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Sastri

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[54] **PROCESS FOR PRODUCING AN IMPROVED CUTTING TOOL**

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Related U.S. Application Data

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[52] **U.S. Cl.** **30/346.53**

[51] **Int. Cl.** **B26b 21/54**

[58] **Field of Search**..... 30/346.53, 346.54, 346.55; 51/285; 204/192

[56] **References Cited**

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[57] **ABSTRACT**

The sharpened edge of a cutting implement such as a razor blade is modified by depositing a layer of dielectric material on the cutting edge and then depositing a layer of electrically conductive material on the dielectric layer and then subjecting the cutting edge to DC ion bombardment so that a portion of the deposited electrically conductive material is removed and the dielectric material is exposed at the tip of the implement.

5 Claims, 3 Drawing Figures

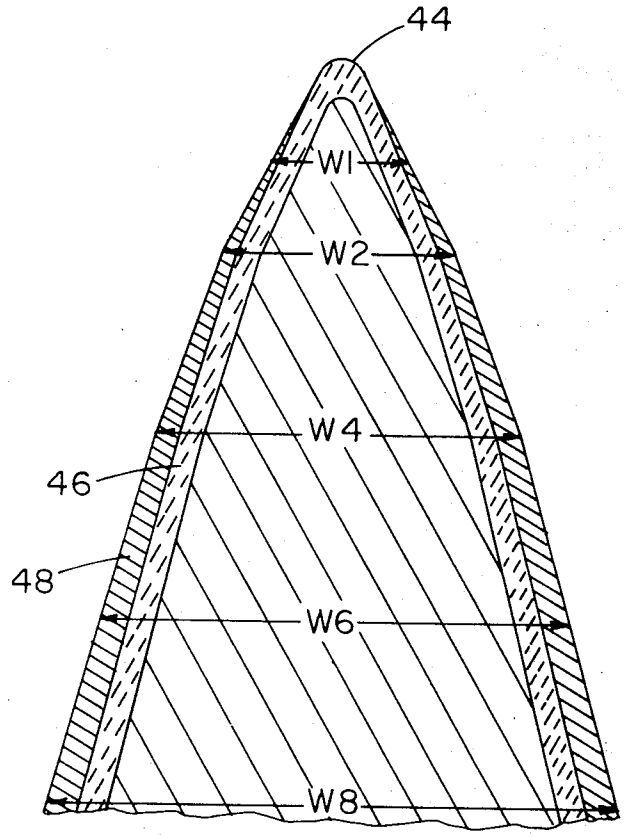
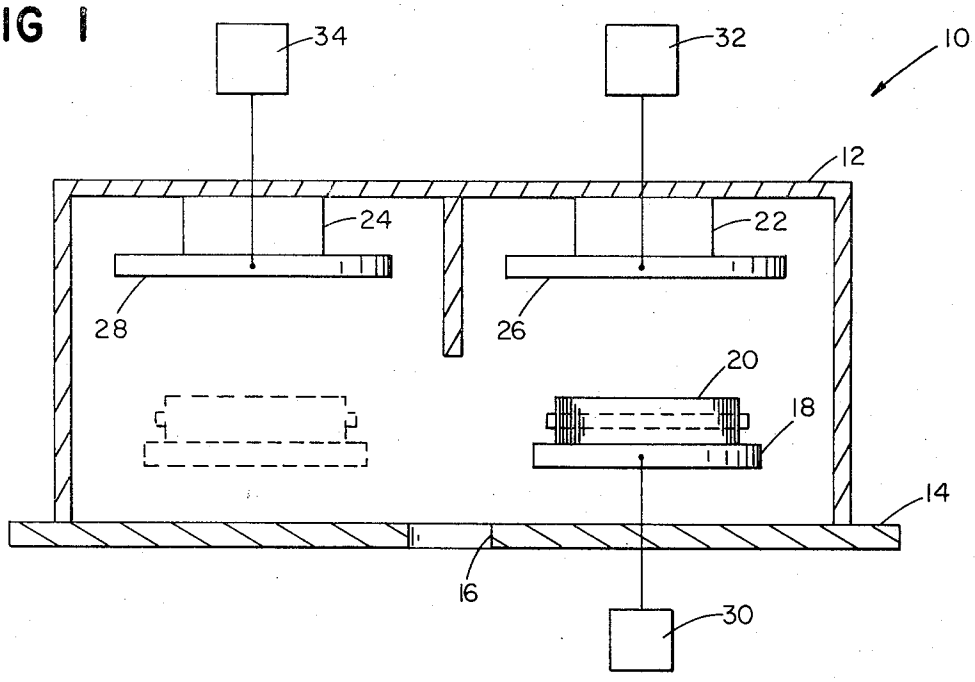


FIG 1



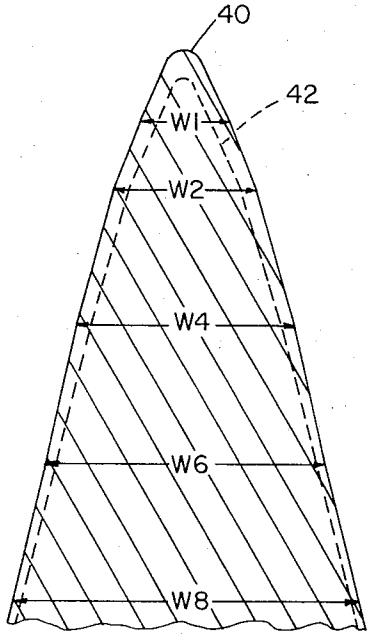


FIG 2

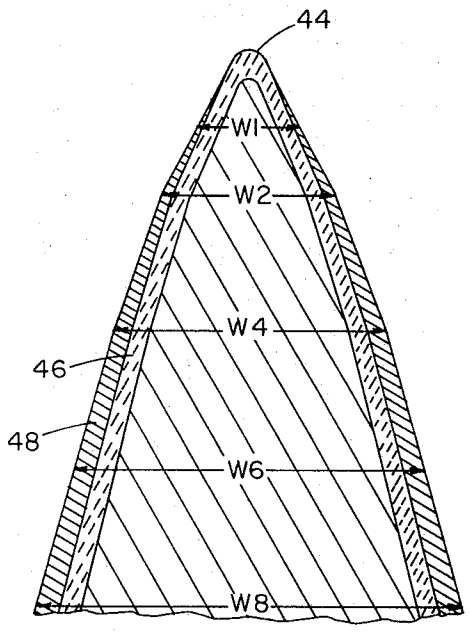


FIG 3

PROCESS FOR PRODUCING AN IMPROVED CUTTING TOOL

This application is a division of Ser. No. 161,159, filed July 9, 1971, entitled "Process for Producing an Improved Cutting Tool," now U.S. Pat. No. 3,761,373.

SUMMARY OF INVENTION

This invention relates to processes for producing an extremely sharp and durable cutting edge on a razor blade or similar cutting tool, and to improved cutting tools.

The forming of the cutting edges of razor blades by mass production techniques conventionally involves a series of abrading operations (grinding and honing) to produce the desired sharp and durable shaving edge. Each abrading operation forms a facet on the blade edge being sharpened, which facet is modified by subsequent abrading operations of increasing fineness. In general, the blade edge configuration is a wedge shape, the included solid angle of which is typically 20°–30°. The faces or sides of such cutting edges may extend back from the ultimate edge a distance up to as much as 0.1 inch or even more. Each face need not be a single uninterrupted continuous surface or "facet," but may consist of two or more "facets" formed by successive grinding or honing operations and intersecting each other along zones generally parallel to the ultimate edge. The final facet, i.e., the facet immediately adjacent the ultimate edge, has a width as low as 7.5 microns or even less compared with the diameter of beard hair which averages about 100 to 125 microns. Through shave test evaluation and measurement of the geometry of such sharpened cutting edges, it has been found that the cutting edge should have an average tip radius of less than 500 Angstroms. A thin adherent layer of a corrosion resistant metal is often applied to the cutting edge of the blade. Further, a shave facilitating layer of polymeric material is also frequently applied to the blade edge. These layers must have adhesion compatability so that they remain firmly adhered to one another and to the substrate throughout the life of the cutting tool and not adversely affect the edge geometry.

It is a general object of this invention to provide novel and improved cutting implements, the cutting edges of which have improved mechanical properties.

Another object of the invention is to provide novel and improved processes for producing improved cutting tools.

A further object of the invention is to provide novel and improved razor blades which possess superior shaving properties.

In accordance with the invention, the edge geometry of a cutting implement such as a razor blade is modified by a process which includes the steps of forming a cutting edge of dielectric material, depositing a layer of electrically conductive material on said dielectric material, and then subjecting the composite cutting edge to a DC ion bombardment step so that a portion of the deposited electrically conductive material is removed so that the dielectric material is exposed at the ultimate tip.

In particular embodiments, the cutting edge is formed in a metal substrate by a suitable procedure

such as grinding, honing, stropping, chemical etching, electrolytic sharpening, or forming with an appropriately shaped die; and then the edge is subjected to two successive strengthening material deposition steps, the first step depositing a layer of dielectric material and the second step depositing the layer of electrically conductive material. Preferably the layers are deposited by sputtering on a multiplicity of blade elements while the blade edges are disposed in parallel alignment with one another and in a plane parallel to a target member spaced from the blade edges. A planar target member is used in one embodiment while a cylindrical target rod is used in another embodiment.

A razor blade in accordance with the invention has an average tip radius of less than 500 Angstroms, the exposed tip material is a dielectric, such as Al_2O_3 and added strengthening metal, such as chromium or a chrome-platinum alloy, is on the flanks of the cutting edge. Such razor blades exhibit excellent shaving characteristics and have a long shaving life. A wide range of blade substrate materials may be used, specific razor blade steel compositions with which the invention may be practiced including the following:

COMPOSITION IN %

C	Cr	Mo	Si	Ni
1.25	0.2	—	0.2	—
1.00	6.0	—	1.4	—
0.96	13.9	—	0.3	—
0.65	10.5	1.0	0.3	—
0.58	14.0	—	0.3	—
0.40	13.5	1.25	0.3	—
0.09	17.0	0.70	1.2	8.0

Other objects, features and advantages of the invention will be seen as the following description of particular embodiments progresses, in conjunction with the drawings in which:

FIG. 1 is a diagrammatic view of apparatus suitable for practice of the invention,

FIG. 2 is a diagrammatic view of the geometry of a razor blade edge sharpened by conventional means; and

FIG. 3 is a diagrammatic view illustrating one example of razor blade edge geometry in accordance with the invention.

DESCRIPTION OF PARTICULAR EMBODIMENT

Diagrammatically shown in FIG. 1 is a sputtering apparatus which includes a stainless steel chamber **10** having wall structure **12** and a base **14** in which is formed a port **16** which is coupled to a suitable vacuum system (not shown). Mounted in chamber **10** is a support **18** on which is disposed a stack of razor blades **20** and support structures **22, 24** for target member **26** of dielectric material and target **28** of electrically conductive material. Support structures **18, 22** and **24** are electrically isolated from chamber **10** and electrical connections are provided to connect blade stack **20** and targets **26, 28** to appropriate energizing apparatus **30, 32, 34.** It will be understood that this is a diagrammatic showing of suitable apparatus. In one embodiment the targets **26, 28** are horizontally disposed discs, each 6 inches in diameter and one-quarter inch thick; and 4 1/2 inch long stack of blades **20** is placed on a 5 inch diameter aluminum support disc **18** disposed parallel to target discs **26, 28.** Disc **18** is movable between

a first position aligned with target **26** and a second position aligned with target **28.** A coil of razor blade strip may be similarly positioned on such a support with its sharpened edges defining a plane exposed to parallel to targets **26, 28.** In another embodiment, target rod that has an exposed length of 29 inches and is 1 1/4 inches in diameter is employed. Suitable coolant is circulated through the rod for cooling purposes. A series of stacks of razor blades (either in coil form or in twelve inch long axial extending stacks) are disposed about the target rod at equal distances therefrom.

The geometry of the edge of a typical razor blade of commercial quality sharpened by conventional abrading techniques is shown in FIG. **2** at a magnification of about 100,000 times. The tip **40** has a radius that is typically in the range of 125–500 Angstroms, a typical average radius (the average of radius measurements taken at 5 to 10 points along the length of the blade edge) being about 250 Angstroms. The W1 flank width (at a distance of 1,000 Angstroms from the ultimate edge **40**) is typically in the range of 1,200 to 1,400 Angstroms. The W2 width (at a distance of 2,000 Angstroms from the tip **40**) is about 2,100 Angstroms; the W4 width (at a distance of 4,000 Angstroms from the tip **40**) is about 3,200 Angstroms; the W6 width (at a distance of 6,000 Angstroms) is about 4,100 Angstroms; and the W8 width (at a distance of 8,000 Angstroms from the tip) is about 5,100 Angstroms.

These measurements were made by a high resolution electron microscopy technique in which a magnified image of a blade edge profile (silhouette) is photographed. The blades are cleaned by immersion in trichloroethylene; subjection to ultrasonic cleaning for 2 minutes; rinsing in a mixture of one-half acetone and one-half methanol; cleaned in warm air; and then demagnetized in a solenoid coil. A blade specimen in the order of one square millimeter in size with four sides, one of which is the original sharpened razor blade edge, is obtained by abruptly snapping the blade with the help of a suitable instrument such as a watchmaker's plier. The blade may be snapped in air or if the blade will not break readily in liquid nitrogen (at a temperature below the ductile to brittle transition value).

A 100 KV RCA EMU4 electron microscope is used with a standard air lock specimen holder modified to accommodate the small blade edge fragment. The microscope was fitted with a liquid nitrogen cooled baffle valve to reduce contamination during photography. The blade edge profile is held in the path of the electron beam so that a shadow image of the ultimate tip is cast on the final viewing screen. The magnification of the final image is controlled by the strength of the intermediate lens current and the focusing is achieved with control of the objective lens current. The microscope magnification was calibrated in terms of focusing lens current.

The tip radius of the resulting photomicrograph was measured by fitting 90° arcs of circles to the tip profile and selecting as the tip radius that edge profile that best fits the profile of the photomicrograph. The point to point resolution of the microscope is in the order of 5 Angstroms. The variation and average radius of a large number of edges from a particular batch of blades using this technique was within ± 12.5 Angstroms. The W1, W2 and other dimensions are similarly measured from the photomicrograph.

In operation of the apparatus shown in FIG. **1,** sharpened blades **20** are disposed in a stack with their sharpened edges aligned and are placed in chamber **10** on support **18.** The chamber is evacuated and the blade edges are subjected to ion bombardment, for example by a glow discharge maintained in argon at a pressure of ten microns to modify the edge geometry as generally indicated by line **42** in FIG. **2** and specifically to reduce the tip radius, a typical radius reduction being about 100 Angstroms. The chamber is again evacuated and argon at a pressure of 5–8 microns is placed in the chamber. With the blade stacks and chamber grounded, an RF potential is applied to dielectric target **26** and argon ions are produced which bombard target **26** and release atoms of the target material. The released atoms of dielectric material are deposited on exposed surfaces, including the sharpened blade edges. This layer is applied uniformly to the thickness of less than 500 Angstroms. The support **18** is then aligned with target **28** and an RF potential applied to that target to cause deposition of an electrically conductive layer on the dielectric layer. The RF power supply is then disconnected from the target **28** and the blades are subjected to DC ion bombardment which removes electrically conductive but not dielectric material, more material being removed from the tip region of the blades than the flanks. The resulting blades have a cutting edge geometry of the nature diagrammatically indicated in FIG. **3** in which the exposed tip **44** is dielectric material and its average radius is about 250 Angstroms and two layers **46, 48** are on the flanks at the W6 dimension.

As a specific example, a 4 1/2-inch long stack of stainless steel razor blades having the following composition:

carbon	0.54–0.62%
chromium	13.5–14.5%
manganese	0.20–0.50%
silicon	0.20–0.50%
phosphorus, max.	0.025%
sulphur, max.	0.020%
nickel, max.	0.50% max.
iron	remainder

and sharpened to the edge geometry as indicated in FIG. **2,** were placed on a 5 inch diameter aluminum disc support **18** in an RF sputtering unit. Two targets were employed, an Al_2O_3 target **26,** and a Cr_3Pt target **28.** The Al_2O_3 target **26** was a sintered compact disc six inches in diameter and 1/4 inch thick, and the Cr_3Pt target **28** was a pure chromium disc 6 inches in diameter and 1/4 inch thick that had squares of pure platinum foil one centimeter on a side and 0.002 inch thick spot welded on its surface. The foil squares were spaced on the surface so that 23 percent of the chromium surface was covered with platinum. The target surfaces were disposed parallel to the sharpened blade edges at a distance of 2 1/2 inches from those edges.

Pressure in the vacuum chamber **10** was reduced to 0.1 micron of mercury and then pure argon gas was bled into the chamber to a pressure of ten microns of mercury. The aluminum support disc **18** was then connected to a DC source of power and with the chamber **10** grounded the blade edges were subjected to ion bombardment at a voltage of 1,800 volts and a current of 35 milliamperes for seven minutes. The targets **26, 28** were covered by metal shields during this step. A 13.56 magahertz RF source was connected to Al_2O_3 target **26** and that target was sputtered for thirty min-

utes while maintaining ten microns of mercury pressure or argon gas in the chamber. The shield was then removed from between the blades **20** and the target **26** and 0.4 kilowatts of power (with a DC negative bias of about 3,400 volts and a superimposed RF signal of about 4,500 volts peak to peak) was applied for 10 minutes while maintaining argon at 10 micrions pressure. The edges of the blades facing target **26** received an aluminum oxide layer **46** to a thickness of about 250 Angstroms. Application of RF power was then terminated and support **18** was aligned with the Cr_3Pt target **28.** The Cr_3Pt target **28** was connected to the RF source and cleaned for five minutes and then a layer **48** of chromium-platinum alloy 250 Angstroms in thickness was deposited by application of 0.4 kilowatts of power for 75 seconds. The blade stack was then connected to the DC source and subjected to ion bombardment for seven minutes at 1,800 volts at a current of 100 milliamperes to remove the chromium-platinum film from the tip region but not the flank region of the blades to provide a blade edge geometry as shown in FIG. **3.** The resulting blades have an average tip radius of 250 Angstroms, an average W1 dimension of about 1,400 Angstroms, a W2 dimension of about 2,500 Angstroms, a W4 dimension of about 4,000 Angstroms, and a W6 dimension of about 5,150 Angstroms. A coating of polytetrafluoroethylene telomer was then applied to the edges of the blades in accordance with the teaching in U.S. Pat. No. 3,518,110. This processing involved heating the blades in an argon environment and provided on cutting edges of the razor blades an adherent coating of solid PTFE. These blades exhibited excellent shaving properties and long shaving life.

It will be understood that a variety of dielectric materials including other metal oxides may be used for the dielectric layer **46** and that other metals and metal alloys may be used for the electrically conductive layer **48.** Ion bombardment between the application of the dielectric and conductive layers is optional. For example, such ion bombardment may be desirable when the process is employed with separate deposition chambers with a single target in each chamber.

The invention provides an improved cutting implement such as a razor blade in which the tip radius of the implement is within the optimum range for cutting effectiveness, the exposed tip is of dielectric material and substantial amounts of edge strengthening materials have been added to the flanks of the cutting edge.

While a particular embodiment of the invention has been shown and described, various modifications thereof will be apparent to those skilled in the art and therefore it is not intended that the invention be limited to the disclosed embodiment or to details thereof and departures may be made therefrom within the spirit and scope of the invention.

What is claimed is:

1. A cutting implement having an average tip radius of less than 500 Angstroms, said cutting implement comprising a metal substrate having a cutting edge with a tip radius of less than 500 Angstroms, a layer of dielectric material on the tip and flanks of said cutting edge, the thickness of said dielectric layer being in the range of about 100–300 Angstroms, the exposed tip of said cutting implement being of said dielectric material and a layer of electrically conductive strengthening metal on said dielectric material on the flanks of said cutting edge.

2. The cutting implement as claimed in claim **1** wherein said dielectric material is a metal oxide.

3. The cutting implement as claimed in claim **2** wherein said metal oxide is aluminum oxide.

4. The cutting implement as claimed in claim **3** wherein said electrically conductive layer includes chromium.

5. The cutting implement as claimed in claim **1** wherein said cutting implement is a razor blade.

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