United States Patent [19]

Hall et al.

[11] **3,927,723**

[45] **Dec. 23, 1975**

[54] **APPARATUS FOR DRILLING HOLES UTILIZING PULSED JETS OF LIQUID CHARGE MATERIAL**

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[22] Filed: **June 11, 1973**

[21] Appl. No.: **368,984**

Related U.S. Application Data

[63] Continuation of Ser. No. 153,582, June 16, 1971.

[52] **U.S. Cl.** **175/422;** 175/67

[51] **Int. Cl.**[2] **E21B 7/18**

[58] **Field of Search** 175/56, 67, 422; 299/177

[56] **References Cited**

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[57] **ABSTRACT**

Apparatus for drilling holes in a formation utilizing pulsed jets of charge material. A housing encloses means for generating pulsed jets of, for example, liquid charge material. One or more acceleration bores extend out the housing in a conical pattern. One or more longitudinal grooves are included in the housing, and means are provided for impelling spent charge material, formation chips, mud, etc. from the hole and out through the longitudinal grooves. A single acceleration bore can have one or more outlet bores angled therefrom to cause a rotational force in the housing in response to expelling of pulsed jets of charge material out the outlet bores. The housing can be made of a first portion with the acceleration bore therein and a nozzle portion with the outlet bores therein and rotatably coupled to the first portion so that only the nozzle portion rotates in response to expelling of pulsed jets. Smoothing tips can extend from the housing to smooth the hole as the housing rotates.

9 Claims, 4 Drawing Figures

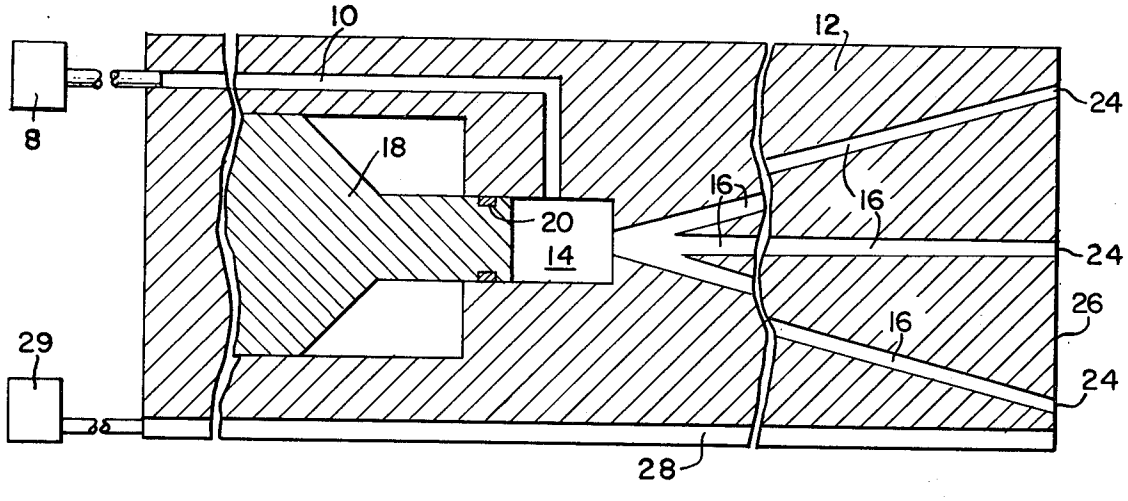


FIG. 1.

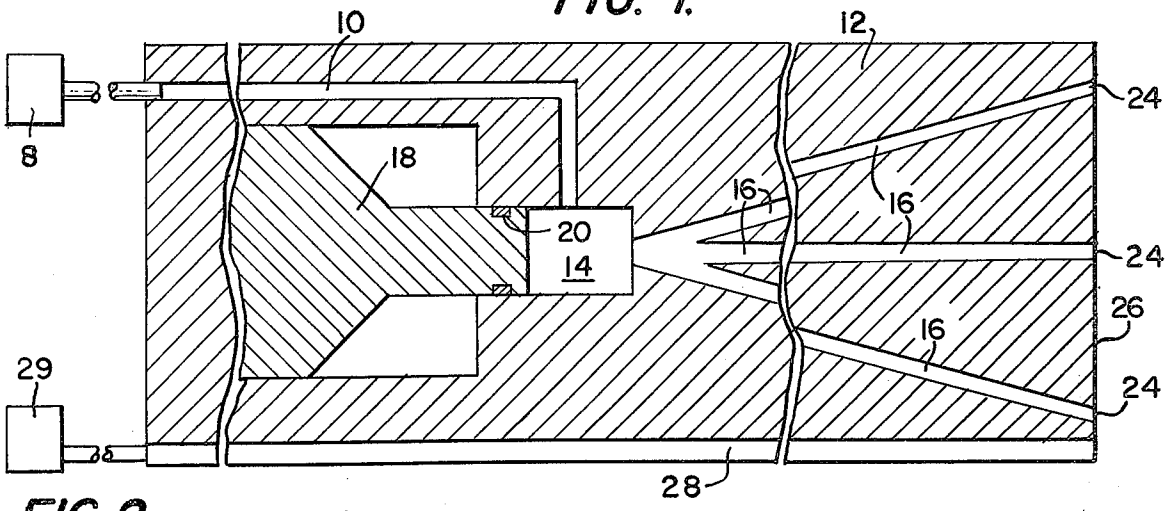


FIG. 2.

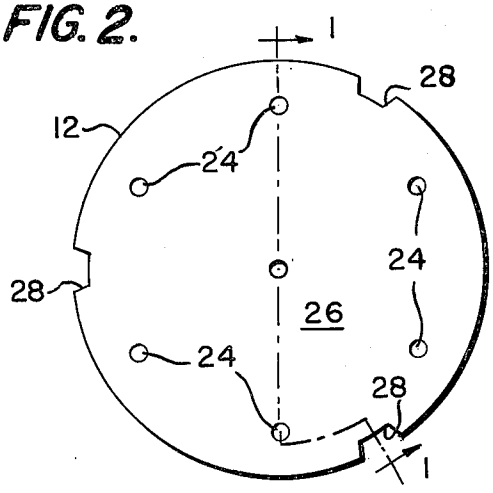


FIG. 4.

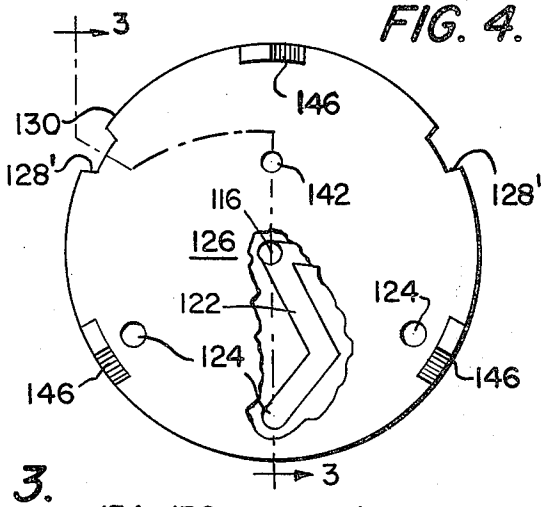
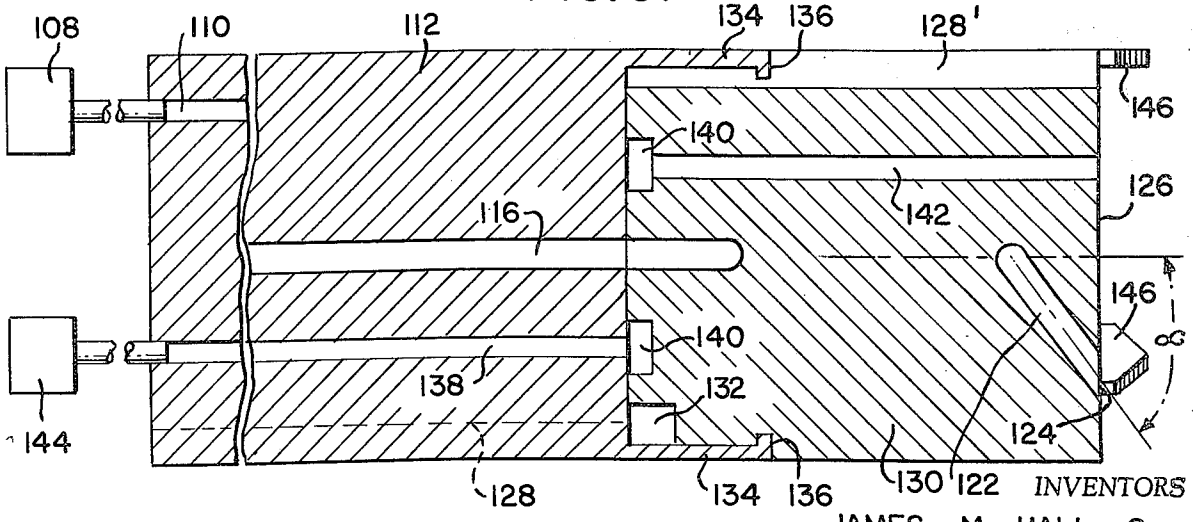


FIG. 3.



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APPARATUS FOR DRILLING HOLES UTILIZING PULSED JETS OF LIQUID CHARGE MATERIAL

This is a continuation, of application Ser. No. 153,582, filed June 16, 1971.

The present invention pertains to a liquid powered drill. More particularly, the present invention pertains to a drill capable of forming holes in rock and utilizing as a drilling substance a liquid such as water.

In many geological activities, such as mining and well construction, drilling of holes into earth formations is desired. Such holes are often filled with explosives which are then detonated to shatter large portions of the earth formations. Other such holes are used within mines for the installation of roof bolts. By way of illustration, the holes may be 1 to 2 inches in diameter and of any required length, for example a length in the range of from about 6 inches to about 30 feet. The holes frequently must go through rock and other hard formations. Drills are available for forming such holes. However, such drills have a relatively short life due to the hard wear experienced in drilling through rock formations. When it is necessary to replace such a drill bit, the entire drill assembly must be removed from the hole. If the hole is of considerable depth, the removal, drill replacement, and reinsertion can be an extremely time-consuming task.

There recently have been developed so-called water cannons, capable of expelling pulsed jets of liquid or gel charge material at pressures sufficient to fracture rock formations, for example pressures in the order of 300,000 to 1,000,000 pounds per square inch (p.s.i.). Use of such water cannons to fracture rock formations offers several advantages. Such devices can utilize, as a charge material, water which generally is readily available at low cost. The direction of the jet pulse can be easily controlled, and so the cannon is a relatively safe device. A water cannon can be operated with a high repetition rate, making it possible to apply several high pressure jet pulses in rapid succession. Examples of such water cannons are found in copending U.S. Pat. application Ser. No. 135,119 filed Apr. 19, 1971, now U.S. Pat. No. 3,712,543 issued Jan. 23, 1973, and copending U.S. Pat. application Ser. No. 135,120 filed Apr. 19, 1971, now U.S. Pat. No. 3,708,121, issued Jan. 2, 1973, both by James M. Hall and Louis L. Clipp.

The present invention is a drill capable of drilling holes through hard formations such as rock and utilizing pulsed jets of a charge material such as water as the drilling medium with the result that there is no drill bit to wear out and require replacement. In accordance with the present invention, there is provided apparatus including a charge chamber adapted to receive a charge of material and communicating with one or more acceleration bores extending from the charge chamber in a conical pattern. A piston acts on charge material in the charge chamber to expel the charge material out the acceleration bores. A single acceleration bore can extend from the charge chamber and communicate with one or a plurality of outlet bores spaced about the outlet end of the apparatus. The communication between the acceleration bore and the one or more outlet bores can be angled so that the charge material flowing through the outlet bore imparts an opposite rotational force to the apparatus outlet end. The resulting rotation of the outlet bores causes the apparatus to drill a hole of substantially the diameter of the device or of a slightly greater diameter. Longitudinal grooves are provided spaced about the periphery of the apparatus through which spent charge material, rock chips, mud, etc. are impelled for removal, either under urging of a vacuum applied to the longitudinal grooves or of air provided through an additional opening.

These and other aspects and advantages of the present invention are more apparent in the following detailed description and claims, particularly when considered in conjunction with the accompanying drawings in which like parts bear like reference numerals. In the drawings:

FIG. 1 is a broken sectional view illustrating apparatus in accordance with the present invention and is taken along line 1—1 of FIG. 2;

FIG. 2 is an elevational view of the embodiment of apparatus in FIG. 1;

FIG. 3 is a broken sectional view of an embodiment of apparatus incorporating alternative features in accordance with the present invention and is taken along line 3—3 of FIG. 4; and

FIG. 4 is an elevational view of the embodiment of apparatus in FIG. 3.

FIG. 1 illustrates in simplified form, apparatus for forming pulsed jets of charge material and expelling the jets through a plurality of openings to drill through earth formations and other such material. Charge material is provided from a source **8** through inlet **10** in housing **12** to charge reservoir **14** which communicates with acceleration bores **16** passing through housing **12.** Piston **18** is positioned adjacent charge reservoir **14** and preferably includes sealing means such as piston ring **20** adjacent its forward end. Charge material is supplied from source **8** through inlet **10** to charge reservoir **14.** Piston **18** is then actuated, moving into charge reservoir **14.** Piston **18** closes off inlet **10,** and piston ring **20** assures that charge material does not leak from charge reservoir **14** out inlet **10.** The charge material is expelled out acceleration bores **16** as pulsed jets. Preferably the diameters of acceleration bores **16** decrease along their length to cause the charge material velocity and pressure to increase as it exits.

The above is a somewhat simplified description of water cannon construction and operation. A more detailed description is contained, for example, in copending U.S. Pat. applications Ser. Nos. 135,119 and 135,120, both filed Apr. 19, 1971 by James M. Hall and Louis L. Clipp.

Acceleration bores **16** extend from charge reservoir **14** in a conical fashion and terminate in outlet openings **24** adjacent the periphery of outlet end **26** of housing **12.** The number of acceleration bores **16** can vary from one to any number, e.g. six as shown. One or more longitudinal grooves **28** are provided on the outer surface of housing **12** and extend the full length of the housing to communicate with a vacuum source **29,** such as a vacuum pump.

Pulsed jets of charge material, resulting from impacting of piston **18** on charge material within charge reservoir **14,** pass down acceleration bores **16** and impact upon the earth formation with a high pressure, for example a pressure in the range of from about 300,000 p.s.i. to about 1 million p.s.i. As a consequence, the earth formation is shattered. A vacuum is applied from vacuum source **29** to each longitudinal groove **28** to impell spent charge material, rock chips, mud, etc. from adjacent outlet openings **24** in the hole as it is

drilled. Since acceleration bores **16** intersect outlet end **26** at an angle at openings **24,** the pulsed jets travel at an angle with respect to the longitudinal axis of housing **12.** Therefore, the resulting hole is of a diameter sufficient to receive housing **12.**

If desired, housing **12** can be rotated during operation, either by mechanical means from its rearward end or due to reaction forces resulting from passage of the pulsed jets through properly oriented acceleration bores **16** in a manner similar to that of the embodiment of FIGS. **3** and **4** described hereinafter.

Housing **12** is of a size dependent upon the desired size of the hole to be drilled. Typically, housing **12** might have a diameter in the range of from about 1 inch to about 2 inches and a length in the range of from about 1 foot to about 30 feet.

FIGS. **3** and **4** depict an embodiment of apparatus incorporating alternative features in accordance with the present invention. As seen in FIGS. **3** and **4,** housing **112,** with a single central acceleration bore **116** therein, includes nozzle portion **130.** Housing **112** includes means for generating a pulsed jet similar to charge reservoir **14** and piston **18** of FIG. **1,** with charge material provided from source **108** through inlet **110.** Within nozzle portion **130,** acceleration bore **116** terminates in one or more outlet portions **122.** Outlet portions **122** are arranged at an angle α with respect to acceleration bore **116.** Angle α may be as great as 15° to 20°. Each pulsed jet passing through outlet portions **122** and outlet openings **124** imparts an opposite reaction force to nozzle portion **130,** causing the nozzle portion **130** to rotate with respect to housing **112.**

One or more longitudinal grooves **128** extend the length of housing **112** and communicate with circumferential groove **132** at the interface of housing **112** and nozzle portion **130.** Housing **112** includes a forwardly extending flange **134** including a lip **136** which fits snugly but slidingly within a corresponding circumferential recess in nozzle portion **130** to maintain housing **112** and nozzle portion **130** in engagement while permitting rotational movement therebetween. Circumferential groove **132** communicates with one or more longitudinal grooves **128'** on the outer surface of nozzle portion **130.** A second longitudinal bore **138** passes through housing **112** and communicates with annular groove **140** at the interface of housing **112** and nozzle portion **130.** Annular groove **140** communicates with a second longitudinal bore **142** through nozzle portion **130.** As the drill of this embodiment is operated, pressurized gas such as air is passed from source **144** through bore **138,** annular groove **140** and bore **142** to impell spent charge material, rock chips, mud, etc. from within the hole being drilled and adjacent outlet openings **124** through grooves **128', 132,** and **128** for discharge.

Outlet end **126** of nozzle portion **130** has extending therefrom one or more high strength tips **146** of, for example, tungsten carbide. The earth formation is broken up by the pulsed jets of charge material, and the hole is smoothed by tips **146** which readily cut the weakened rock or other material as nozzle portion **130** rotates.

Although the present invention has been disclosed with reference to preferred embodiments, numerous modifications and rearrangements could be made, and still the result would be within the scope of the invention.

What is claimed is:

1. Apparatus for drilling holes comprising:

a housing with a first end and a second end and having a longitudinal bore passing therethrough and having at least one acceleration bore passing thereinto from said housing second end and at an angle with respect to the housing longitudinal axis and having at least one longitudinal groove extending the length thereof;

first means for generating a pulsed jet of charge material for passage through the at least one acceleration bore;

a pressurized gas source adjacent said housing first end and coupled to the longitudinal bore for impelling material from said housing second end through the longitudinal groove to the housing first end

whereby as a hole is drilled in a formation adjacent said housing second end by pulsed jets of charge material expelled out the at least one acceleration bore, spent charge material and formation chips are impelled from the hole through the longitudinal groove for discharge at the housing first end.

2. Apparatus for drilling holes comprising:

a housing with a first end and a second end and having at least one valveless acceleration bore passing thereinto from said housing second end and at an angle with respect to the housing longitudinal axis, said acceleration bore having no impediment to the flow of fluid therethrough, said housing having at least one longitudinal groove extending the length of said housing;

a single pulsed jet generator for generating a pulsed jet of charge material for passage through each acceleration bore in said housing located at said first end;

impelling means for impelling material from said housing second end through the longitudinal groove to the housing first end

whereby as a hole is drilled in a formation adjacent said housing second end by pulsed jets of charge material expelled out each acceleration bore, spent charge material and formation chips are impelled from the hole through the longitudinal groove for discharge at the housing first end.

3. Apparatus as claimed in claim **2** in which said second means comprises a vacuum pump adjacent said housing first end and connected to the longitudinal groove.

4. Apparatus as claimed in claim **2** in which said housing has a single longitudinal acceleration bore therein and communicating with at least one outlet bore, each outlet bore passing out said housing second end and intersecting the acceleration bore at an angle α with respect to the housing longitudinal axis.

5. Apparatus as claimed in claim **4** in which angle α is an angle up to about 20°.

6. Apparatus as claimed in claim **2** in which said housing includes a first portion having a single longitudinal acceleration bore therein and a nozzle portion having at least one outlet bore therein communicating with the acceleration bore, at an angle α, said nozzle portion rotatably coupled to said first portion.

7. Apparatus as claimed in claim **6** in which angle α is an angle up to about 20°.

8. Apparatus as claimed in claim **6** in which said housing has a plurality of acceleration bores, each acceleration bore at an angle α with respect to the housing longitudinal axis.

9. Apparatus as claimed in claim **8** in which said housing further has a longitudinal acceleration bore.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,927,723

DATED : December 23, 1975

INVENTOR(S) : JAMES M. HALL & LOUIS L. CLIPP

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 64, "claim 6" should read --claim 2--.

Signed and Sealed this

ninth Day of *March 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks