DIAMOND CUTTING TOOL HAVING AN EDGE THICKNESS OF 0.001 TO 0.01 MICRON

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1 Claim.

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The invention relates generally to improvements in diamond knives particularly suitable for use in cutting machines useful for cutting very thin sections.

In a cutting machine of the character indicated, such as described in my co-pending application Serial No. 460,745, filed October 6, 1954, now Patent No. 2,961,908, the cutting edge may consist of steel, hard metal or glass, as known in the art. However, the materials are not useful for producing ultrathin sections having a thickness in the range of 0.001-0.001 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 the thickness. Therefore, it is an object of this invention to provide a process and an apparatus 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 co-pending application Serial No. 460,745, now 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 of the present invention, particularly when used in the microtome of my said application, show complete preservation of the same 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 light microscope (especially with phase contrast microscope), electron microscope and X-ray microscope, or 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 of this invention 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 ultra-thin sections obtained in this way can be used for all physical, physicochemical and chemical experiments where thin layers of crystalline and amorphous materials 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 this invention; and

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

The diamond used in making the knife of this invention is preferably the industrial diamond (Brazilian or Venezuelan Bortas). It may have a weight of 0.2-0.5 carats 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, are built up of submicroscopic layers (the thinnest only 0.001-0.003 micron thick), the diamonds being easy to cleave along the planes of these layers. The irregular edges obtained by such cleaving are then 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, diaminite 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 carried by a turntable 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 journaled 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 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 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-bearing and a pointed supporting end of the shaft, the balanced grinding disk acquires an entirely smooth and vibrationless motion even at the highest 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 fas-
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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 ultracentrifugation (about 30,000 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 (50 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 claim.

This application is a division of my application Serial No. 460,745, filed October 6, 1954, now Patent No. 2,961,908.

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

A diamond cutting tool comprising a diamond body portion with a perfectly uniform and stable cutting edge having a thickness of 0.001 to 0.01 micron built up of the crystalline unit layers of the diamond arranged in stable configuration and orientation to give smooth facets defining angles of about 50° to 80°, said tool being effective to produce thin sections having a thickness of the order of 0.001 to 10 microns of both soft and hard materials, with complete preservation of their structural relationships down to the molecular and atomic levels.

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