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Rasquin et al.

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[54] PROCESS FOR MAKING DIAMONDS

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[73] Assignee: **The United States of America as represented by the Administrator of the National Aeronautics and Space Administration**

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[21] Appl. No.: **136,086**

Related U.S. Application Data

[62] Division of Ser. No. 3,418, Jan. 16, 1970, Pat. No. 3,632,242.

[52] **U.S. Cl.** **423/446,** 423/625

[51] **Int. Cl.** **C01b 31/06**

[58] **Field of Search** 423/446, 409, 625; 425/77

[56] **References Cited**

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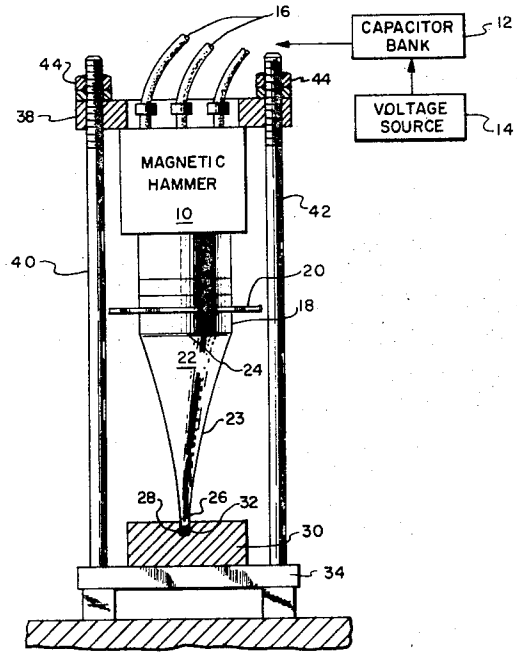
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[57] **ABSTRACT**

Apparatus and process for the production of diamond is disclosed. The apparatus includes an exponential horn tapering from a large end to a small end. A copper plate is mounted against the large end of the horn and a magnetic hammer abuts the copper plate. The magnetic hammer and copper plate function to create a shock wave in the exponential horn. An anvil having a small pocket formed therein is mounted adjacent to the small end of the exponential horn so that the small end rests in the pocket. The anvil, horn and hammer are all secured together by bolts or other suitable means and, in operation, graphite is placed in the anvil pocket. The magnetic hammer generates a shock wave in the exponential horn and because of the horn shape, which is critical, the velocity of the shock wave is amplified and the shock wave energy concentrated so that all of the energy in the shock wave arrives simultaneously at the small end of the horn. This energy is transferred to the graphite in the anvil pocket and results in pressure and temperature levels that causes the graphite to be transformed, in part at least, to diamonds.

4 Claims, 3 Drawing Figures



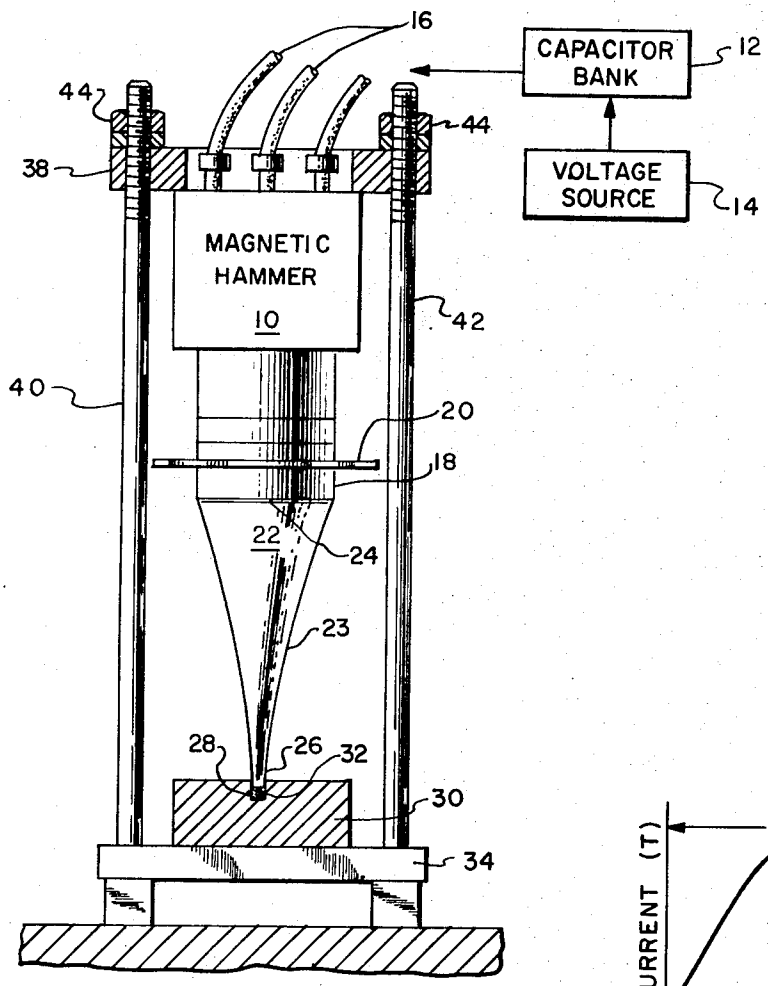


FIG. 1

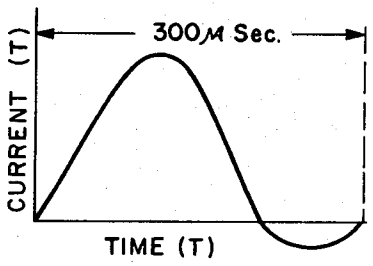


FIG. 2

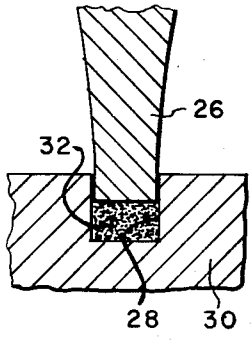


FIG. 3

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PROCESS FOR MAKING DIAMONDS

This application is a division of application Ser. No. 3,418 filed Jan. 16, 1970, now U. S. Pat. No. 3,632,242.

ORIGIN OF THE INVENTION

The invention described herein was made by an employee of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to the art of making industrial type diamonds and in particular, the invention is a simplified technique for making such diamonds with a simple, but effective apparatus. Industrial grade diamonds are a very important item in the American economy as indicated by the fact that industrial diamonds have been classified by the United States Department of Defense as a special strategic material. There are two sources of industrial grade diamonds; those occurring naturally and obtained by mining, and synthetic diamonds. One application of industrial diamonds is in the making of diamond powder used in grinding wheels for sharpening sintered metal carbide cutting tools used in the metal working industries and other industries wherein mass production techniques are utilized. Diamond powder is suspended in oil, water or grease and used in polishing and lapping operations. A deficiency of these industrial diamonds could no doubt cause a serious slow down in the modern metal working industry and possibly curtail the mass production of many items. Better quality industrial diamonds are used for drills of various types ranging in size from large ones for drilling oil wells and the like to small precision type drills like those used by a dentist.

2. Discussion of Prior Art

There have been many attempts in the past to make synthetic diamonds and until recently such attempts met with little success. It was only within the last twenty-five or so years that synthetic diamonds have been made successfully. Principal efforts in the past to make synthetic diamonds were by J. B. Hannay and Henri Moissan. In 1880 or thereabouts Hannay alledgedly made diamonds by heating a mixture of hydrocarbons, hone oil and lithium at a red heat in sealed wrought-iron tubes. Thereafter around 1890 Moissan dissolved sugar charcoal in molten iron and quenched the solution in cold water to crystallize the carbon under the great internal pressures supposedly generated by contraction as the mass cooled. Efforts to repeat these two methods have not met with success.

In 1955 the General Electric Company in Schenectady, New York, successfully made industrial grade diamonds by subjecting carbonaceous materials to pressures in excess of 1,500,000 pounds per square inch and simultaneously to temperatures above 5,000°F. Industrial diamonds were made on a large scale by 1960 and up to one-tenth of a carat was produced in a single run. In this same general time frame diamonds were made by a few other firms including the DeBeers Adamant Laboratory in Johannesburg, South Africa.

To date, diamonds of gem quality have not been made, but synthesized industrial diamonds have been found superior to natural diamonds for use as a grit in polishing compounds. This is because the synthetic diamonds are single crystals, roughly octahedral in shape with many cutting edges. In making grit from naturally occurring diamonds it is necessary to crush the diamonds and this crushing operation results in many elongated slivers and flats which reduce the efficiency of the grit produced.

A primary object of this invention is to provide a simplified technique and apparatus for the production of industrial grade synthetic diamonds. Synthetic diamonds are produced by the application of tremendous heat and pressure to carbon materials, but the equipment presently used to generate this great heat and pressure is very massive and expensive. The present invention can be made much simpler and smaller because it utilizes a greatly amplified shock wave to produce the necessary pressure. Since the pressure build-up is extremely rapid, enough heat is generated by the shock along with the pressure to result in the production of diamonds from graphite.

The apparatus employed includes an exponential horn of solid hardened steel that tapers from a large end to a small end. A magnetic hammer is positioned adjacent the large end of the exponential horn with a copper plate positioned between the horn and magnetic hammer. An anvil having a small pocket substantially equal in size to the small end of the exponential horn is arranged below the small end of the horn so that the small end fits into the pocket. Pure graphite to be converted into diamonds is placed in the pocket of the anvil and then the hammer, copper plate, exponential horn and anvil are all secured together by a suitable supporting frame work.

The magnetic hammer is connected to a capacitor bank and voltage source that delivers an electrical discharge in the form of a fast rising current pulse for operating the hammer and generating a mechanical shock wave in the exponential horn that is directed to the graphite in the anvil. The shock wave generated in the large end of the exponential horn travels through the horn, and due to the shape of the horn, the shock wave is velocity amplified and concentrated so that substantially all of the energy in the shock wave arrives simultaneously in the small end of the horn contacting the graphite. As a result of this, a high speed pressure front is applied or transferred to the graphite which generates sufficient heat and pressure therein to convert a part of the graphite to diamond grit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partially cross sectioned elevational view of an apparatus for practicing the invention;

FIG. 2 is a chart illustrating the shape of the current pulse applied to the magnetic hammer; and

FIG. 3 is an enlarged view illustrating the arrangement of the small end of the exponential horn and the graphite in the anvil pocket.

DETAILED DESCRIPTION OF THE INVENTION

The apparatus illustrated in FIG. 1 consists of a magnetic hammer 10 connected to a capacitor bank 12 and voltage source 14 through electrical transmission lines

16. The magnetic hammer has a large coil in the lower end thereof (not shown) and a copper plate **18** is mounted in abutting relation to the lower end of the magnetic hammer. The copper plate and the hammer are separated by a sheet of plastic material **20**, mylar for example, to prevent any arcing that might occur between the copper plate and the magnetic hammer during the operation of the apparatus. An exponential horn **22** is positioned immediately below the copper plate. Horn **22** has a large end **24** that tapers down to a small end **26** that fits into a pocket **28** formed in an anvil **30**. The horn is fabricated from extremely hard steel, preferably a maraging steel having a Rockwell hardness of **50**.

The curvature of horn surface **23** is determined by the equation $y=ce^{ax}$ where x and y are customary points on a plane defined by two coordinate axes, c is a constant, e is the transcendal number used as the base of the system of natural logarithms, and a represents a constant. The shape of the horn must exactly duplicate that shape which is obtained when the above equation is, by appropriate mathematical manipulations, rotated about the x-axis to obtain a body of revolution. This shape is critical and it has been found, as will be discussed hereafter, that even small variations in shape will result in a loss of efficiency in transmitting and concentrating the energy of the shock wave generated in the large end of the horn. When diamonds are to be made, pure graphite **32** is positioned in the pocket underneath the small end of the horn.

The apparatus is held together by means of two plates, lower plate **34** and upper plate **36**, the upper plate having a hole **38** formed in the center thereof for passage of electrical transmission lines from the magnetic hammer. The two plates are secured together by a plurality of elongated rods **40** and **42** which are threaded at each end to accept nuts **44**. Any desired number of elongated rods could be used to assemble the apparatus, four being used in the apparatus shown and in the actual model successfully tested.

The operation of the device is as follows: assuming that the apparatus has been assembled in the manner shown in FIG. 1 and graphite has been placed in the pocket of the anvil. The capacitor bank is charged from the voltage source and an electrical discharge current pulse having characteristics like that illustrated in the chart of FIG. 2, is applied to the coil (not shown) of the magnetic hammer. The useful portion of the pulse or wave is the first **75** microseconds. The coil is positioned so as to be adjacent the copper plate. Magnetic hammers are known devices and one such hammer which is very similar to that used in this apparatus is described in U. S. Pat. No. 3,360,972 issued on Jan. 2, 1968. The discharge from the capacitor bank flows through the coil in the magnetic hammer generating an intense magnetic field thereabouts. The magnetic field generated by the coil in the magnetic hammer induces powerful eddy currents in copper plate **18** that are opposite in direction to the current in the coil of the magnetic hammer. The eddy currents also generate a strong magnetic field and the magnetic field developed by the eddy currents in the copper plate is such that it reacts against the magnetic field generated by the coil in the magnetic hammer. In effect the magnetic hammer and copper plate tend to be driven apart and would in fact be driven apart if not held together by the supporting frame work discussed above. By utilizing an electrical discharge in which the rise time of the current pulse applied to the coil is very rapid, the reaction just discussed will result in the generation of a shock wave in exponential horn **22**. As the shock wave travels down the horn it is velocity amplified and concentrated, due to the shape of the horn, so that all of the energy arrives at the small end of the horn substantially simultaneously. The shock wave then leaves the horn and enters into the graphite. The shock wave entering the graphite is in effect a very rapid pressure front which compresses and heats the graphite sufficiently to promote the formation of diamonds from the graphite.

In tests conducted with the apparatus, a small shock wave was first generated to pack the graphite in the anvil pocket and then a second shock wave was used to produce the diamonds.

Several test runs were made with the apparatus using different voltages. The capacitor bank employed had a capacity of 360 microfarads. The energy applied to the apparatus from the capacitor bank can be determined by the equation $J = \frac{1}{2} CV^2$ where J is the energy in joules, C is the capacitance in farads and V is the voltage applied to the capacitor bank. The graphite was packed in each test run by a 1,000 volt discharge and then a larger voltage was applied. When 3,000 volts were used to charge the capacitor bank only yellow diamonds were produced. However, a 4,000 volt discharge resulted in diamonds that were a brighter yellow and at 5,000 volts clear diamonds were produced.

In the test using 5,000 volts a portion of the small end of the exponential horn was broken away. The horn was placed in a lath and smoothed up so that it approached its original shape. However, subsequent tests employing high voltages resulted only in a low yield of yellow diamonds. This leads to the conclusion that the shape of the exponential horn is critical.

The apparatus described herein could be utilized to make other crystalline materials by replacing the graphite with other materials. For example, sapphire could be made from aluminum oxide (Al_3).

What is claimed is:

1. A method of making diamonds comprising the steps of:

confining a predetermined amount of pure graphite in a pocket in an anvil, and

directing a pressure front into the graphite by positioning an exponential horn having a large end and a small end, the shape of said horn being determined by the equation $y=ce^{ax}$, so that the small end of the horn is in contact with the graphite and generating a shock wave in the large end of the horn that is velocity amplified and concentrated so that all of the energy in the shock wave arrives simultaneously at the end of the horn in contact with the graphite whereby a pressure front is transferred to the graphite that compresses and heats the graphite to a level that promotes the formation of diamonds.

2. The method recited in claim 1 which further includes the step of actuating a magnetic hammer to generate the shock wave in the horn.

3. A method of synthesizing diamonds from graphite comprising the step of:

confining a quantity of graphite in a pocket in an anvil,

positioning a tapered exponential horn having a large end and a small end, the shape of said horn being determined by the equation $y=ce^{ax}$, so that the small end thereof contacts the graphite,

generating a first shock wave in the large end of the horn that travels through the horn and is velocity amplified and concentrated thereby to transmit a pressure front to the graphite for settling the graphite in the anvil pocket,

generating a second and more intense shock wave in the large end of the horn that travels through the horn and is velocity amplified and concentrated thereby to transmit a second pressure front to the graphite that compresses and heats the graphite to a level that promotes the formation of diamonds.

4. The method recited in claim 3 wherein a magnetic hammer is used to generate a shock wave in the exponential horn.

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