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METHOD OF MAKING DIAMOND KNIVES

Original Filed May 19, 1959

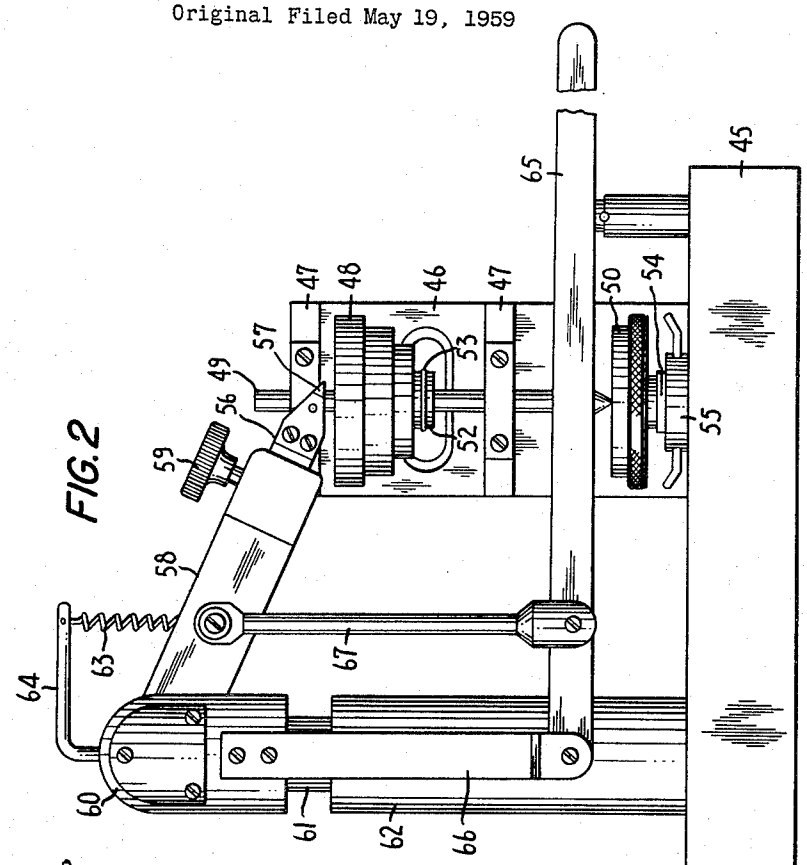


FIG. 2

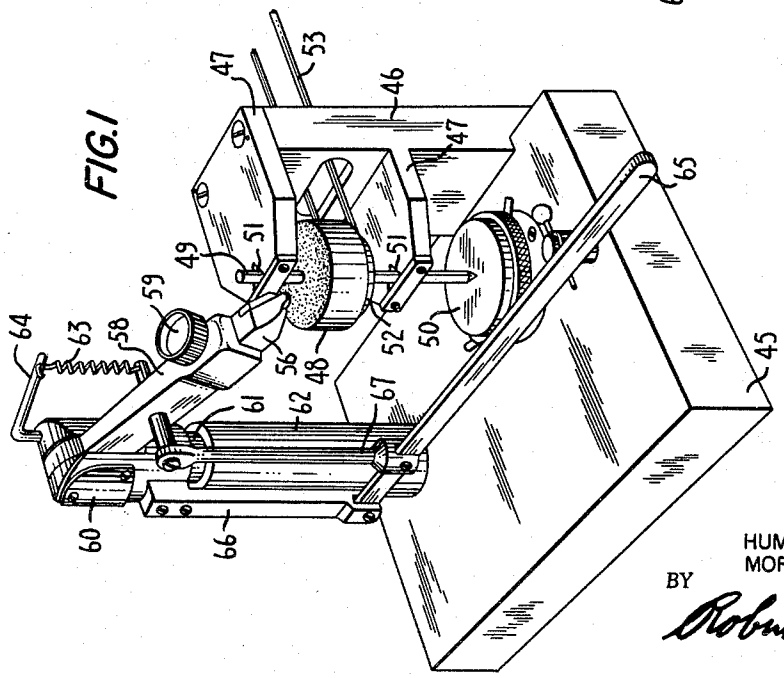


FIG. 1

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METHOD OF MAKING DIAMOND KNIVES

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Original application May 19, 1959, Ser. No. 814,217, now Patent No. 3,060,781, dated Oct. 30, 1962. Divided and this application June 11, 1962, Ser. No. 201,703
5 Claims. (Cl. 51—283)

This application is a division of my copending application Serial No. 814,217, filed May 19, 1959, now Patent No. 3,060,781, dated October 30, 1962.

The invention relates generally to a process for making diamond knives which are particularly suitable for use in cutting machines or microtomes useful for cutting very thin sections.

In a cutting machine or microtome of the character indicated, such as described in my Patent No. 2,961,908, filed October 6, 1954, the cutting edge may consist of steel, hard metal or glass, as known per se. However, these materials are not useful for producing ultrathin sections having a thickness in the range of 0.01–0.001 micron. When a finished edge of steel or hard metal is observed in great magnification, the edge line will appear as a wave line, and in connection with the thin sections here in question such irregularities would involve essential variations as to thickness.

It is an object of this invention to provide a process for making a cutting tool which consists of a diamond which is ground very smooth. A diamond knife can be ground to obtain an absolutely straight edge line, and its edge can be given an extraordinary sharpness of 20–50 A.U. (Angstrom units) by means of the special sharpening and polishing process of this invention, which will be described below. Since the hardness of the diamond is unsurpassed and its crystalline structure makes it possible to obtain stable cutting edges of such molecular thickness, the use of this knife extends the cutting range of the instrument to metals, crystals and all other hard substances which cannot be cut with previously available knives. On the other hand, the improved microtome described in my said Patent No. 2,961,908 has made it possible for the first time to take advantage of the improved efficiency of such a diamond knife.

The thin and ultrathin sections (10–0.001 micron) obtained with the diamond knife, particularly when used in the microtome of my said patent, show complete preservation of the fine structure and integrity of the structural relationships of the specimen down to the molecular and atomic level. The sections are therefore ideally suited for examination with a light microscope (especially with phase contrast microscope), an electron microscope and an X-ray microscope, or for examination by electron diffraction or X-ray diffraction methods. Generally the sections are suited for all methods of structural physical and chemical analysis.

Since the sectioning carried out by this microtome with the diamond knife does not alter the physical and chemical properties of the specimen, it can be used to divide completely small pieces of crystals, amorphous material and all other stable substances in the solid state into intact sections of a thickness down to 0.001 micron. The thin or ultrathin sections obtained in this way can be used for all physical, physicochemical and chemical experiments where thin layers of crystalline and amorphous matter of these dimensions are required. As an example it may be mentioned that thin and ultrathin intact sections of germanium and other semiconductors can be prepared to be used in manufacturing transistors and similar elements.

The invention will be more closely described hereinafter with reference to the accompanying drawings,

though this detailed description must in no way be considered as involving any limitation.

In the drawings:

FIG. 1 shows a perspective view of a suitable machine for grinding cutting diamonds in accordance with the method of this invention; and

FIG. 2 shows the same grinding machine as seen from the side.

The diamond used in making the knife is preferably of the industrial diamond type (Brazilian or Venezuelan Boarts). It may have a weight of 0.2–0.5 carat and an edge of 2.5–3.5 mm. length. The edge angle is preferably kept between 50 and 80° depending on the material to be cut. About 60° is most suitable for cutting soft and elastic or plastic materials, while 75–80° is most suitable for cutting metals and other hard materials.

When grinding the edge I make use of the fact that certain industrial diamonds, for instance boarts, are built up of submicroscopic layers (the thinnest only 0.001–0.005 micron thick), the diamonds being easy to cleave along the planes of these layers, viz. the octahedron cleavage faces. The irregular edges obtained by such cleaving are first smoothed by grinding with fine diamond powder on a smooth iron disk according to the method generally used for polishing diamonds.

To obtain particularly sharp and smooth edges (0.001–0.01 micron) this grinding must be followed by a polishing with ultrafine diamond, diamantine or aluminum oxide powder having an average particle size of 0.001–0.005 micron (controlled in electron microscope). The polishing could be carried out with an extremely good effect by using an apparatus constructed exclusively for this purpose and described below.

The apparatus shown in FIGS. 1 and 2 operates according to the principle that a diamond, the edge of which is to be sharpened, is fastened to the end of a pivotable lever and advanced towards the surface of a rotating disk covered by a paste containing the ultrafine powder. The apparatus is built on a base plate **45**. A post **46** carrying two brackets **47** is fixed to one edge of said plate. The grinding disk **48** is carefully balanced and centered around a vertical shaft **49** joined to it, and its upper surface (the grinding surface) is carefully polished. The pointed lower end of the shaft **49** rests on a polished, adjustable plate **50** of hard metal, Carborundum or diamond. The shaft is journalled in two V-bearings **51** of bronze or diamond provided in the two brackets **47**. A pulley **52** is fixed to the shaft **49** below the grinding disk and is adapted to be driven by a motor (not shown) by means of a belt **53**. The grinding disk as well as the pulley are placed between the two bearings **51**, and the elevation may be adjusted by turning the plate **50** which is fixed to a screw **54**, threaded into the base **45**. A locking washer **55** keeps the screw fixed in the adjusted position.

The electric driving motor can have a speed of rotation of 5,000–40,000 r.p.m. By means of suitable gearing the grinding disk may be driven at a speed varying from 10,000 up to 400,000 r.p.m. In most cases speeds between 20,000 and 40,000 r.p.m. are used. For producing extremely sharp cutting edges, however, speeds between 50,000 and 400,000 r.p.m. are preferred. Owing to the combination of V-bearings and a pointed supporting end of the shaft, the balanced grinding disk acquires an entirely smooth and vibrationless motion even at the higher speeds.

A holder **56** for the diamond **57** to be sharpened is mounted in the sleeve-shaped outer end of a lever **58** and may be fixed in any desired position by means of a screw **59**. The lever is pivotable around a horizontal pivot inserted in a fork-shaped member **60** which is fastened to the upper end of a vertical column **61**. This latter, in

turn, is rotatably journalled in a vertical cylinder 62 mounted on the base plate 45.

The lever 58 is normally held in a lifted position over the grinding disk by a spring 63 which is suspended from a rod 64 projecting from the fork 60. One end of another lever 65 is pivoted to the lower end of a rod 66 extending downwards from the fork 60. A link 67 connects the two levers 58 and 65 with each other. Thus, the diamond holder 56 may be raised and lowered, as well as swung in a horizontal direction by means of a lever 65 serving as an operating handle.

The ultrafine powder used for the grinding is obtained by means of repeated centrifugation and ultra-centrifugation (about 60,000 r.p.m.) of an oil suspension of fine powder. When a powder of the desired grain size has been separated off, it is dispersed in a suitable liquid, e.g. glycerol or distilled mineral oil, to form a paste which is smeared in a thin layer on the grinding disk. The previously-ground diamond is mounted in the holder and carefully brought into contact with the grinding material along its entire edge. The operation is controlled all the time in a microscope (30 times magnification). A skilled expert may in this way obtain an extremely sharp edge which appears as an entirely straight line even when magnified 1400–20,000 times. The appearance of the edge is of decisive importance for the quality of the sections produced by the microtome.

The invention is not restricted to the embodiment shown and described, but various modifications may be effected within the scope of the invention as defined in the appended claims.

What I claim and desire to secure by Letters Patent is:

1. A method of producing a knife edge which comprises selecting a diamond, cleaving said diamond along the plane of a cleavage face of the diamond, grinding said face with fine abrasive powder on a smooth disc, polishing said face on a disc rotating at a speed higher than 10,000 r.p.m. and coated with a paste containing a grinding powder having a particle size smaller than 0.005 micron and cutting and polishing in like manner a second face intersecting said first mentioned face at an angle of 50° to 80° to produce a cutting edge having a sharpness of 20 to 50 Angstrom units.

2. A method according to claim 1, in which said disc is rotated at a speed of 20,000 to 400,000 r.p.m.

3. A method of producing a knife edge which comprises selecting a diamond, cutting a first plane face on said diamond, suspending ultra-fine abrasive powder in oil centrifuging said oil suspension at a speed of the order of 60,000 r.p.m. to separate from said suspension powder having a particle size less than .005 micron, dispersing said separated powder in a carrier liquid to form a paste, smearing a thin layer of said paste on a smooth plane surface of a grinding disc, rotating said disc at a speed higher than 10,000 r.p.m., bringing said face of said diamond into contact with said surface of the rapidly rotating disc under controlled pressure to polish said face and cutting and polishing in like manner a second face intersecting said first mentioned face at an angle of 50° to 80° to produce a cutting edge having a sharpness of 20 to 50 Angstrom units.

4. A method according to claim 3, in which said particle size is controlled with an electron microscope.

5. A method according to claim 3, in which said disc is rotated at a speed of 20,000 to 400,000 r.p.m.

References Cited by the Examiner

UNITED STATES PATENTS

1,213,164 1/17 De Graaf ..... 51—283

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