Dec. 9, 1969 J. A. BROWNING 3,482,640

BLAST HOLE DRILLING METHOD

Filed April 29, 1968

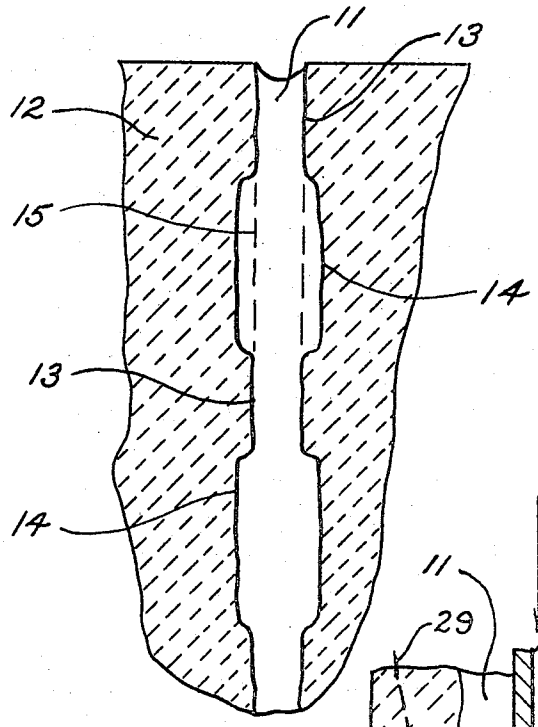


Fig. 1

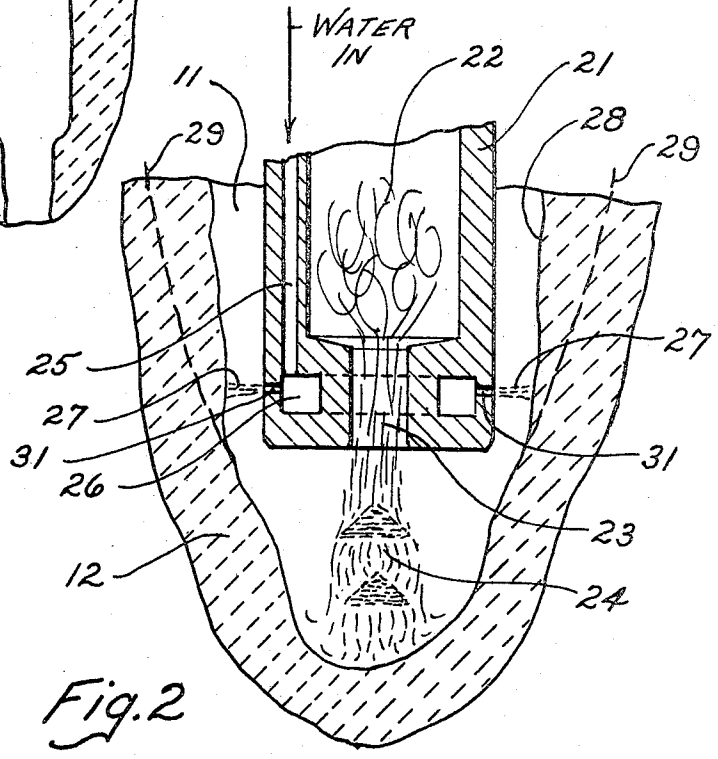


Fig. 2

JAMES A. BROWNING
INVENTOR

BY Wm O Moeser

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BLAST HOLE DRILLING METHOD

James A. Browning, Hanover, N.H., assignor to Browning Engineering Corporation, a corporation of New Hampshire

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Int. Cl. E21b 7/14, 7/18, 21/04
U.S. Cl. 175—14 1 Claim

ABSTRACT OF THE DISCLOSURE

Disclosed here is a method for drilling holes in rock and other mineral materials using a flame jet issuing from the nozzle of a rocket burner. The holes produced are for receiving explosives (for blasting) and may be chambered to larger diameters at selected points by controlling a stream of abrasive particles introduced in the flame jet stream.

My invention relates to the separation of ores, rocks, and other mineral materials from their masses in situ by blasting. It is necessary to couple the energy of a charge of dynamite or other explosive to the mass to achieve separation in the form desired. This is done presently by drilling blast holes into the material, and charging the holes with explosives.

The advent of flame drilling as discussed in a copending application, Ser. No. 725,030, filed Apr. 29, 1968, by James A. Browning and Marshall Fitzgerald, has made possible the rapid production of holes having smaller diameters than heretofore attainable. At the same time, such methods permit the drilling of holes of varying diameter. This versatility now leads to a unique system, in accordance with the present invention, of substantially increasing the blast effectivenesses of explosive charges in drilled holes.

The effectiveness is enhanced by placing the explosive charges to occupy the enlarged portions of the hole. The reduced diameter sections serve to contain the explosion for maximum coupling to the mass surrounding the hole.

Holes of varying diameter have already been produced, using first a mechanical drill, and then a flame drill to "chamber" portions of the hole so drilled. Such a system, with two basically different drilling methods is complex and the operation unduly time consuming.

In accordance with my invention a single basic method is employed to produce holes of the desired geometry.

A complete understanding of the principles of my invention may be had from the following description and drawings, in which FIGURE 1 is a view in cross-section of a hole of the type desired and produced using my invention; and

FIGURE 2 illustrates one embodiment of a flame drilling unit capable of producing the hole of FIGURE 1.

In FIGURE 1 a hole **11** is being drilled in rock or soil **12** using a flame drill (not shown). The hole **11** is characterized by two different diameters along its length—a narrow diameter **13** and a larger diameter **14**. When explosives, such as ANFO (ammonium nitrate plus fuel oil) is placed in the hole, it is seen that the greater portion is held in the enlarged hole cavities **14**. The narrow sections **13** increase the effectiveness of the explosion (over that of a hole of constant diameter). Were the hole of constant large diameter, a good portion of the explosive energy would be lost directly upward to the atmosphere through the conduit available; were the hole of constant small diameter, the same effect would be present, plus the fact that the small hole would accommodate less explosive material.

Presently, holes of this general geometry are made by drilling the small hole (shown extended by dashed lines

15) using a mechanical drill such as a rotary or hammer drill with tungsten carbide cutting edges. This is necessary as conventional flame drills cannot drill these small holes. After the small hole is thus mechanically drilled, a flame drill is used to ream out the larger sections as required.

By various means I have found that a flame drill can be used alone to produce the hole geometry of FIGURE 1. This may be done in one of several manners, each now described. First, a flame unit which normally drills a relatively large hole at its maximum drilling rate is selected. In granite, for example, a 7-inch diameter hole is drilled at a rate of about 30 feet per hour using 600 cubic feet of compressed air (under standard conditions) and fuel oil. In order to produce the minimum size hole possible using the flame alone, water can be added to the hole being drilled in a plane close to bottom of the hole. This technique is discussed in further detail in my copending application Ser. No. 733,727, filed herewith. This technique for producing a narrower hole is shown in FIGURE 2 in which the burner **21** combusts fuel and an oxidizer in an enclosed chamber **22** to produce a supersonic flame jet **24** through nozzle **23**. The flame spalls the rock **12** to form hole **11**. I have found that the full size of the hole is not reached until the region from one to two feet above the bottom of the hole. The hole at its very bottom where the jet directly impinges is quite small and it enlarges as additional heat is added by the hot gases passing upwards through the hole. In the absence of water flow the final hole shape would be that shown by the heavy dashed lines **29**. By introducing water by means of a ring of circumferentially-placed holes **31** further spalling action is effectively halted. The smaller hole **28** results.

In FIGURE 2, water provided for reducing hole size is separately delivered and controlled from water to a closed jacket (not shown) which may be required to cool the burner itself.

The water to control hole size is introduced to manifold **26** through hole **25** in the outer shell structure of the burner. High-velocity water jets **27** issue from holes **31** to impinge against the wall of the hole being produced.

A second technique for producing hole diameters smaller than possible when applying a flame jet alone may be done by adding solid particles to the flame jet as shown in the Browning-Fitzgerald application referred to above. These particles are best selected to be abrasive particles such as hard sand to provide a rapid cutting action ahead of the burner. I have found that such flame plus abrasive cutting produces a hole diameter which is much smaller than when the flame is used alone.

This is probably the result of the somewhat faster action, with less dwell time to permit hot gases to further scour out the hole to approach the diameter depicted at dashed lines **29**.

The addition of water (as shown in FIGURE 2) and the use of an abrasive addition to the flame jet are useful where the hole diameter desired is smaller than that which can be produced using a conventional flame jet drilling device. As an example, the 600 s.c.f.m., 250 p.s.i. compressed air burner cannot make a hole much smaller than 7 inches in diameter. Use of one of these first two methods can reduce the hole diameter to that which will just allow the burner to pass through. Such a burner is about 3½ inches in diameter.

Where extremely large drill holes are to be drilled two other methods (among others) may be used. In this case, and taking the same 7-inch drill, the narrow portion of the hole is held at the 7 inches normally produced. Where sections are to be made even larger the drill advance speed may be slowed down. Slower advance rates produce a larger diameter hole at the region of reduced advance

rate or dwell. A second technique, which may be used in conjunction with all these means, is to reduce the jet velocity of the flame by reducing the chamber pressure of the reactants being burned. This may be done at selected points along the hole as drilling progresses. The lower velocity flame jet drills a larger hole, but, of course, at reduced drilling rates. The essential principle of my invention is the use of a single basic process to produce specialized hole geometries as required for most effective use of explosives.

A further variation of this basic process is to reduce the fuel flow at selective points as drilling progresses to lower the fuel-air ratio; thus the flame jet temperature is somewhat reduced, but the heat contained in the upward sweeping gases is greatly reduced. It is these gases which contribute largely to hole enlargement above the point of initial jet impact.

A test run with fuel content reduced to about 50% of that of stoichiometric combustion results in reduced linear drilling rates, but holes only slightly larger than the burner itself.

The foregoing discussion is illustrative of the method herein taught and comprehended in the spirit and scope of the following claim:

I claim:

1. The method of producing a blast hole by flame drilling with an internal burner comprising applying a flame jet against a mineral mass; advancing said burner as a hole is produced in said mass; feeding a flow of abrasive particles into said flame jet to strike said mineral mass, and reducing or stopping said flow of particles at selected points along the line of drilling to produce enlarged hole diameters at such points.

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DAVID H. BROWN, Primary Examiner

U.S. Cl. X.R.

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