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METHOD OF DIAMOND DRILLING

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This invention relates to a method of perforating difficultly workable materials such as diamonds, corundum and similar hard substances. More particularly, it relates to a method of drilling diamond dies.

In the manufacture of diamond dies, it has generally been the practice to drill a conical cavity more than half way through the diamond and then drill another cavity from the opposite side until a break through occurs, thus completing the perforation. Ordinarily a diamond split is used to start a small conical hole which is subsequently enlarged by using a revolving steel needle coated with diamond dust and oil. When this cavity is completed to more than half way through the diamond, a similar operation is carried out from the opposite side until the two cavities meet. The axes of the two cavities must coincide exactly. With the methods and apparatus generally in use in work of this kind, it is extremely difficult to effect exactly symmetrical conical cavities and to ensure that the axes of the cavities drilled from opposite sides will coincide.

A high degree of accuracy in this respect is necessary and even very slight deviation from axial symmetry will greatly impair the usefulness and efficiency of the die.

Moreover, by this method of drilling, particularly when drilling fine sized holes, very little bearing surface in the passage through the die is obtainable except with great difficulty. This is for the reason that when the break through is made, the edge at the point of breaking through, where the two cavities meet, is ordinarily quite sharp and may not be truly circular in contour with the cone surfaces flaring away on each side. It is highly desirable, however, that at the point of breaking through, the passage should be for a short distance cylindrical, in order to provide bearing surfaces to ensure exact diameters in the wire which is to be drawn therethrough.

It has been proposed to drill diamonds and other hard materials by means of an electric spark with currents of low voltage, as, for instance, 110 volts, or even as low as 40 to 50 volts, and at low frequencies such as 50 cycles or even by direct current. But while this method works moderately well in drilling glass or quartz, it has not been appreciably successful in drilling diamonds or corundum. In addition to this objection, the method permits of better bearing surfaces than the old method of drilling with diamond dust.

It is an object of the present invention to provide a method of drilling difficultly workable materials such as diamonds or corundum by an electrical method and to produce thereby perfectly symmetrical perforations.

It is a further object to effect a drilling which is not only symmetrical but which possesses an adequate bearing surface within the perforation.

It is a further object to provide a controllable process of rapid drilling with a substantial saving of labor and material.

According to the present invention, the diamond or corundum is first prepared to be drilled by making two exactly parallel faces. This can be done in known manner by first mounting the diamond in lead or silver solder in a suitable holder and lapping the surfaces flat by means of an iron disk impregnated with diamond powder. In order that the contour of the hole later to be drilled may be readily examined, two additional parallel faces are lapped and polished at right angles to the first two faces.

The diamond is next centered on one side and the entrance started in any one of a number of ways known in the art; for instance, the position where the entrance is to be made must first be carefully determined. Thereupon, a diamond split held in a suitable holder is pressed against the center point on the face of the rotating diamond, thus cutting a small conical hole in the diamond.

When the diamond has been thus spotted, a tungsten needle having suitable electrical connections is brought to bear on the small starting hole thus bored. The diamond is placed in an electrolyte in a container in which also an electrode is introduced spaced some distance from the diamond. A high frequency electric current, the power output of which may be varied so as to give approximately 100 watts at a voltage of from 350 to 1500 volts at a frequency of about 35 kilocycles or over, is passed through the needle and a conical cavity is rapidly drilled to a distance somewhat more than half way through the diamond.

A hole is then drilled in like manner from the opposite side. It is spotted with a diamond split as in the first instance but great care must be exercised and the exact axis of the first conical hole must be determined with the aid of microscopic cross hairs in order to ensure symmetry of the boring and exact coincidence of the axes of the two cavities. The drilling on this side is not carried to the point of break through. The contour of the two cavities, while preferably conical, may be controlled by shaping the tungsten needle to the contour desired.
The diamond is now removed from the electrolyte and dried and two tungsten needles in suitable electrical connections are brought to bear through the sides of the drum in the conical cavities formed as described. The drilling then proceeds without an electrolyte in a high frequency circuit. The high frequency energy may be generated by means of two adjustable high decrement quench spark gaps, a primary high frequency circuit and coupled to a high voltage tank circuit. It will be apparent, however, that similar high frequency currents may be produced in circuits including vacuum tubes instead of spark gaps.

The high frequency current passes from needle point to needle point through the diamond and the two conical cavities are rapidly joined by a cylindrical passage. This cylindrical passage, when polished in the usual manner, constitutes a bearing surface insuring exact diameters to wires drawn therethrough.

The invention will be more clearly understood from the drawings in which Fig. 1 represents the diamond spotted and centered in the known manner; Fig. 2 is a diagrammatic representation of the apparatus in circuit for burning the tungsten needles; Fig. 3 represents the diamond with conical borings on both sides effected in this apparatus; Fig. 4 represents diagrammatically the dry drilling apparatus employing two tungsten needles; Fig. 5 represents an operative circuit for use in the apparatus of Fig. 2, and Fig. 6 illustrates the diamond as finally bored.

The diamond, after being first provided with polished parallel sides, as heretofore described, is then spotted, this being done in any known manner, for instance, by grinding a steel needle or a diamond split to provide the slight depression a on the upper side. The diamond is then ready for drilling which is done in the apparatus illustrated in Fig. 2. The spotted diamond i is placed upon a glass block 2. The glass block is placed in the glass cup 3 and an electrolyte 4, such as nitric or sulphuric acid, in quantity just sufficient to cover the diamond 1 is introduced into the glass cup 3. An electrode 5 is also placed in the glass cup 3 and in the electrolyte 4, spaced some distance from the diamond 1. The shaft 6 holds the needle 7 which is centered thereon and the shaft is then rotated by the pulley 8 connected to a suitable source of power, not shown. The shaft 6 is slidably mounted in the glass cup 3 and 10 of the standard 11 and it is now brought down into the previously centered hole c of the diamond 1. The variable high frequency generator 12, when the switches 14 and 16 are closed, delivers a high frequency current at a frequency of 50 kilocycles or more through the lead 13 to the shaft 6, through the shaft to the needle 7, through the diamond 1, electrolyte 4, electrode 5 and return line 15. When the circuit is thus closed, an arc will be observed to pass between the needle point 1 and the diamond 1 and the duration of this arc can be controlled by controlling the shape of the needle and the strength and height of the electrolyte.

The strength of the arc is, of course, controlled and determined by the high power output of the high frequency generator 12, and it is generally the case that at the beginning a higher voltage is employed than in the later stages, when the drilling proceeds rapidly with the high frequency generator 12 delivering about 100 watts power at a frequency of 20 megacycles.

Control of the desired contour of the hole drilled may be effected by shaping the needles, it being possible to obtain exceedingly fine holes with the exceedingly sharp points on the needle. It is in the case that after the discharge has continued for a short period, say five to ten minutes, the cavity has become somewhat enlarged and also the shape of the needle has changed. A new sharp needle may then be inserted as desired, the circuit closed again and the desired shape or contour outlined. In some cases it is desirable to change the needle from time to time in order to control the size and contour of the drilling by supplying new needles of the proper size and contour to effect the desired end, it being understood that in the final drilling very sharp slender needle points may be employed to obtain very fine perforations.

At this stage of the drilling the diamond is removed and the reverse side is then operated upon in similar manner as before, the cavity at the bottom of the diamond being drilled to a point short of break-through and the diamond then may be represented by Fig. 3 in which the cavity a at the top of the diamond is seen to proceed somewhat more than half way through the diamond while the cavity b on the under side is seen nearly half the way through the diamond cavity a on the upper side of the diamond 27 and the needle 28 passes through the glass block 28 and bears on the conical cavity b in the bottom of the diamond 27. The glass block 28 acts as insulation for the tungsten needle 28.

The circuit will be understood from Figs. 4 and 5. A source of alternating current 31 delivers a current of about 120 volts at 60 cycles when the switch 32 is closed. The step up transformer 33 raises this to 10,000 to 20,000 volts and serves the spark gap coil 31 through leads 34 and 35. The spark gap coil 21 of Fig. 6 includes the spark gap 36, the condensers 37 and 38, and the coil 39 shown in Fig. 5. Similarly, the step up transformer 40 delivers a current of 10,000 to 20,000 volts to the spark gap coil 44 through the leads 41 and 42. The spark gap coil 24 of Fig. 4 includes the spark gap 43, the condensers 44 and 45, and the coil 45 shown in Fig. 5.

When the switch 32 is closed, a high frequency current flows from the transformers 33 and 40 through the needles 23 and 25 and through the shortest distance between the diamonds which is the axis of the conical cavities a and b and a cylindrical perforation between the two cavities is rapidly effected. The diamond is thus finished in the form represented by Fig. 8 in which the upper conical cavity a and the lower conical cavity b are united by the cylindrical passage a.

By the method of this invention, drillings as small as one quarter of a thousandth (000025) of an inch may be easily and rapidly bored, and it is possible to obtain with greatest accuracy in securing axial symmetry between the bores on the top and bottom of the diamond.

Having thus described our invention, what we claim is:

1. The method of manufacturing a die of diam-
diamond or like material comprising the step of drilling, on opposite sides of said diamond, conical cavities having coinciding axes by subjecting said diamond to the action of high frequency electrical current passing between a needle point and another electrode in an electrolyte, and then joining said conical cavities by drilling a cylindrical axial passage by the action of high frequency electrical current passing between opposed needle points extending into said conical cavities in the absence of an electrolyte.

2. The method of drilling diamonds or similar difficulty workable materials which comprises a first step of immersing the diamond in an electrolyte, bringing a tungsten needle to bear on a previously formed small cavity in the diamond, passing a high frequency current between said needle and an electrode which extends into said electrolyte until a conical cavity is drilled more than half way through said diamond; then reversing said diamond and drilling a conical cavity with coinciding axis in similar manner from the opposite side to a distance short of break through; and then in a second step, placing said diamond between two tungsten needles without an electrolyte, said needles bearing on the two conical cavities and passing a high frequency current at a voltage of about 10,000 volts to 30,000 volts between said needles, thereby drilling a cylindrical passage connecting said two conical cavities.

3. The method of manufacturing a die of diamond or like material comprising the step of uniting the apexes of opposed coaxial conical cavities previously formed in said diamond by a cylindrical coaxial passage formed by centering needles in each of said cones and passing a high frequency electrical current between the points of said needles in the absence of an electrolyte.

4. The method of drilling cavities in a diamond or like material which comprises freely supporting said material to be drilled on an insulating block in an electrolyte, centering a tungsten needle on said diamond and passing a high frequency current between said needle and another electrode spaced from said diamond in said electrolyte.

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