# United States Patent [19]

**Siegmund et al.**

[11] **3,805,387**

[45] **Apr. 23, 1974**


[54] **FIBER RAZOR BLADE**


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[73] Assignee: **American Optical Corporation**, Southbridge, Mass.



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[52] **U.S. Cl.** .......................... **30/346.53,** 76/DIG. 8

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

[58] **Field of Search** ............ 30/346, 346.5, 346.53, 30/346.54, 346.55, 346.58, 346.61; 76/104 R, DIG. 6, DIG. 8; 51/206 R, 205 R



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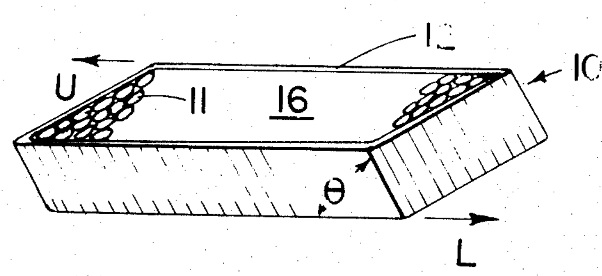
[57] **ABSTRACT**

A cutting instrument wherein a plurality of generally axially aligned hollow fibers are fused to form a substantially integral assembly. The assembly has at least one surface contoured to define a desired angle between portions of the fiber end faces and their axes respectfully. The fiber end faces so defined then form a plurality of cutting edges on the surface. Translational movement of the surface with respect to the material produces a cutting action.

**11 Claims, 8 Drawing Figures**

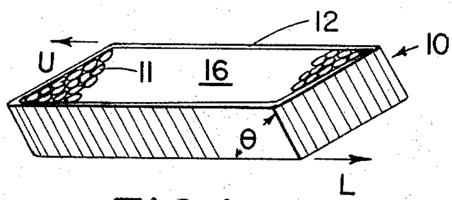



FIG. 1

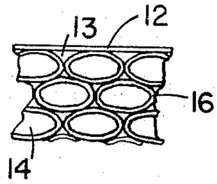



FIG. 2

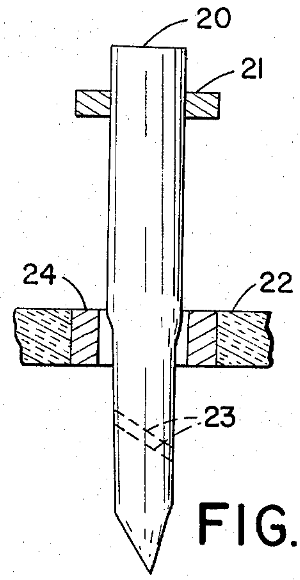



FIG. 3

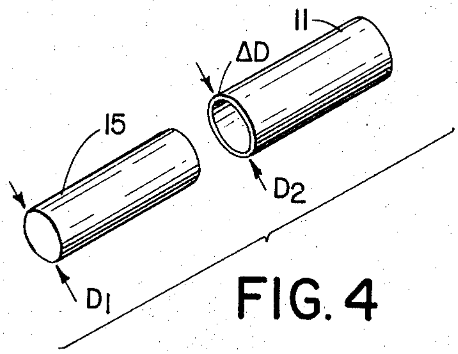



FIG. 4

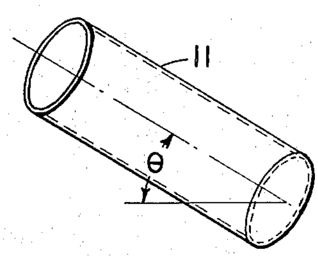



FIG. 5

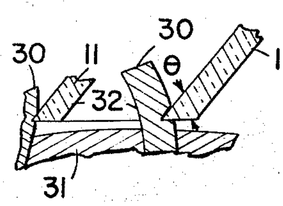



FIG. 6

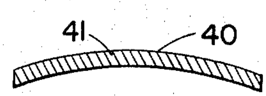



FIG. 7

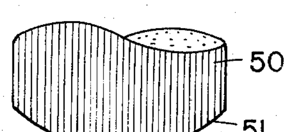



FIG. 8

# FIBER RAZOR BLADE

## BACKGROUND OF THE INVENTION

The present invention is subject to a wide range of applications, it is however especially suited for use as a shaving instrument and is particularly described in that connection.

Heretofore cutting instruments generally and more particularly those of the razor blade type having comprised cutting edges defined by two intersecting planes having a narrow included angle therebetween. In modern razor blade technology, the cutting edges are formed from hardened stainless steel appropriately ground to have the necessary or optimum performance included angle. A second facet of a narrower included angle is groud into the blade at a position further removed from the ultimate edge thus providing a relief to the hair being cut. Almost universally blades are now coated with a polytetrafluoroethylene dispersion assuring a low coefficient of friction between the skin and the hair being parted. The first facet or the intersecting planes forming the ultimate edge of the blade extend approximately two to three thousandths toward the center of the blade. In razor blades of the double edge type, an opposing cutting edge is placed upon the extreme opposite margin of the blade blank thus providing an overall increase of cutting edge length.

The useful life of razor blades is principally limited by two factors. The blades being fabricated of metal are subject to severe corrosion particularly due to the harsh environment normally experienced. The second factor limiting life is the ultimate strength of the metal. In normal use a razor blade must cut beard hairs having a toughness equivalent to that of soft copper wire of equal diameter, it must perform this task employing an ultimate cutting edge having a radius in the neighborhood of 300 to 500 Angstroms. Realizing the extreme fatigue induced by this almost impossible task, it is amazing that useful blade life has reached present day standards. The applicants' invention is directed to the ameleoration of these prior art problems and the production of an improved cutting instrument.

It is therefore an object of the present invention to provide an improved cutting instrument. Another object of the applicants' invention is to provide an improved razor blade, yet another object of the applicants' invention is a glass cutting instrument.

## SUMMARY OF THE INVENTION

To achieve the aforegoing objects and to eliminate the problems of prior art devices the applicants' invention contemplates a cutting instrument in which a plurality of generally axially aligned thin hollow fibers are fused to form a substantially integral assembly. The fused assembly has at least one surface appropriately contoured to define or establish a desired included angle between portions of the fiber end faces and their axes respectfully. Establishing the desired included angle thereby forms a plurality of cutting edges on the surface. Translational movement of these cutting edges with respect to a particular material produces the required cutting action.

For a better understanding of the present invention together with other and further objects thereof reference is had to the following description taken in connection with the accompanying drawings. Its scope will be pointed out in the appended claims.



## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a fiber cutting instrument.

FIG. **2** is a fragmentary plan view of the cutting instrument of FIG. **1.**

FIG. **3** is a partial diagramatic representation of apparatus for the drawing of glass fibers.

FIG. **4** is an exploded perspective view of a glass fiber assembly.

FIG. **6** is a partial fragmentary cross-sectional view of a single fiber cutting edge penetrating a beard hair.

FIG. **5** is a typical perspective view of a single fiber contained in the cutting instrument of FIG. **1.**

FIG. **7** is a cross-sectional view of a fiber razor blade having a cylindrically contoured surface.

FIG. **8** is a plan view of a fiber cutting instrument having a spherically contoured cutting surface.

The drawings are intended to be illustrative of the applicants' invention and in no way delimiting of its scope. Conventional drawing symbols are used and like numbers indicate like or similar parts in the various figures.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** represents a cutting instrument of the applicants' invention finding principal utilization as a razor blade. Razor blade **10** constitutes a plurality of fused glass fibers **11** having their end faces formed at a desired included angle $\theta$ with respect to their axes. End faces **16** of hollow fibers **11** are co-planar with the upper and lower cutting surfaces of razor blade **10.** Translational movement of blade **10** in the direction of arrow L produces a cutting action on the lower surface while translational movement in a direction of arrow U Produces cutting on the upper surface. Fibers **11** are encapsulated or clad by an outer glass sleeve **12** thus forming an integral structure with fibers **11.**

Referring to FIG. **2,** the structure and cutting action of blade **10** may be better understood. There is shown a fragmentary view of the upper portion of blade **10.** Fibers **11** are shown as having eliptical end faces **16** fused together at tangential points of contact. The outer sleeve **12** is shown fused to those fibers **11** located near the periphery of the structure. Interstices **13** between the fibers **11** as well as the center apertures **14** of the fibers are shown as hollow thus providing a maximum of cutting edges. End faces **16** form cutting edges in the direction of the narrow included angle and on those portions substantially transverse to the cutting direction. The eliptical shape of fibers **11** maximizes the cutting edge formed by the fiber end faces **16.** Of course the final geometry of the fiber **11** end faces **16** may be controlled to have almost any desired shape to best solve the particular cutting problem and to maximize cutting edge. The control of fiber geometry is easily achieved by methods well known to those skilled in the art. In the preferred embodiment of FIG. **1,** the thickness of end faces **16** is greater than approximately eight thousandths of an inch with the fiber openings **14** of substantially greater dimension to provide relief for the beard hair being cut.

Apparatus and methods for drawing glass fibers to desired shapes and sizes are well known to those skilled in the art. FIG. 3 demonstrates in schematic form apparatus for achieving this purpose. A fiber optic bundle **20** comprising a plurality of fibers clad within an outer sleeve are clamped within the apparatus by a mechanism **21.** The bundle **20** is then placed within an aperture surrounded by heating coil **24** held within an insulative member **22.** As the end of the fiber bundle **20** is slowly drawn down, the application of heat approximating but below the softening point of the glass involved causes a reduction in diameter with a retention of original geometry. Methods and apparatus suitable to this purpose are adequately described in U.S. Pat. No. 2,992,516, entitled "Method of Making Fiber Optical Components," Inventor — F. H. Norton, Issued — July 18, 1961, which patent is herein incorporated by reference.

Briefly, blade **10** is fabricated from a large number of fibers **11** as depicted in FIG. **4.** A sectional core **15** made of soluble glass and having a diameter $D_1$ is assembled to a cladding **11** having a complementary diameter D2 and length and a wall thickness Δ D. Wall thickness Δ D provides the desired strength for the blade **10** cutting edges as well as the overall cutting edge facet depth. These fibers are axially aligned and assembled within a tube or sleeve **12.** The sleeve is then clamped by a fixture **21** and the distal end of the bundle is placed within an area defined by heating coil **24.**

With the application of heat above the fusing temperature of the fibers **11** but below their softening point, the entire bundle is fused and drawn to the desired diameter for providing the necessary shaving area. Upon drawing, the resultant boules or fiber assembly is parted along lines **23** thereby providing the desired blade **10** thickness as well as the included angle $\theta$ of the cutting edges. The parting angle of lines **23** with respect to the axis of the bundle is complementary of the included angle $\theta$. The final geometry of the blade is determined by the shape of the bundle after placement in the sleeve or by utilization of rollers and other shaping techniques. Techniques and devices useful in forming a glass fiber bundle are further described in U.S. Pat. Nos. 3,227,032, 3,216,807, and 3,190,735.

The wafers are cut from the boule **20** by a diamond saw or convenient parting instrument and although any included angle $\theta$ may be selected, it has been found that an included angle of between 15° and 45° is most suitable. The wafers are then ground and polished using standard optical techniques. After grinding and polishing, they are placed in a bath containing a solution in which the core **15** is soluble. The cladding or fiber **11** is of course insoluable in this solution and thus after appropriate etching time only the core **15** is removed. Removal of core **15** opens up the lumens of fibers **11** exposing cutting edges on those portions of the inner circumference having narrow included angles. External portions of the end faces having the same included angle $\theta$ may also form cutting edges due to the exposure provided by interstices **13.** There is thus created a large number of cutting edges on blade **10** and a vast amount of cutting surface relative to the ordinary straight line cutting instrument or razor blade.

FIG. **5** shows a single typical fiber of razor blade assembly **10.** The depth of the cutting surface is proportional to the wall thickness of fiber **11** and inversely proportional to sine $\theta$. As previously indicated, although the preferred shaving edge depth may be in the range of eight thousandths, any facet depth compatible with cutting requirements and structural integrity may be utilized. The included angle $\theta$ may be varied anywhere between 10° and 90°. The final anciliary step in producing the razor blade **10** is coating the surfaces with a low coefficient of friction material. Found of particular merit is a coating of polytetrafluoroethylene dispersion having a molecular weight of approximately twenty thousand. Such dispersion is well known to those skilled in the art of razor blades and methods for its application are similarly well known. A lubricious coating may similarly be supplied by placing a reservoir of appropriate material above the razor blade and allowing it to suffuse down through the fibers across the cutting surface. Other coatings that may be used are, for example, silicone, polyhexafluoropropylene, polychlorotrifluoroethylene polymers, polyethylene and many other low friction fluids.

In addition to the incorporation of lubrication coatings, the life and performance of blade **10** may be improved by placing on the cutting surfaces a coating of metal or refractory material. Such coatings have been found to increase the cohesion between the lubrication coating and the cutting surface and to some extent improve the wear characteristics of the blade. One method of applying such coatings is described in U.S. Pat. No. 3,632,494 issued Jan. 4, 1972 entitled Coating Method and Apparatus; Inventors — L. F. Herte et al. This patent describes a method of sputtering metalic coatings as well as lubricious coatings onto razor blade edges and may be similarly employed for the application of refractory materials. This application is incorporated by reference within this specification.

The following example sets forth methods and materials employed in the making up of an experimental boule for the fabrication of a glass fiber shaving blade:

## Example

1. Monofibers were drawn consisting of a soluble glass such as a lanthanum crown with a soda lime cladding glass of desired thickness. The cores were ground and polished round and the cladding was used as tubing. Three cladding tubes were used to yield a desired 50 percent clad cross-sectional area which appears to provide the optimum structural integrity. Core diameter after drawing was approximately 1 mm. This provided a wall thickness of approximately eight thousandths of an inch.
2. The monofibers approximately 250 were assembled and axially aligned into an outer tubing of the same soda lime glass as the cladding. This assembly was drawn under a very slight drawing ratio to fuse the monofibers together. A bundle or boule approximately one inch in diameter was provided.
3. The bundle or boule was then sliced into wafers of about one-sixteenth of an inch thickness. Various wafers were cut at angles to yield included cutting edge angles $\theta$ of 15°, 20°, 30°, 45°, 60°, 75° and 90°.
4. The wafers were then ground and polished using standard optical finishing techniques.
5. The ground and polished wafers were then placed in a 50 percent by volume nitric acid bath and the soluble cores were removed.

As apparent from the above example, various size fibers and glass compositions may be used in fabricating a razor blade or cutting instrument in compliance with the applicants' invention. The cutting angles as well as necessary relief are susceptible of variation over a wide range and thereby suitable for varied tasks. It further becomes apparent that a fiber cutting instrument may be made from materials other than glass such as drawn metal fibers or refractory materials thereby providing improved cutting characteristics or shaving efficacy as the case may be. Again the techniques and apparatus necessary to accomplish this are well known to those skilled in the art of fabricating fiber instruments and devices when guided by the teachings of this specification.

It is noted at this juncture that the blade **10** so fabricated need only be placed on a suitable handle or other holding appendage before finding utilization for cutting or shaving purposes. FIG. **6** in schematic form displays the mechanism involved in a fiber razor blade cutting or parting a single beard hair. The wall **11** of a single fiber having included angle $\theta$ is shown impinging upon a single hair **30** protruding above the skin **31**. The leading internal edge **32** has penetrated the hair and is shown as both cutting and wedging apart the fiberous material. Obviously, the placement of lubricious coatings on the cutting surfaces involved reduce the friction in cutting or slicing through the hair itself as well as in any contact with the skin **31** surface. Again, it is seen that the hair **30** must find some relief within the core diameter $D_1$ of the fiber **11**. It is also apparent that at the same time the exterior leading edge of fiber **11** may be contacting another hair **30** in a similar manner. Referring to the aforegoing example, this would mean that well in excess of 250 cutting edges are being worked in normal operation of blade **10**. It is further noted that it is difficult if not impossible for skin **31** to protrude sufficiently into the cutting instrument recesses so as to come in contact with the cutting edges. This eliminates the nicking and scraping normally associated with the use of razor blades.

In fashioning a razor blade instrument, it may be desirable to contour the cutting surface in a peculiar manner for ease of shaving as well as fitting into or around normally inaccesable areas. FIG. **7** demonstrates a razor blade **10** having a cylindrical cutting surface. It is seen that surface **40** generates a portion of a cylinder and that fibers **41** are at a particular angle necessary to provide the included angle $\theta$ thereby forming cutting edges. Again, it is noted similar to the razor blade of FIG. **1** that the blade is unidirectional, i.e., can only cut when translated in a particular direction. The blade of FIG. **7** is further limited by the fact that as opposed to that of FIG. **1**, it may only cut on a particular surface **40**. It does provide the advantage, however, of having a variable cutting surface with respect to the skin as well as providing a variation of cutting angles. FIG. **8** demonstrates a fiber cutting instrument having an omnidirectional cutting surface **51**. In this configuration, the fibers **50** remain perpendicular to a transverse section or plane of the fiber bundle. The cutting surface **51**, however, is contoured to have a spherical or eliptical shape. As obvious from the geometry of the situation, the spherical or eliptical surface **51** provides a variation in cutting angle $\theta$ with respect to each fiber **50** of the bundle. The minimum included angle $\theta$ occurring near the periphery of the blade and the maximum angle $\theta$, actually reaching 90°, closer to the axis of the instrument. Irrespective of the direction of translation with respect to the material being cut, edges of narrow included angle are met thus providing an onmidirectional cutting instrument.

The Applicants' invention has thus provided an economical durable cutting instrument particularly adapted for use as a razor blade. It consists of a plurality of generally axially aligned thin hollow fibers fused to form a substantially integral assembly. The assembly has at least one surface defining desired included angles between portions of the fiber end faces and their axes respectively. The included angles so defined thereby form a plurality of cutting edges on the surface giving greatly enlarged cutting edge length as well as safety and ease of use. While the invention has been described in what are at present considered to be the preferred embodiments, it will be obvious to those skilled in the art that various changes and modifications may be made. It is therefore intended that this disclosure be illustrative of the applicants' invention and all such changes and modifications come within its spirit and scope.

We claim:

**1.** A cutting instrument having a plurality of individual cutting edges comprising a plurality of generally axially aligned thin hollow glass fibers drawn to a desired diameter and fused in side-by-side relationship within an outer sleeve to form a substantially integral assembly, said drawn fused fibers further formed into disk-like sections exposing opposite end faces of said fibers, said assembly having at least one surface in which one of said opposite end faces of said fibers lie in co-planar relation, said surface defining a desired included angle between portions of said fiber end faces and axes, thereby forming a plurality of cutting edges on said surface.

**2.** The cutting instrument of claim **1** wherein said surface is planar thereby providing unidirectional characteristics.

**3.** The cutting instrument of claim **2** wherein said included angle is between approximately 10° and 90°.

**4.** The cutting instrument of claim **3** wherein said cutting angle is approximately 18°.

**5.** The cutting instrument of claim **1** wherein said end faces are coated with a lubricious material of low coefficient friction.

**6.** The cutting instrument of claim **5** wherein said lubricious coating is polytetrafluoroethylene having a molecular weight of approximately twenty thousand.

**7.** The cutting instrument of claim **5** wherein said lubricious coating comprises a low viscosity lubricant suffusing over the cutting surface.

**8.** The cutting instrument of claim **6** wherein said portions of said fibers end faces are greater than approximately eight thousandths of an inch, and wherein said fibers have an internal diameter selected to provide necessary relief for the material being cut.

**9.** The cutting instrument of claim **1** wherein the drawn fibers have a soluble inner core, said core being removed by etching after slicing, grinding and polishing of said cutting instruments.

**10.** The cutting instrument of claim **3** wherein said surface is curved thereby providing at least bi-directional cutting motion.

**11.** The cutting instrument of claim **5** wherein said lubricious coating is selected from the group consisting of polytetrafluoroethylene, polyhexafluorapropylene, polycholotrafluorothylene and polyethylene.

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