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Description

This invention relates to razor blades and is particularly concerned with the shaping of the cutting edge.

The invention resides in a razor blade having a cutting edge tip of stainless steel, the cross-sectional shape of which up to a distance of 40 μm from the extreme edge is substantially described by the equation:

$$w = ad^n$$

in which w is the thickness in μm of the tip at a distance d in μm from the extreme edge of the blade; wherein a and n are constants, a is defined as a factor of proportionality not greater than 0.8 and n is defined as an exponent having a value in the range 0.65 to 0.75.

Preferably, the included angle between the tip facets in the region from 40 μm to 100 μm from the extreme edge is within the range 7°—14° and preferably 9° to 11½°.

It has been found that blades having these tip characteristics provide improved shaving on comparative shave testing, but are sufficiently strong to give a reasonable useful life.

In order to convey a proper understanding of the nature of the present invention, it is convenient to describe and illustrate the background prior art in some detail. In the accompanying drawings:

Figure 1 is a greatly magnified view of a blade tip of typical, or average shape;

Figure 2 is a tip shape diagram illustrating the principle of "chord-width" measurement, the tip shape shown being purely for the purpose of illustration;

Figure 3 is a highly diagrammatic representation of the cutting of a facial hair;

Figures 4 to 7 are cross-sections of various respective blades currently marketed by a variety of manufacturers;

Figure 8 is a view, like Figures 4 to 7, of the tip shapes described in British Patent Specification 1465697.

Cutting edges on razor blades are sharpened by grinding a succession of pairs of facets (usually three) of different included angles onto a strip of steel by means of suitably arranged abrasive wheels. The cross-section through such an edge is illustrated in Figure 1 with typical values for dimensions and angles shown, and is customarily described as a "3-facet edge". While the final pair of facets is being ground, (this stage is usually called "honing"), strip deflection in the sharpening machine together with the mechanical interaction between the steel and the abrasive particles of the wheel, produces final facets which are usually not planar but slightly convex. The curvature is a function of the type of steel and abrasive wheel used, as well as the sharpening machine setting parameters. Because of this convexity of the final facets, the blade tip cross section in this region is customarily referred to as "Gothic arched". The curvature prohibits precise geometrical definition of this part of the blade tip by means of a single parameter so that it is usual to characterise the shape by defining tip thicknesses (or "chord widths") at various distances back from the edge. An alternative method is to ascribe a mathematical equation to fit the form of each half of the facet cross-section. These methods are illustrated in Figure 2.

During use, a razor blade is held in the razor at an angle of approximately 25°, and with the edge in contact with the skin, it is moved over the face so that when the edge encounters a beard hair, it enters and severs it by progressive penetration, aided by a wedging action. It is believed that the cut portion of the hair (which is on average about 100 μm diameter) remains pressed in contact with the blade facets remote from the facial skin surface for a penetration up to only about half the hair diameter. Beyond this, the hair can bend and contract away from the blade to relieve the wedging forces. The resistance to penetration through reaction between hair and blade facets therefore occurs only over about the first 50 μm of the blade tip back from the edge and the geometry of the blade tip in this region is regarded as being the most important from the cutting point of view. This is illustrated in Figure 3.

It is clear that a reduction in the included angle of the facets would correspondingly reduce the resistance to continued penetration of the blade tip into the hair. However, if the included angle were reduced too much, the strength of the blade tip would be inadequate to withstand the resultant bending forces on the edge during the cutting process and the tip would deform plastically (or fracture in a brittle fashion, depending on the mechanical properties of the material from which it is made) and so sustain permanent damage, which would impair its subsequent cutting performance, i.e. the edge would become 'blunt' or 'dull'.

In order to design a suitable shape for the blade tip which is just strong enough to prevent such bending induced damage, an estimation has been made of the magnitude of the bending stresses imposed during the severing of a hair. From these values and a knowledge of the yield strength of the steel from which the blade is made, minimum dimensions can be calculated for the tip section. The stresses imposed during cutting were assumed to arise from the visco-elastic flow of saturated hair material past the blade tip.

Blades currently produced have tip geometries with some dimensions which are below these minimum values and are known to become dulled by edge bending during the normal shaving life (which is on average, approximately 10 days for a blade made from conventional razor blade stainless steel).

We have now found that by careful control of the tip geometry in specific regions 0—40 μm from the edge, the overall cross-section can be reduced so that cutting performance and shaving satisfaction are improved, while retaining adequate strength to resist edge bending damage and so maintain acceptable durability.

The tip shapes of various manufacturers blades currently on the market are shown in Figures 4 to 7, and Figure 8 illustrates blade tip forms as described in British Patent 1 465 697.

These known blade tip shapes are compared with the preferred blade tip shape of the present invention in Figures 10 and 10A.

In one form of the present invention, the blade tip cross-section is first narrowed by grinding the three facets to smaller included angles than those typified in Figure 1. This produces a blade tip whose cross-section is generally narrower throughout and, importantly, in the 0—40 μm distance back from the edge, which is of particular interest during hair cutting. Such an edge is too weak to withstand stresses during shaving and must be further modified. This is achieved by adding what amounts to a fourth sharpening stage. It is carried out using rotating interlocking discs or spirals of leather or synthetic leather, (usually called "strops") with abrasive material added to their peripheries. The sharpened blades pass between the strops, which polish the facets, removing a small amount of steel from their surfaces, and so changing the "Gothic arch" dimensions. This stage is called "abrasive stropping". Because of the flexibility of the strop leather, allowing it to conform somewhat to the sharpened blade tip, abrasive stropping increases the curvature of the final facet, close to the edge, while having less effect on the facet shape further back.

It has been found that when blades are sharpened with suitably reduced facet included angles, followed by an appropriate abrasive stropping treatment, the tip shape is changed so that the chord widths close to the edge become larger than those on conventionally sharpened edges, while the chord widths further away from the edge remain smaller than those on conventionally sharpened edges. This results in the blade tip close to the edge being stronger than normal, so that it can better resist the bending stresses imposed on it during hair cutting, while the reduced section further back from the edge, presents less resistance to penetration during hair cutting, so facilitating the cutting process.

The ultimate tip radius of the edge should be conventional, with an average value of less than 1000°A and preferably less than 500°A as stated, for example, in British Patent Specification 1,378,550 (U.S. 3,761,374), that is, within the normal range for conventionally sharpened edges.

Blades in accordance with the invention have been found to have superior shaving performance when compared with conventional blades on a standard shaving test.

One embodiment of a blade in accordance with the invention and the manner in which it is formed are described in detail below, by way of example, with reference to Figures 9 and 10, in which:

Figure 9 is a diagrammatic illustration of a blade tip stropping operation; and

Figures 10 and 10A are representations of blade tip forms in accordance with the present embodiment, compared with the known blade tip forms seen in Figures 4 to 8. Figure 10A is a detail from Figure 10 on a larger scale.

Stainless steel razor blade strip, of nominal composition 13% Cr, 0.6% C, was hardened and tempered in accordance with conventional practice, and sharpened by grinding and honing to produce edges of three facet configuration, as illustrated in Figure 1, but with included angles smaller than those conventionally manufactured. The blades were passed between rotating strops of artificial leather, whose surfaces contained fine alumina abrasive, in the manner of conventional abrasive stropping, where the angle set on the strops (which is the included angle between the tangents to the strops at their point of intersection, as shown in Figure 9) was in the range 30°—34°. The facets were provided with a metallic coating of an alloy of chromium and platinum (applied in accordance with U.S. Patent 3,829,969) with a superimposed coating of fluorocarbon material, (such as described in British Patent 906,005).

The processes of grinding, honing and stropping are well known in the art, but it will be understood that less conventional methods could be employed for sharpening the tip, e.g. deforming the strip between appropriately shaped dies or rollers, or by electrolytic or chemical dissolution shaping or by ion bombardment shaping.

The blade tip cross-sections were measured using optical interferometry. A blade is placed under the objective lens of a metallurgical microscope fitted with Michelson type interferometer and viewed at a magnification of about 1000×. The interferometer is adjusted to produce fringes which are oriented at right angles to the edge of the blade. The blade is tilted at an appropriate angle so that the fringes are displaced to reveal the topography of the blade facets. The fringe spacing is adjusted so that fringe displacements can be readily measured at various distances back from the edge. Knowing the angle of tilt, the tip shape is calculated from the sum of these fringe displacements, measured at corresponding positions on each side of the blade.

The results of these measurements are shown in Figure 10, in which the spread of profiles of the preferred blade tips over the first 40 μm are shown by solid shaded bands, and the spread of profiles of known blades is indicated by the cross-hatched bands.

In this specific example, the chord widths w at distances d from the extreme edge were as set out below:—

d (µm)	w (µm)
0.25	.20— .30
0.5	.34— .50
0.75	.53— .72
1.0	.71— .92
2.0	1.17— 1.37
4.0	1.86— 2.16
8.0	3.05— 3.52
20.0	6.12— 6.85
30.0	8.43— 9.52
40.0	10.73—12.11

The geometry of this profile was re-plotted on a graph using logarithmic scales for tip thickness as a function of distance from the edge. In the resultant plot, a straight line can be fitted to the plotted points.

From the slope and intercept of the straight line, the tip shape can be defined by the equation $w=ad^n$ in which a is a factor of proportionality not greater than 0.8 and n an exponent having a value of not more than 0.75, and more specifically within the range 0.65—0.75.

The known blades measured were found to have best fit straight lines with exponents (or gradients) within the range 0.76—1.0.

The smaller gradient is a primary characteristic of the present embodiment and results in the fact that the blade tip of the present embodiment, compared with those of the prior art, is relatively thick and strongly arched close to the extreme edge, but relatively thin over the remainder of the tip.

The included facet angles in the region 40—100 µm from the tip are in the range 9° to 11½° but making due allowance for manufacturing tolerances could be in the range 7° to 12° or even 7° to 14°.

It must be appreciated that the tip shapes described above are for stainless steel blades and could be made substantially thinner for harder blade materials such as sapphire, titanium carbide or diamond.

To produce an equivalent tip shape from a material harder than stainless steel, we reduce the corresponding chord widths in inverse proportion to the square root of the yield strength of the harder material in comparison with stainless steel. In the case of diamond, for example, the chord widths would be approximately 40% of those calculated for stainless steel.

Furthermore, the tip region of a stainless steel blade may be coated with a material harder than stainless steel and having a higher yield strength. In such a case the chord widths given by the basic equation are reduced by adopting the modified formula:

$$w \geqslant \frac{1}{\sqrt{m}} ad^n$$

in which m is the ratio of the yield strength of the coating material to that of stainless steel.

Furthermore, in order to ensure the integrity of the steel substrate, the value for w must also satisfy the equation

$$w^3 \geqslant (w-2h)a^2d^{2n},$$

where h is the thickness of the coating.

It will be understood by those skilled in the art that the blade tips may, in each case, be coated with materials such as p.t.f.e, which further enhance the cutting action. The thicknesses of such coatings are, of course ignored for the purposes of calculating the tip chord widths.

Claims

1. A razor blade having a cutting edge tip of stainless steel, the cross-sectional shape of which up to a distance of 40 µm from the extreme edge is substantially described by the equation: $w=ad^n$ in which w is the thickness in µm of the tip at a distance d in µm from the extreme edge of the blade; wherein a and n are constants, a is defined as a factor of proportionality not greater than 0.8 and n is defined as an exponent having a value in the range 0.65 to 0.75.

2. A razor blade according to claim 1, modified in that the tip at least of the blade is of a material which has a higher yield strength than stainless steel, wherein the width w obtained from the said equation is reduced in inverse proportion to the square root of the ratio of the yield strength of the harder material to that of stainless steel.

3. A razor blade according to claim 1, modified in that the cutting edge tip is coated with a material having a greater yield strength than stainless steel, wherein the cross-sectional shape of the tip is defined by the equation

$$w \geqslant \frac{1}{\sqrt{m}} ad^n$$

in which m=the ratio of the yield strength of the hard coating to that of stainless steel, and wherein w also satisfies the equation:

$$w^3 \geqslant (w-2h)a^2d^{2n},$$

in which h is the thickness in µm of the coating.

4. A razor blade according to claim 1, wherein the blade tip is formed with facets at a distance between 40 and 100 µm from the extreme edge, which facets converge towards the edge at an included angle in the range 7°—12° and preferably 9° to 11½°.

Patentansprüche

1. Rasierklinge mit einem Schneidkantenende aus Edelstahl, deren Querschnittsgestalt bis zu einer Entfernung von 40 µm von der außersten Kante im wesentlichen durch die Gleichung:

$$w=ad^n$$

beschrieben wird, wobei w die Dicke in µm des Endes in einer Entfernung d in µm vom äußersten Rand der Klinge ist, wobei a und n Konstanten sind, a als ein Proportionalitätsfaktor von nicht größer als 0,8 definiert ist und n als ein Exponent eines Wertes im Bereich zwischen 0,65 und 0,75 definiert ist.

2. Rasierklinge nach Anspruch 1, dadurch modifiziert, daß wenigstens das Schneidende der Klinge aus einem Material besteht, das eine höhere Streckfestigkeit als Edelstahl hat, wobei die Dicke w, die man aus der genannten Gleichung erhält, umgekehrt proportional zu Quadratwurzel des Verhältnisses der Streckfestigkeit des härten Materials zu derjenigen von Edelstahl vermindert ist.

3. Rasierklinge nach Anspruch 1, dadurch modifiziert, daß das Schneidkantenende mit einem Material beschichtet ist, das eine größere Streckfestigkeit als rostfreier Stahl aufweist, wobei die Querschnittsgestalt des Schneidkantenendes durch die Gleichung

$$w \geqslant \frac{1}{\sqrt{m}} ad^n$$

definiert ist, wobei m das Verhältnis der Streckfestigkeit der Hartbeschichtung zu der von Edelstahl ist und a ebenfalls die Gleichung:

$$w \geqslant (w-2h)a^2 \cdot d^{2n}$$

befriedigt, wobei h die Dicke in um der Beschichtung ist.

4. Rasierklinge nach Anspruch 1, bei der die Klingenkante mit Waten in einer Entfernung zwischen 10 und 100 µm von der äußersten Kante versehen ist, welche Waten gegen die Kante mit einem eingeschlossenen Winkel im Bereich von 7° bis 12° und vorzugsweise von 9° bis 11,5° konvergieren.

Revendications

1. Lame de rasoir présentant une pointe d'arête de coupe en acier inoxydable, dont la forme de section droite, jusqu'à une distance de 40 µm du bord extrême est sensiblement décrite par l'équation:

$$w=ad^n$$

dans laquelle w est l'épaisseur en µm de la pointe à une distance *d* en µm du bord extrême de la lame; *a* et *n* étant des constantes; a est défini comme facteur de proportionnalité non supérieur à 0.8 et *n* est défini comme exposant dont la valeur est sur la plage 0.65 à 0.75.

2. Lame de rasoir selon la revendication 1, modifiée en ce sens qu'au moins la pointe de la lame est en un matériau qui présente une limite élastique supérieure à celle de l'acier inoxydable, lame dans laquelle on réduit la largeur *w* obtenue à partir de ladite équation en proportion inverse de la racine carrée du rapport entre la limite élastique du matériau plus dur et celle de l'acier inoxydable.

3. Lame de rasoir selon la revendication 1, modifiée en ce sens que la pointe de l'arête de coupe est revêtue d'un matériau présentant une limite élastique supérieure à celle de l'acier inoxydable, lame dans laquelle la forme de section droite de la pointe est définie par l'équation:

$$w \geqslant \frac{1}{\sqrt{m}} a \cdot d^n,$$

dans laquelle *m*=le rapport de limite élastique du revêtement dur à celle de l'acier inoxydable, et lame dans laquelle *w* satisfait également l'équation:

$$w \geqslant (w-2h)a^2d^{2n},$$

dans laquelle *h* est l'épaisseur en µm du révêtement.

4. Lame de rasoir selon la revendication 1, dans laquelle la pointe de la lame présente des facettes à une distance située entre 40 et 100 µm du bord extrême, facettes qui convergent vers l'arête sous un angle inscrit dont la valeur est sur la plage 7°—12° et de préférence 9° à 11½°.

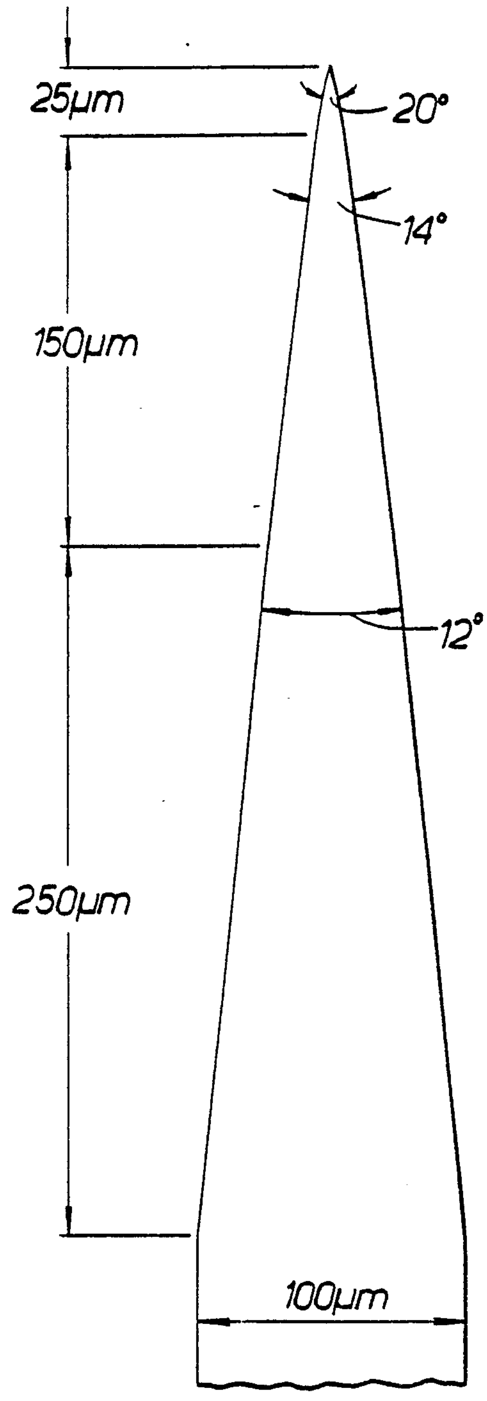

FIG. 1.

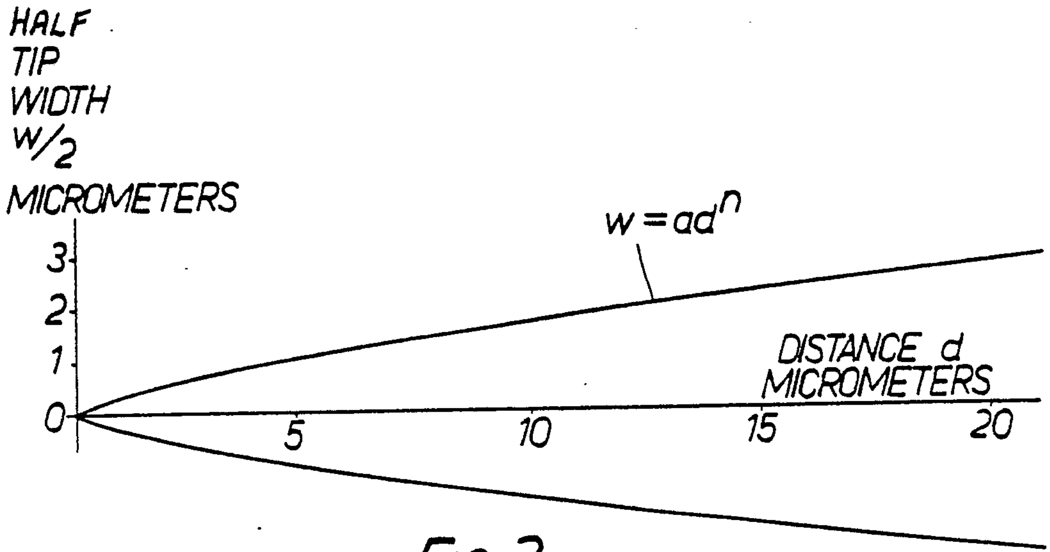
HALF
TIP
WIDTH
W/2
MICROMETERS
w = ad^n
3
2
1
0
DISTANCE d
MICROMETERS
5
10
15
20

FIG. 2.

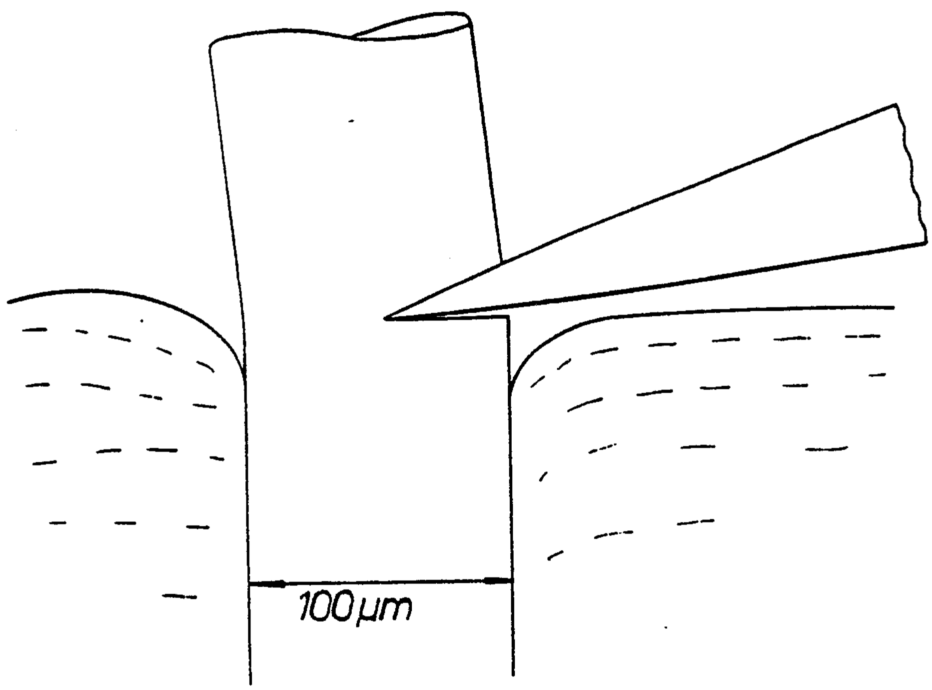
100 µm

FIG. 3.

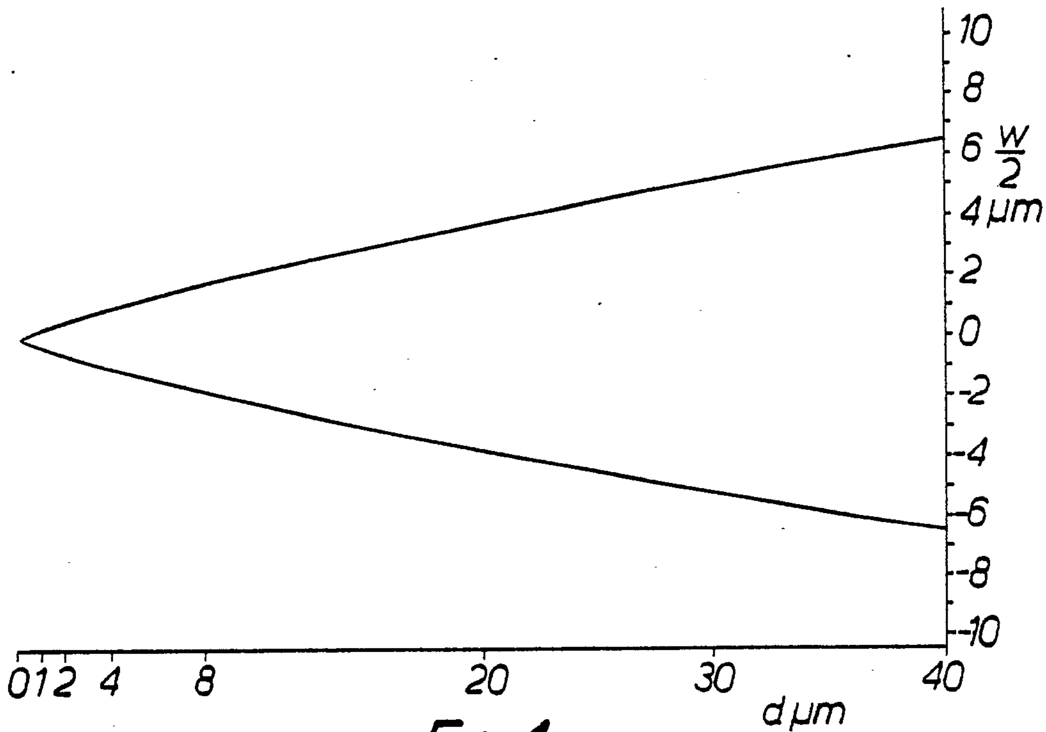
10
8
6
4
2
0
-2
-4
-6
-8
-10
W/2 µm
0 1 2 4 8 20 30 40
d µm

FIG. 4.

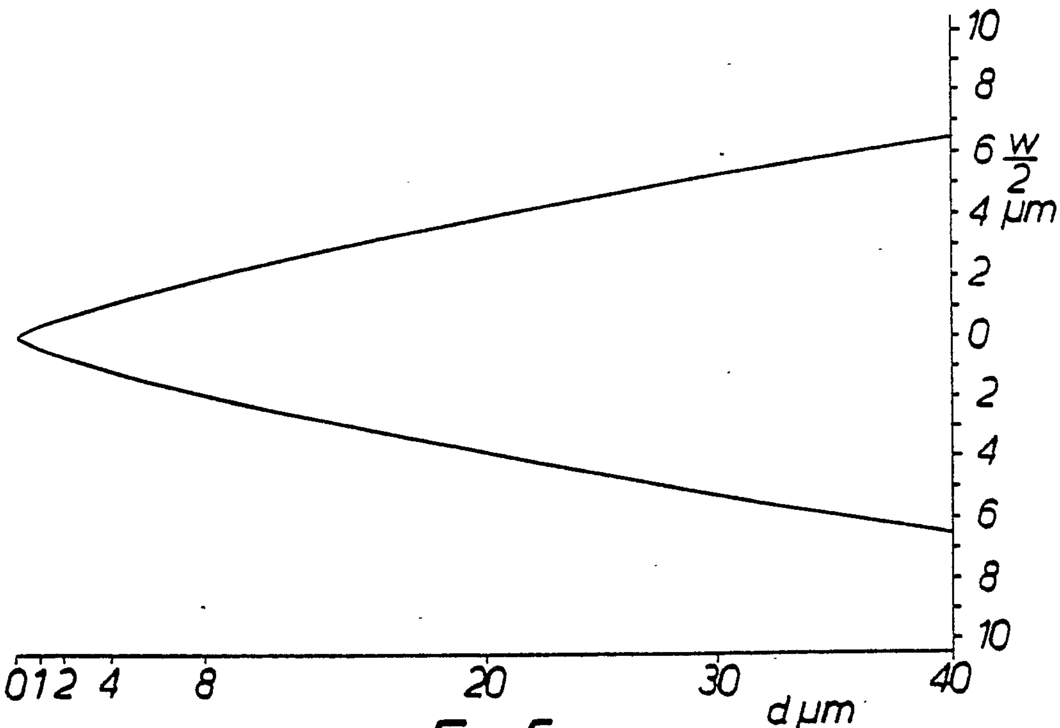
10
8
6
4
2
0
2
4
6
8
10
W/2 µm
0 1 2 4 8 20 30 40
d µm

FIG. 5.

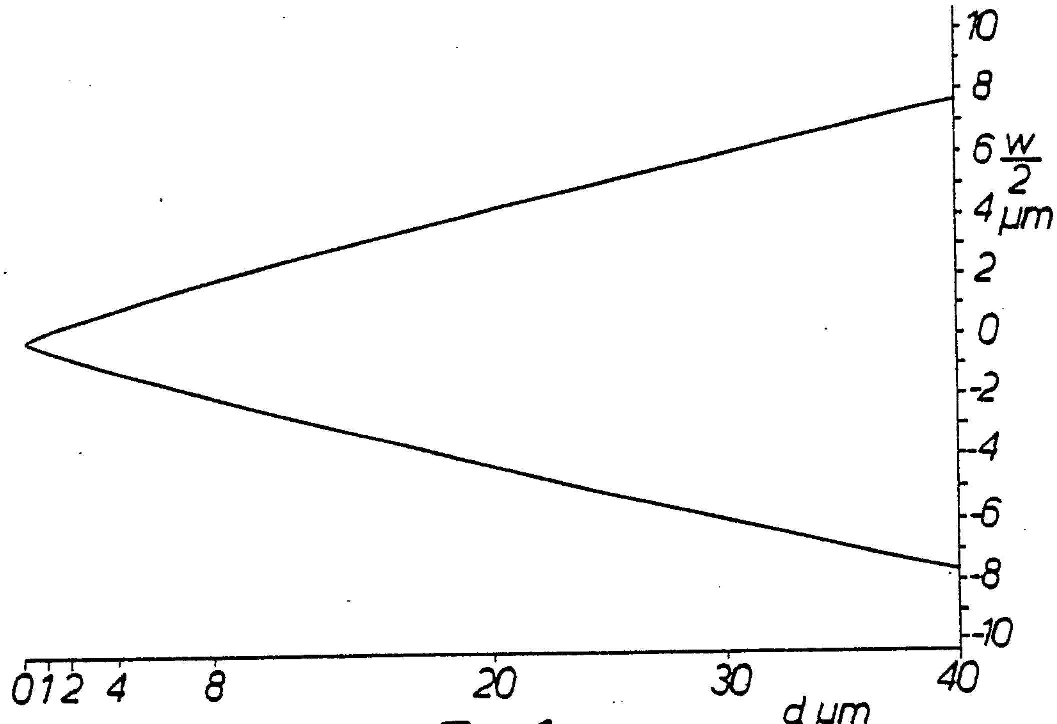
10
8
6 w/2 µm
4
2
0
-2
-4
-6
-8
-10
0 1 2 4 8 20 30 40
d µm

FIG.6.

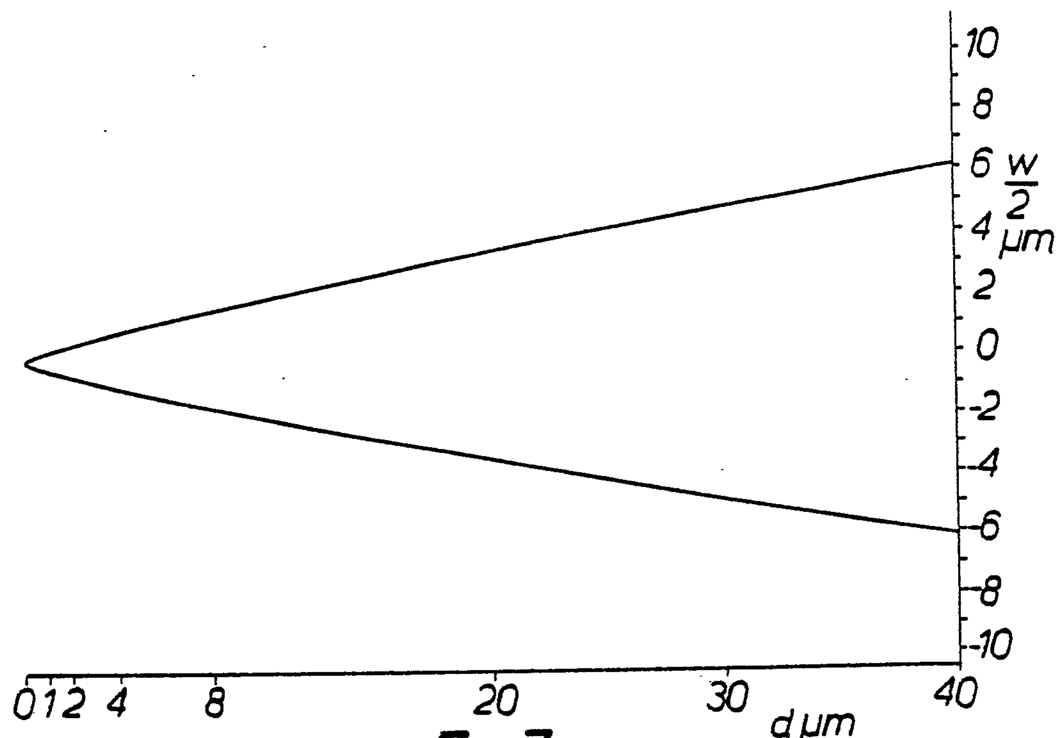
10
8
6 w/2 µm
4
2
0
-2
-4
-6
-8
-10
0 1 2 4 8 20 30 40
d µm

FIG.7.

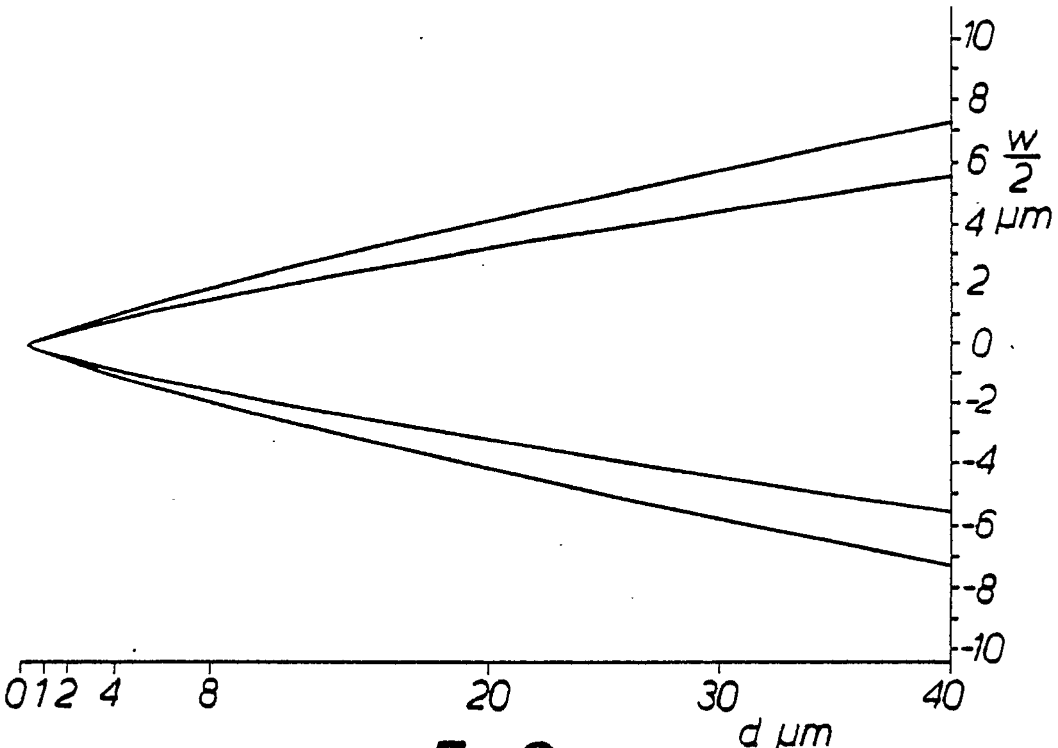

FIG. 8.

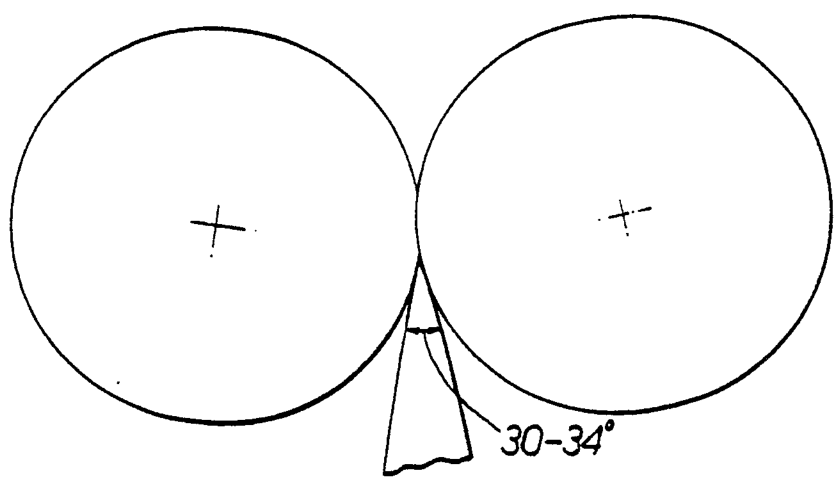

FIG. 9.

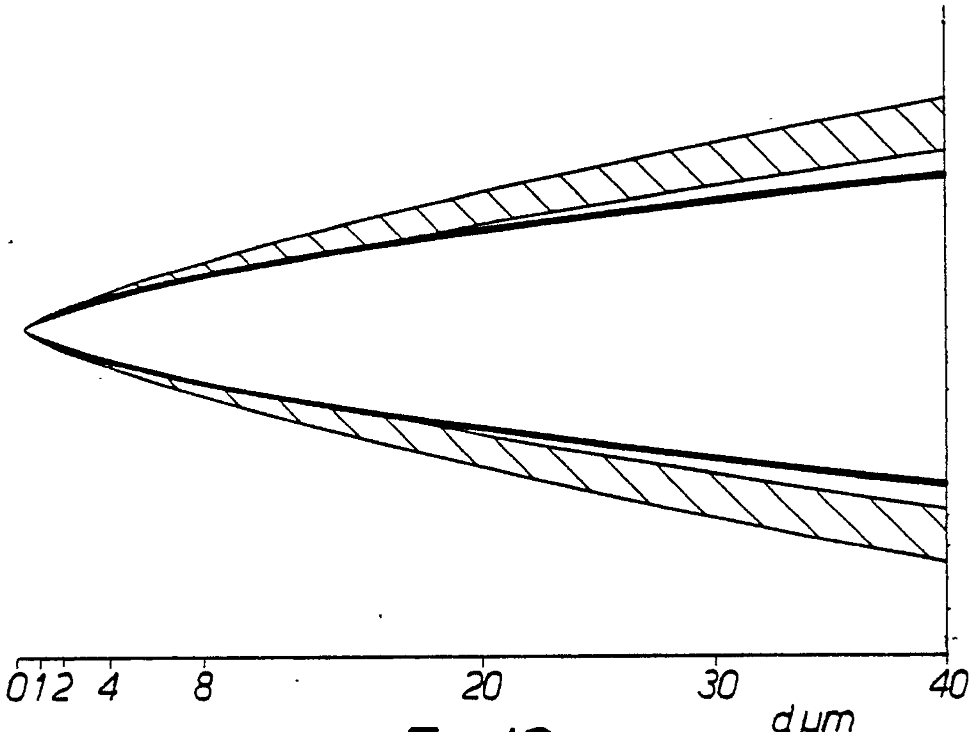

FIG. 10.

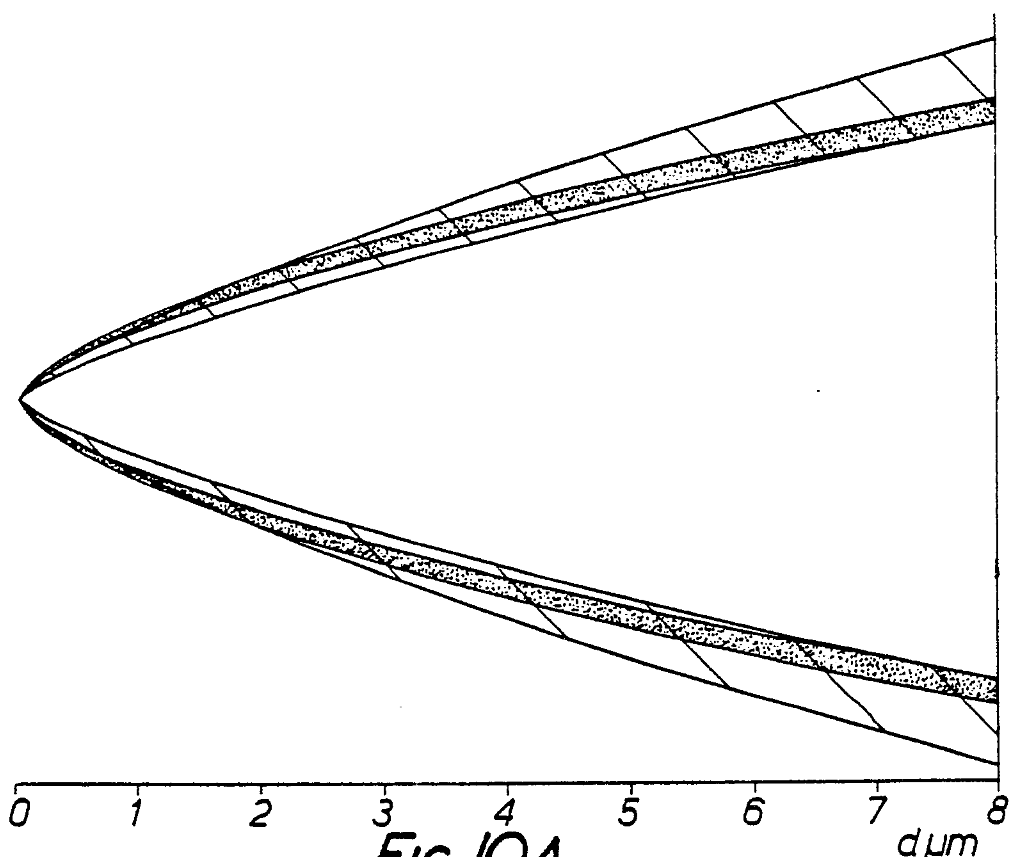

FIG. 10A.