

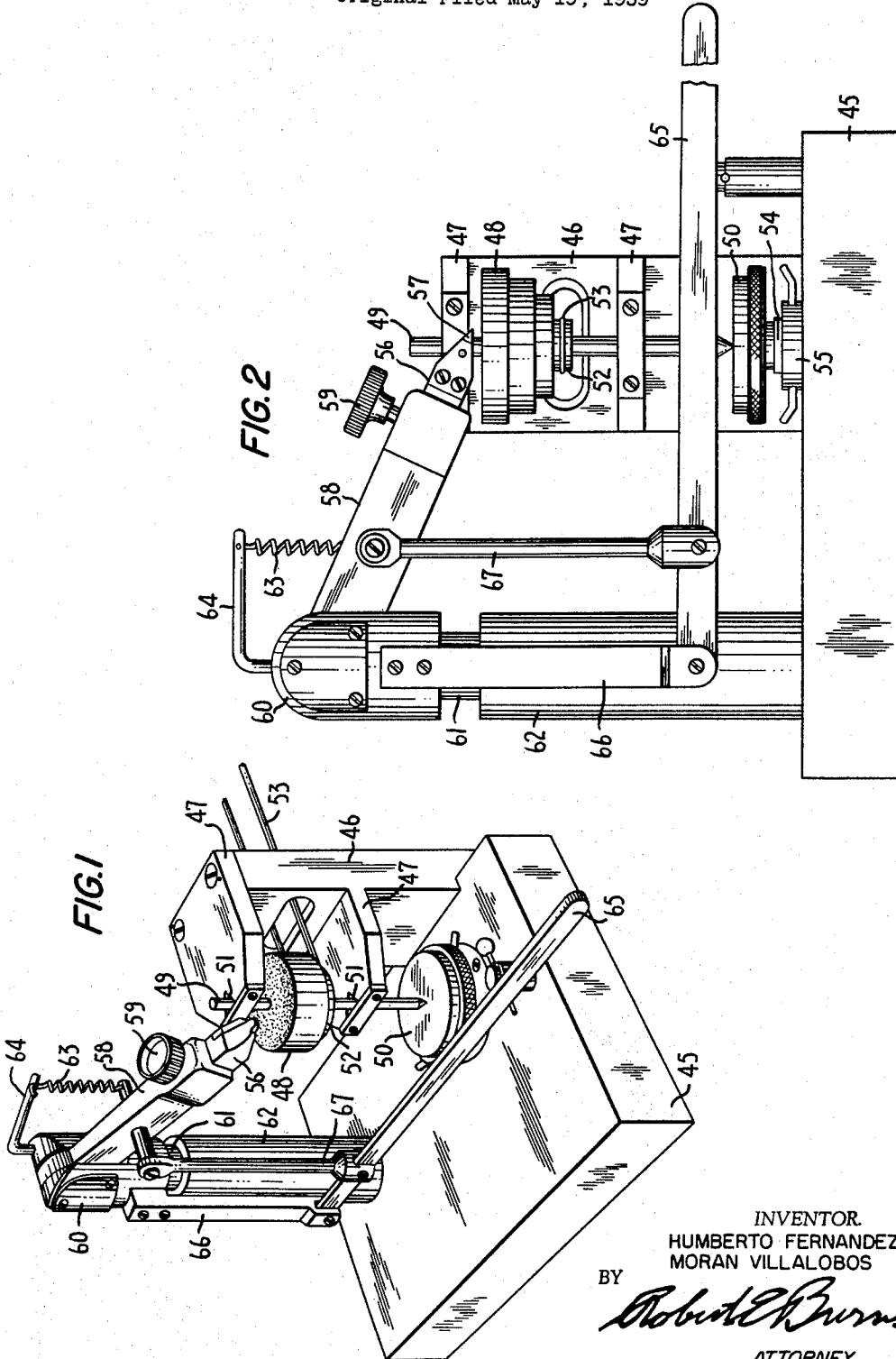
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APPARATUS FOR GRINDING DIAMOND KNIVES

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APPARATUS FOR GRINDING DIAMOND KNIVES
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7 Claims. (Cl. 51—124)

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 an apparatus 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 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 the thickness.

It is an object of this invention to provide 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 apparatus 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 herein-after with reference to the accompanying drawings, though

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

In the drawings:

FIG. 1 shows a perspective view of a 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 is preferably of the industrial diamond type (Brazilian or Venezuelan Boarts). 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 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). Such polishing is carried out with an extremely good effect by using the apparatus of this invention 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 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 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 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 fastened to the upper end of a vertical column 61. This latter, in

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turn, is rotatably journaled 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. In apparatus for grinding diamond knives; the combination of a base, a smooth substantially horizontal bearing surface on said base, a support projecting up from said base, two vertically spaced V-shaped bearings carried by said support and vertically aligned with one another above and spaced from said bearing surface, a vertical shaft rotatably journaled in said V-shaped bearings and having a pointed lower end resting on said bearing surface, a horizontal grinding disc having a smooth upper surface and fixed centrally on said shaft to rotate therewith, a pulley fixed on said shaft below said disc, said disc and pulley being disposed adjacent one another and between and adjacent said V-shaped bearings, a driving belt running around said pulley and holding said shaft in contact with said V-shaped bearings by belt tension, a holder for a diamond above said disc, an arm carrying said holder, means pivotally supporting said arm for pivotal movement about a horizontal axis above said base, said holder being positioned to present a diamond to the upper surface of said disc at a selected angle and means for selectively varying the vertical distance between said bearing surface and said pivotal supporting means to select the precise angle at which said diamond is presented to the upper surface of said disc.

2. Apparatus according to claim 1, in which said pivotal supporting means comprises a universal mounting permitting said arm to swing about both horizontal and vertical axes.

3. Apparatus according to claim 1, further comprising

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means for rotating said shaft at a speed of not less than about 20,000 r.p.m.

4. Apparatus according to claim 1, in which said pivotal supporting means comprises a vertical post on the upper end of which said arm is pivotally mounted with a horizontal axis and means supporting said post on said base for rotation about a vertical axis.

5. Apparatus according to claim 4, further comprising an operating lever pivotally mounted on said post and link means connecting said lever and said arm for movement of said arm by said lever about both horizontal and vertical axes.

6. In apparatus for grinding diamond knives; the combination of a base, a smooth substantially horizontal bearing surface on said base, a support projecting up from said base, two vertically spaced V-shaped bearings carried by said support and vertically aligned with one another above and spaced from said bearing surface, a vertical shaft rotatably journaled in said V-shaped bearings and having a pointed lower end resting on said bearing surface, a horizontal grinding disc having a smooth upper surface and fixed centrally on said shaft to rotate therewith, a pulley fixed on said shaft below said disc, said disc and pulley being disposed adjacent one another and between and adjacent said V-shaped bearings, a driving belt running around said pulley and holding said shaft in contact with said V-shaped bearings by belt tension, a hollow cylinder projecting up from said base and spaced from said shaft, a post rotatable in said cylinder and projecting above said cylinder, an arm pivotally mounted with a horizontal axis on the upper end of said post and extending over said disc, a holder on said arm for holding a diamond in contact with the upper surface of said disc, spring means tending to swing said arm upwardly, a bar secured to the projecting end of said post and extending down alongside said cylinder, a lever pivotally connected to the lower end of said bar, linkage connecting said lever and arm for movement of said arm by said lever about both horizontal and vertical axes and means for selectively varying the vertical distance between said bearing surface and the pivot axis of said arm to select the precise angle at which said diamond is presented to the upper surface of said disc.

7. Apparatus according to claim 6, in which said varying means comprises means for accurately positioning said bearing surface vertically relative to said base.

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