of borehole **14** to outlet port **36,** located near the top end of drill stem **10.** Thus, the inside diameter of outlet port **36** must be large enough to pass the largest piece of spalled rock that will be produced by electrohydraulic pulser **16.** The fluid **28** may be recycled through the drill provided the spalled rock is first removed therefrom. Electrohydraulic pulser **16** in conjunction with gasket **30** divides drill stem **10** in two compartments **38** and **40.** Of course, a plurality of compartments of various shapes are possible. The only requirement being that the compartments do not interrupt the fluid flow.

Shock waves from electrohydraulic pulser **16** travel through fluid **28** to the rock face **42.** These stress waves load the face **42** which spalls on rebound. Rock particles spalled from the face **42** are removed by fluid **28** circulating through drill stem **10** and drilling head **12.** The high-intensity stress waves generated by electrohydraulic pulser **16** are typically of microsecond duration. It is noted that electrohydraulic pulser **16** is but one means for generating high-intensity stress waves.

Obviously many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described herein.

We claim:

1. A stress wave drill for drilling a hole in rock comprising:

a drill stem having a first and a second end; a hardened drilling head having a first and a second open end, said first open end being connected to said second end of said drill stem;

means located in said hardened drilling head and said drill stem for generating high-intensity stress waves in said hardened drilling head capable of spalling the rock at the bottom of the hole;

means for dividing said drill stem into a plurality of compartments, each of which extends the entire length of said drill stem; and

interconnection means between said compartments for injecting and retrieving a fluid, said fluid passing through said hardened drilling head, thereby carrying the spalled rock from the hole.

2. The drill of claim **1** wherein said second open end of said hardened drilling head is flared, thereby preventing said drill stem from jamming in the hole.

3. The drill of claim **1** wherein said means for generating stress waves is capable of controlled movement with respect to said drill pipe and said hardened drilling head about the longitudinal axis of said drill stem and said hardened drilling head.

4. The drill of claim **1** wherein said means for dividing said drill stem into a plurality of compartments comprises a single block of material dividing said drill stem into two compartments.

5. The drill of claim **1** wherein said means for generating stress waves comprises an electrohydraulic pulser.

6. The drill of claim **5** wherein said electrohydraulic pulser comprises:

a high voltage electrode;

a first ground electrode;

a second ground electrode;

means for electrically insulating said electrodes from said drilling head, said drill stem, and said fluid, except adjacent to the bottom of the hole, whereby said stress waves are created only in said hardened drilling head; and

said electrodes are supported and protected by said means for dividing said drill stem into a plurality of compartments.

7. The drill of claim **6** wherein said means for electrically insulating said electrodes includes:

a solid block of insulating material located in said hardened drilling head through which said electrodes extend, said electrodes protruding downward from said solid block of insulating material adjacent to the bottom of the hole, thereby preventing short-circuiting of the discharge, said solid block of insulating material only partially filling said hardened drilling head so that the flow of said fluid is not impeded.

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