United States Patent [19]

Atwater

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[54] **RAZOR BLADE CUTTING EDGE STRUCTURE**

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[73] Assignee: **The Gillette Company**, Boston, Mass.

[21] Appl. No.: **244,371**

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Related U.S. Application Data

[62] Division of Ser. No. 62,911, Jun. 17, 1987, Pat. No. 4,807,401.

[51] **Int. Cl.**[4] **B26B 21/54**

[52] **U.S. Cl.** **30/346.55;** 51/285

[58] **Field of Search** .... 51/74 BS, 80 R, 80 A, 51/80 B, 80 BS, 81 R, 81 BS, 82 R, 82 BS, 87 R, 87 BS, 285; 76/86, 87, DIG. 9; 30/346, 346.53, 346.54, 346.55

[56] **References Cited**

U.S. PATENT DOCUMENTS

1,734,494	11/1929	Kohlmiller	51/80 BS
1,828,663	10/1931	Jopp	51/80 A
1,941,501	1/1934	Steiner	51/80 BS
3,461,616	8/1969	Nissen et al.	51/285 X
3,494,081	2/1970	Taylor et al.	51/285
4,265,055	5/1981	Cartwright et al.	51/285 X
4,608,782	9/1986	Chylinski	51/285 X
4,723,375	2/1988	Linden	51/102

FOREIGN PATENT DOCUMENTS

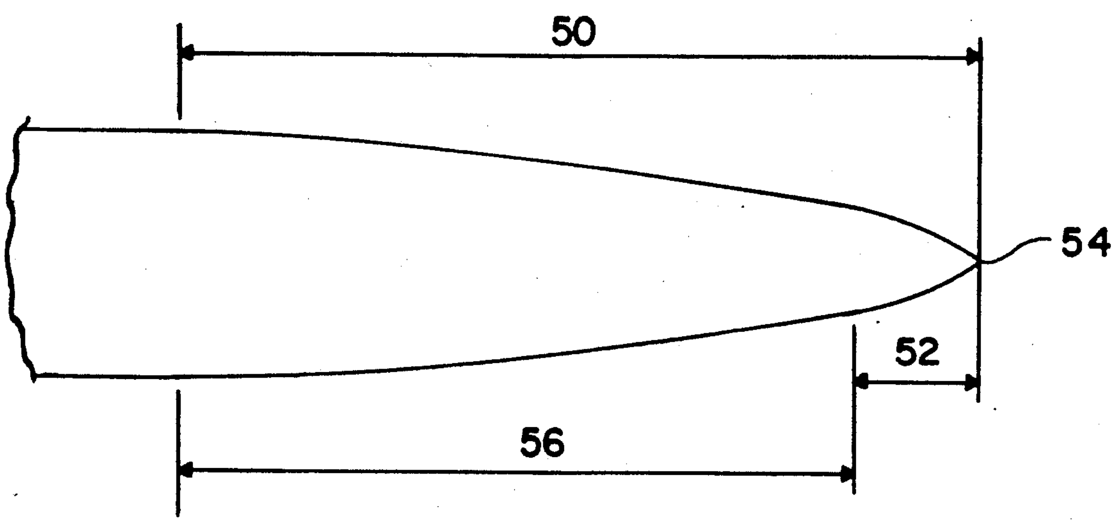
2428889	1/1975	Fed. Rep. of Germany	30/346.55
110301	10/1960	Pakistan	30/346.53

Primary Examiner—Robert P. Olszewski
Attorney, Agent, or Firm—John P. Morley

[57] **ABSTRACT**

Novel methods and apparatus for providing a facet on opposed surfaces of a cutting instrument such as a razor blade or the like. Essentially, the methods and apparatus are designed to initially abrade opposed surface portions of the instrument concurrently with a relatively high degree of coarseness at a relatively low included angle and thereafter concurrently abrading the opposed surface portions with progressively decreasing degrees of coarseness at progressively increasing included angles. The facets provided by the methods and apparatus on the opposed surfaces of the instrument have a surface in which the included angle decreases as the distance from the edge of the instrument increases.

6 Claims, 4 Drawing Sheets



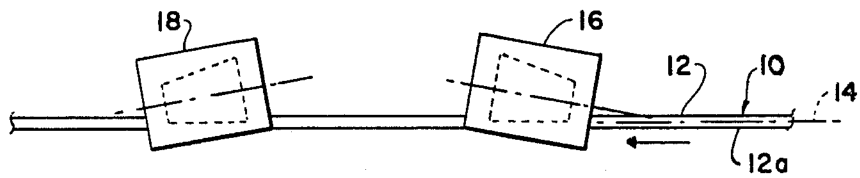


Fig. 1

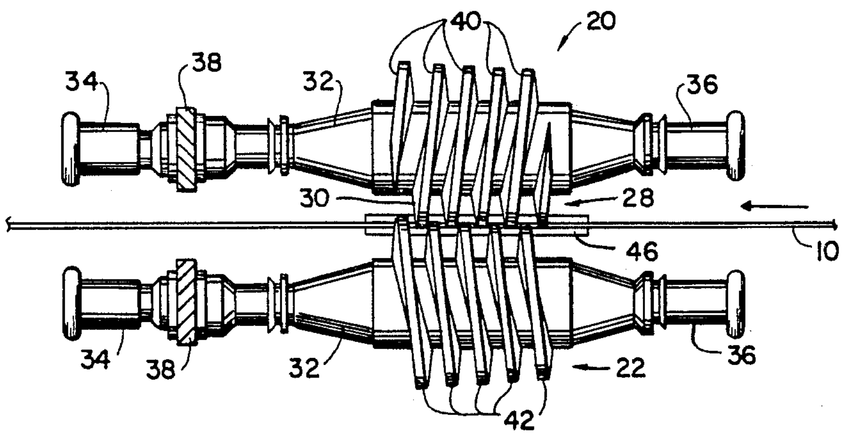


Fig. 2

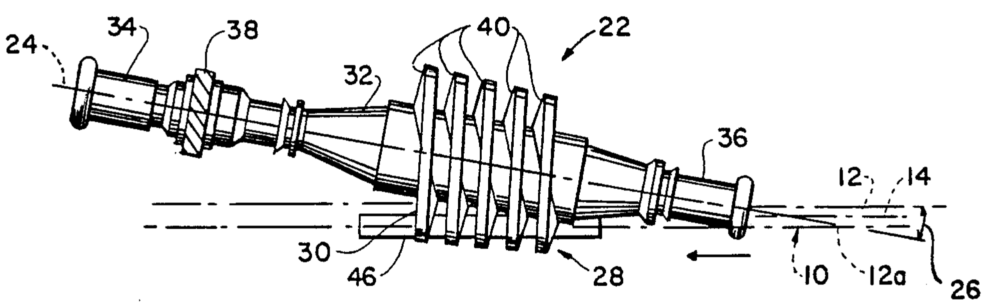


Fig. 3

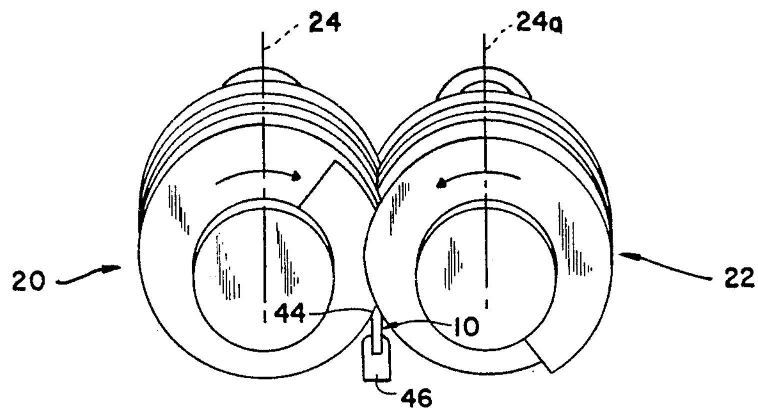


Fig. 4

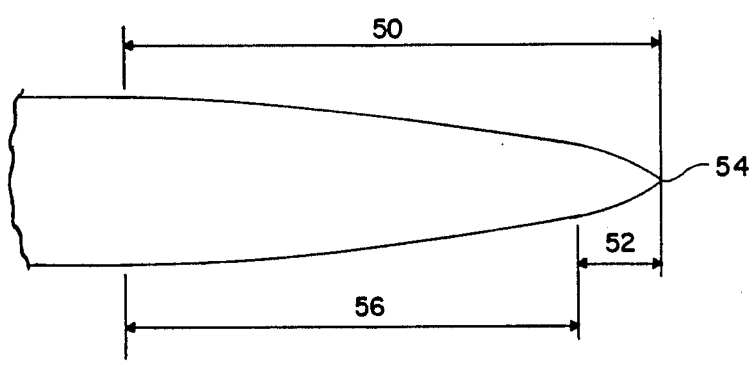


Fig. 5

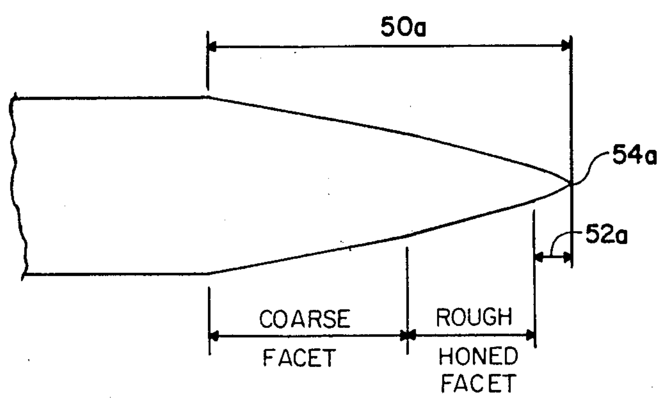


Fig. 6

PRIOR ART

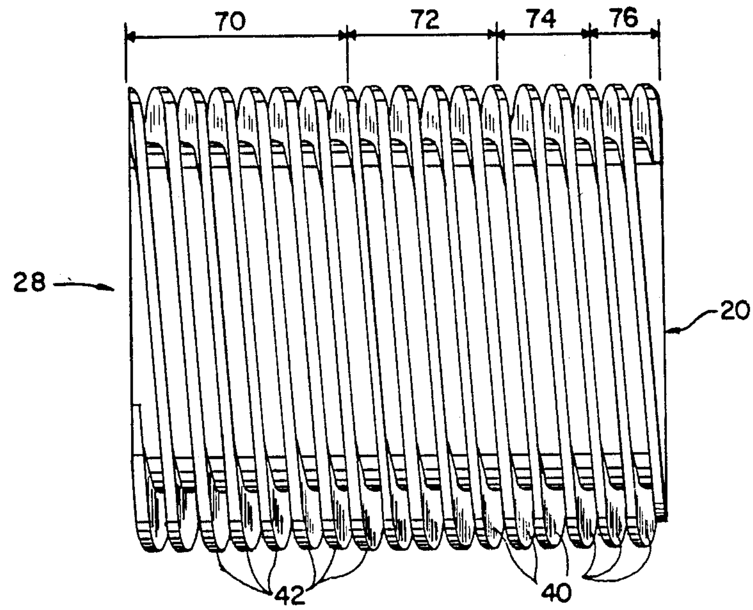


Fig. 7

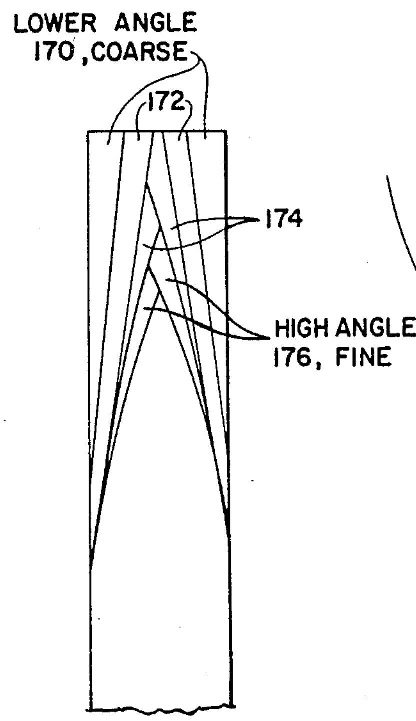


Fig. 8

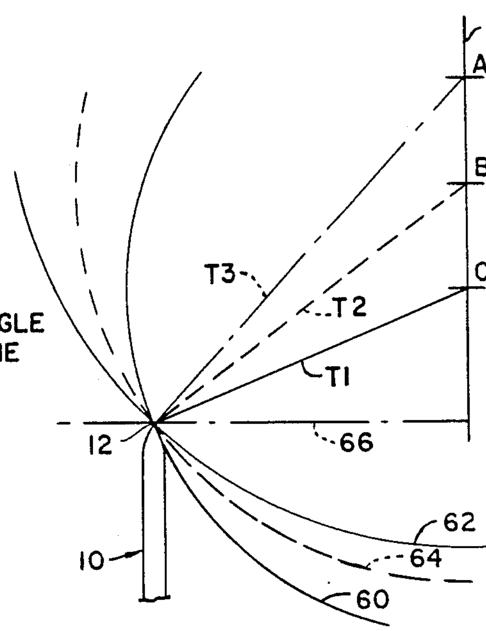


Fig. 9

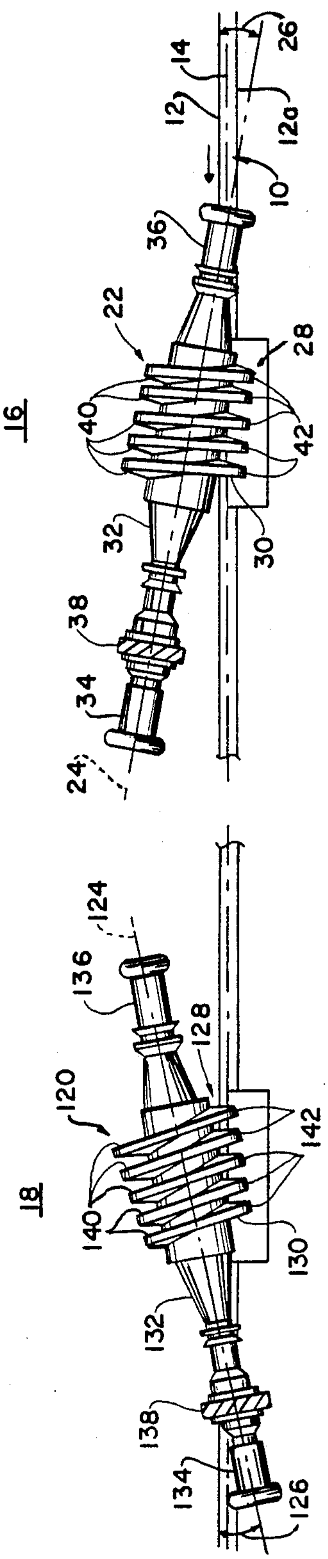

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Fig. 10

RAZOR BLADE CUTTING EDGE STRUCTURE

This application is a division of application Ser. No. 062,911, filed June 17, 1987 now U.S. Pat. No. 4,807,401.

BACKGROUND OF THE INVENTION

1. The Field of the Invention

This invention relates to novel, improved processes and apparatus for producing cutting surfaces for cutting instruments. More particularly, the present invention relates to novel, improved processes and apparatus for producing razor blades and the like.

2. Description of the Prior Art

Presently, razor blades are produced by way of continuous, high-speed mass production techniques involving a plurality of sequential abrading operations to provide the cutting surface including the cutting edge. Each abrading operation provides a facet on opposed surfaces of the cutting surface and the facet may or may not be modified by subsequent abrading operations. Normally, at least three abrading operations are required to provide the facets defining the cutting surface of the finished razor blade. The first operation is the grinding operation and involves abrading opposed surfaces of a continuous sheet of metal to provide a first or "ground" facet on opposed surfaces. Thereafter the metal sheet is subjected to a rough honing operation to provide a second facet or "rough honed facet" on the surfaces while a finish honing operation provides the cutting edge facets for opposed edge surfaces of the blade. Additional details relating to present commercial razor blade manufacturing processes and apparatus can be found in commonly owned U.S. Pat. No. 3,461,616. As disclosed there, a continuous metal strip is subjected to a grinding operation, a rough honing operation and a final honing operation which provides a convex cutting edge. U.S. Pat. No. 3,461,616 is expressly incorporated herein in its entirety by reference.

The processes and apparatus disclosed in U.S. Pat. No. 3,461,616 represent a significant advance in the high-speed, continuous manufacture of razor blades. Essentially, the disclosed processes and apparatus include the three conventional abrading operations, i.e, the grinding, rough honing and finish honing operations. In the grinding operation, one of the opposed edge surfaces of a strip of blade metal is abraded first while the other opposed surface is abraded later to provide the ground facet of the cutting surface. In both the rough and finish honing operations, the opposed surfaces are abraded substantially simultaneously since the abrading means involved includes two juxtaposed abrading wheels. The novel and distinctive feature presented in the processes and apparatus of U.S. Pat. No. 3,461,616 involves the finish honing operation. In this operation, the opposed surfaces of the blade's cutting surface providing the cutting edge is abraded with abrading means arranged and adapted to initially abrade opposed edge surfaces at a relatively high included angle and thereafter abrade the opposed edge surfaces at progressively decreasing included angles to provide curved, convex cutting edge facets on the opposed surfaces. The finish honing operation of U.S. Pat. No. 3,461,616 provides several distinct advantages in commercial razor blade manufacturing processes. The most significant advantage involves the achievement of an increase in the production rate of razor blades by about five or more times.

In the processes and apparatus of U.S. Pat. No. 3,461,616, the grinding operation has been found to be a factor having an effect on the overall efficiency of the production process. Oftentimes, the grinding operation leaves a residual wire or burr at the edge of the ground surface and removal of the wire increases wear of the abrading surfaces in the entry region of the abrading means providing the rough honed facet. Additionally, automatic monitoring and adjusting means are normally arranged between the grinding and rough honing stations to detect irregularities in the ground facets and to signal appropriate adjustments to the grind station to compensate for detected irregularities. The monitoring and adjustment means are expensive, highly sophisticated and can have a limiting effect on the production rate. Accordingly, although the processes and apparatus of U.S. Pat. No. 3,461,616 are highly efficient and cost effective, there still remains a need in the art for processes and apparatus providing maximized efficiency and cost effectiveness in the mass volume production of razor blades having high quality performance characteristics. The present invention is addressed to that need and provides an extremely effective response to it.

BRIEF SUMMARY OF THE INVENTION

This invention presents to the art novel, improved processes and apparatus for producing cutting surfaces for cutting instruments which are especially adaptable to razor blade manufacture. Essentially, the novel processes and apparatus are designed to abrade a portion of opposed surfaces selected to carry the cutting surface to provide rough honed facets on the surfaces. The abrading operation involves abrading means having the capability for initially concurrently abrading the surfaces with a relatively high degree of coarseness at a relatively low included angle and thereafter abrading the surfaces concurrently with progressively decreasing degrees of coarseness at progressively increasing included angles. In this way, the surfaces of the metal strip are initially subjected to a grinding operation but, as abrading continues across the axial length of the metal strip, the surfaces are subjected to a rough honing operation to provide rough honed facets on the finished abraded surfaces. The cutting edge facets can be provided on the opposed edge surfaces by known finish honing operations. Accordingly, razor blades of the present invention have a cutting surface defined by rough honed and finished honed facets on opposed surfaces of the blade.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic side view of apparatus of the present invention used in manufacturing razor blades;

FIG. 2 is a diagrammatic top view of two abrading wheels employed in the preferred practice of the invention;

FIG. 3 is a diagrammatic side view of the two abrading wheels of FIG. 2;

FIG. 4 is a diagrammatic right end view of the two abrading wheels of FIG. 2;

FIG. 5 is an enlarged diagram of the configuration of a cutting surface of a razor blade produced in accordance with the practice of the invention;

FIG. 6 is an enlarged diagram of the configuration of a cutting surface of a razor blade produced in accordance with the practice of the invention of U.S. Pat. No. 3,461,616.

FIG. 7 is a diagrammatic illustrative top view of the abrading wheels of FIGS. 2-4 showing variations in the degree of abrasiveness provided by the wheels;

FIG. 8 is a diagrammatic illustration of the abrading action performed on a cross-section of a razor blade strip material by the abrading wheels of FIG. 4;

FIG. 9 is a geometric diagram illustrating the contour and mounting of the wheels of FIG. 2; and

FIG. 10 is a more detailed side view of an illustrative arrangement of apparatus of the invention used in the manufacture of razor blades.

DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 illustrates an arrangement of apparatus suitable for providing a cutting surface on one edge of a razor blade in accordance with the practice of the invention. A razor blade stock in the form of a thin metal strip **10** of uniform width having top edge **12** and bottom edge **12***a* is arranged to be driven along a path defining a plane **14** for moving opposed surfaces of edge **12** into abrading relationship with abrading stations **16** and **18**. Abrading station **16** includes two abrading wheels **20** and **22** (FIGS. 2-4). Each wheel **20** and **22** is rotatable about spaced, coplaner (preferably parallel) axes **24** and **24***a* (FIG. 4) which define a plane. Axes **24** and **24***a* are arranged to form an angle **26** (tilt angle) between the plane of axes **24** and **24***a* and the path of top edge **12** (i.e., plane **14**). Abrading wheels **20** and **22** are preferably arranged in juxtaposed interengagement and have the capability to concurrently abrade opposed surfaces of strip **10** near edge **12** with a relatively high degree of coarseness and at a relatively low included angle at their entry or leading ends **28** (FIG. 2). Thereafter, as strip **10** is moved from entry ends **28** toward exit or trailing ends **30** of wheels **20** and **22**, the wheels concurrently abrade the surface portions with progressively decreasing degrees of coarseness and at progressively increasing included angles. The abrading of the opposed surfaces in station **16** provides a rough honed facet **56** on opposed surfaces of cutting surface **50** (FIG. 5) in which the included angle of the facet surface progressively decreases as the distance from the edge **54** increases.

After exiting station **16**, strip **10** is moved to abrading station **18** where cutting edge facets **52** (FIG. 5) are provided for opposed surfaces of cutting surface **50** (FIG. 5). Cutting edge facets **52** may be provided with apparatus of known design such as by two juxtaposed abrading wheels rotatably mounted and arranged to abrade opposed surfaces of edge **12**. Preferably, cutting edge facets **52** are provided in accordance with the processes and apparatus disclosed in referenced U.S. Pat. No. 3,461,616 mentioned before. The finished blade consists of two facets on each opposed surface of cutting surface **50**. These facets are shown in FIG. **5** as rough honed facets **56** and cutting edge facets **52**. Representative dimensions of opposed surfaces of cutting surface **50** of razor blades produced in accordance with the practice of the present invention are between about 0.010 to about 0.025 inch. Representative dimensions of cutting edge facets **52** are between about 0.0006 to about 0.008 inch while representative dimensions of rough honed facets **56** are between about 0.002 to about 0.0244 inch.

Referring now to FIGS. 2-4, abrading wheels **20** and **22** are of modified frustoconical configuration mounted for rotation about spaced parallel axes **24** and **24***a* to provide a tilt angle **26** between the plane of axes **24** and **24***a* and path of edge **12**. Each wheel is mounted on a spindle **32** including bearing mounts **34** and **36** with a drive gear **38** positioned on each spindle between the bearing mounts and the wheels. Spindles **32** are mounted in suitable bearing blocks (not shown) for rotation. The circumferential surface of each wheel has spiral helixes formed on it to define a plurality of lands **40** providing or carrying an abrasive surface **42**. Abrasive surface **42** may be any of the known grades of abrasive materials such as carbides, nitrides, alumina or diamond among others suitable for abrading razor blade metals. Preferably, the wheels are interengaged to form a nip **44** (FIG. 4) through which strip **10** passes while supported by holder **46** as best shown in FIG. 4. The diameter of each wheel changes along its length so that each wheel is effectively tapered and accordingly, the angle between abrading surfaces **42** at nip **44** changes along the axial length of interengaged wheels **20** and **22**. The diameters of wheels **20** and **22** are at the minimum at entry ends **28** and thereafter, the wheel diameters progressively increase toward exit ends **30** so that the included angle of abrading at entry ends **28** is relatively low but progressively increases along the wheel lengths to exit ends **30**. Representative illustrative relatively low included angles of abrading are between about 10° to about 17° and these low included angles progressively increase to included angles of abrading between about 14.5° to about 21.5°. Representative illustrative diameters for wheels **20** and **22** at entry ends **28** are between about 4.5 to about 6.5 inches and representative illustrative diameters for the wheels at exit ends **30** are between about 4.6 to about 6.6 inches.

As shown in FIG. 7, each wheel is divided into sections **70**, **72**, **74** and **76** providing different degrees of coarseness for abrading surfaces **42** in each section. The degree of coarseness of abrading surfaces **42** in section **70** is relatively high while the degree of coarseness of surfaces **42** in sections **72**, **74** and **76** progressively decreases. In this way, the opposed surface portions of strip **10** encounter a high degree of coarseness at entry ends **28** which abrades the surfaces to provide transient ground facets on the surfaces which are progressively modified over the length of the wheels to provide rough honed facets on the opposed surface portions emerging from exit ends **30**.

The abrading action of wheels **20** and **22** will be better appreciated by reference to FIG. 8 which diagramatically illustrates the abrading action performed by sections **70**, **72**, **74** and **76** (FIG. 7) on a cross-section of strip **10**. As can be seen, section **70** which provides a relatively high degree of coarseness in combination with a relatively low included angle of abrading removes segments **170** to provide ground facets. However, sections **72**, **74** and **76** provide progressively decreasing degrees of coarseness and progressively increasing included angles of abrading to remove segments **172**, **174** and **176** respectively and provide rough honed facets on the opposed edge surfaces. Accordingly, the abrading action of wheels **20** and **22** effectively combines the abrading of the ground and rough honed facets into a single operation. The appearance of the resulting rough honed facets depends upon the differentials existing between the included angles of abrading provided by each of sections 70–76 and/or upon the differentials between the degree of coarseness provided by each section. When viewed with the eyes, the resulting rough honed facets produced on opposed surfaces of cutting surface **50** appear to be facets having a continuous surface. Under magnification, some of the rough honed facets provided in the practice of the invention appear to comprise a plurality of individual adjacent facets of narrow width. However, in the preferred practice of the invention, the widths of any individual adjacent facets are so narrow they are not easily detected under magnification and the rough honed facets are seen as substantially continuous surfaces. In any event, the resulting rough honed facet presents a convex surface in which the included angle of the surface progressively decreases as the distance from edge **54** (FIG. **5**) increases. In the preferred practice of the invention, the resulting rough honed facets have a convex surface as shown in FIG. **5** in which the included angle progressively decreases in a substantially continuous fashion as the distance from edge **54** increases.

The differences between razor blades produced in accordance with the practice of the present invention and blades produced by known production techniques will be better appreciated by reference to FIGS. **5** and **6**. FIG. **6** diagrammatically illustrates the configuration of a cutting surface **50*a*** of a razor blade produced in accordance with the invention of U.S. Pat. No. 3,461,616. As can be seen in FIG. **6**, cutting surface **50*a*** includes cutting edge facets **52*a*** on opposed surfaces of cutting surface **50*a***. Cutting edge facets **52*a*** are convex surfaces in which the included angle of the convex surfaces progressively decreases as the distance from edge **54*a*** increases. Cutting surface **50*a*** also includes distinct rough honed and coarse facets on opposed surfaces. The included angles of these facets are essentially straight and are lower for each facet as the distance from edge **54*a*** increases. Accordingly, cutting surface **50*a*** has three visually distinct facets provided by the grinding, rough honing and finish honing operations. In contrast, cutting surface **50** of FIG. **5** includes only two facets on opposed surfaces, rough honed facets **56** and cutting edge facets **52** and both facets have convex surfaces so that the included angle of the facet surfaces progressively decreases as the distance from edge **54** increases. The opposed convex surfaces provide a cutting surface having a relatively thin cutting edge coupled with improved cross-sectional strength for the cutting surface thereby providing improved performance characteristics in terms of shaveability and durability.

As mentioned, the plane of axes **24** and **24*a*** and path of edge **12** are arranged to provide a tilt angle **26**. As shown in FIGS. **3** and **4**, tilt angle **26** is reversed from the tilt angle of the wheels shown in FIGS. **3** and **4** of U.S. Pat. No. 3,461,616. The combination of the reverse tilt angle and the design features of the abrading means of the present invention cooperate to provide an extremely efficient and rapid removal of metal in the manner shown in FIG. **8**. As shown in FIG. **8**, the abrading action achieved by the cooperation between the tilt angle and the abrading means removes metal from the opposed surfaces of strip **10** at progressively higher included angles with successive cuts. In this way, progressively decreasing amounts of metal are removed from the opposed surfaces as the surfaces are moved toward exit ends **30** of wheels **20** and **22**. Accordingly, sections **70** and **72** having the higher degrees of coarseness are arranged to achieve maximized effectiveness in performing the function they are designed to perform, and remove the greater amount of metal. Sections **74** and **76** having the lesser or finer degree of coarseness remove lesser amounts of metal, and the finer abrading action in these sections is directed progressively toward the edge. The abrading action achieved through the cooperation between the tilt angle and the design features of the abrading means permits strip **10** to be moved through wheels **20** and **22** at higher speeds. Reverse tilt angle **26** can be varied over a wide range depending upon various factors including the length or diameter of the wheels or the orientation of the axes of the wheels or variations in abrading angles or in the degree of coarseness desired in the sections of the abrading wheels. Illustrative suitable reverse tilt angles **26** include angles between about 0.3° to about 10° and preferably between about 0.5° to about 5°.

FIG. **9** illustrates the geometry of the tilt angle **26** of one of the abrading wheels **20** or **22** relative to the path of edge **12** of blade **10**. As shown, the smaller or entry circumference of the wheel at entry end **28** is indicated by arc or ellipse **60** while the larger or exit circumference at exit end **30** is indicated by arc or ellipse **62**. An intermediate circumference is indicated as arc or ellipse **64**. The path of the blade edge **12** (and plane **14**) are perpendicular to line **66** and to the paper. Axis **24** (or **24*a***) of the wheel is indicated by line **68** and the position of axis **24** in the longitudinal direction at entry end **28** of the wheel is indicated at point C while the position of axis **24** (or **24*a***) at exit end **30** is indicated at point A. Additional details of the especially preferred embodiments of the invention are described in the following illustrative nonlimiting Example.

EXAMPLE 1

The arrangement of the especially preferred apparatus used in this Example is described in connection with FIGS. **1**, **2**, **3**, **7** and **10**. As shown, abrading station **16** includes two juxtaposed, interconnecting helical wheels including helical wheel **20** arranged in interconnection with another helical wheel (**22**) as shown in FIGS. **2**, **3** and **10**. Multiple helix wheels such as double, triple, quadruple, etc. helix wheels are preferred since they provide completely balanced metal removal without burrs or wire and also provide balanced wheel wear. Additionally, multiple helix wheels provide a tighter nip action with larger normal forces on the abrasive particles resulting in increased metal removal and higher blade speeds. Moreover, the tighter nip can reduce the effects of wheel wear. Each wheel (**20** and **22**) was between about 6.5 to about 7.5 inches long and had an entry diameter of between about 6.0 to about 4.75 inches, an exit diameter of between about 6.05 to about 5.80 inches and a total taper (hyperbolic) of between about 0.02 to about 0.05 inches or between about 0.01 to about 0.025 inches per side. Axes **24** and **24'** of each wheel were arranged in a common plane to provide a tilt angle **26** of between about 0.75° to about 1.25° relative to the path of edge **12**. The tilt angle provided an entry abrading angle of between about 5.5° to about 8° at entry end **28** and an exit abrading angle of between about 8.0° to about 10.0° at exit end **30** for each wheel.

Each wheel **20** and **22** was divided into four sections as shown in FIG. 7. The preferred abrasive materials for use with wheels **20** and **22** are resin or vitrified bonded cubic boron nitride. Preferably, section **70**, (FIG. 7) adjacent entry end **28**, includes between about 6 to about 8 lands **40** and each land **40** carried an abrasive surface **42** which included resin bonded abrasive material having an average particle size of between about 50 to about 70 microns to thereby provide a relatively high degree of coarseness for section **70**. Preferably, section **72** includes between about 5 to about 6 lands **40** carrying abrasive surfaces **42** with each surface including resin bonded abrasive material having an average particle size of between about 20 to about 40 microns. Section **74** preferably includes about 3 to about 4 lands **40**. Resin bonded abrasive material of each abrasive surface **42** in section **74** had an average particle diameter of between about 10 to about 20 microns. Section **76** preferably includes between about 0.5 to about 2 lands and each abrasive surface **42** of section **76** included resin bonded abrasive having an average particle size of between about 5 to about 7 microns. The preferred width of abrasive surfaces **42** is between about 0.1 to about 0.2 inch.

The surface configuration of each of the above-described wheels were modified (or dressed) substantially in accordance with the methods disclosed and claimed in commonly owned U.S. Pat. No. 3,566,854 to provide a substantially straight line of intersection between the two wheels. U.S. Pat. No. 3,566,854 is also incorporated herein in its entirety by reference. The two wheels were mounted in bearing blocks at abrading station **16** so that their axes were parallel and inclined to provide a reverse tilt angle **26** of about 1° relative to plane **14**. A grease was applied to the wheels and the wheels were gently fed into blade edge **12** to determine the precise abrading head setting. The setting of spindles **32** were then adjusted to obtain uniform blade edge contact over the entire length of the wheels.

In the preferred embodiment of the invention, abrading station **18** includes the finish honing abrading means of U.S. Pat. No. 3,461,616. A representative preferred finish honing abrading means includes two juxtaposed, interconnecting helical wheels including wheel **120** arranged with the other juxtaposed interconnecting wheel in the manner described and shown in U.S. Pat. No. 3,461,616. Each wheel was between about 2.5 to about 3.5 inch long and included between about 5 to about 7 lands **140** and each land **140** carried an abrading surface **142** which includes a resin bonded, hard, metallic oxide abrasive having an average particle size of between about 7 to about 9 microns. The entry diameter of each wheel was between about 6.0 to about 5.5 inches, the exit diameter was between about 5.9 to about 5.4 inches and the total taper (hyperbolic) of each wheel was between about 0.02 to about 0.11 inches or between about 0.045 to about 0.055 inches per side. Axes **124** of wheels **120** and the juxtaposed interconnecting helical wheel **122** (not shown) were arranged to provide a tilt angle **126** of between about 4.5° to about 5.5° relative to the path of edge **12**. This tilt angle provided an included entry abrading angle for each wheel of between about 26° to about 32° at entry ends **128** and an included exit abrading angle of between about 16° to about 20° at exit end **130** for each wheel.

Each wheel was mounted on a spindle **132** including bearing mounts **134**, **136** with a drive gear **138** arranged on each spindle between the bearing mounts and the wheels. Spindles **132** were mounted in suitable bearing blocks (not shown) for rotation. The diameter of each wheel changed along its length so that each wheel was effectively tapered. Accordingly, the abrading angle between abrading surfaces **142** at the nip formed between the interconnecting wheels changed along the length of wheel **120** and the juxtaposed interconnecting wheel **122**. As mentioned, the abrading angle at entry ends **128** of the wheels was higher than the abrading angle at exit ends **130**. In this way, edge **12** was abraded initially at a relatively high included angle of abrading and the included angle of abrading progressively decreases as edge **12** is moved toward exit ends **130** of the wheels. As disclosed in U.S. Pat. No. 3,461,616, the abrading action achieved in abrading station **18** provides finished honed or edge facets **52** (FIG. **5**) at opposed edge surfaces of cutting surface **50**. Edge facets **52** have a convex surface in which the included angle of the facet surfaces progressively and substantially continuously decreases as the distance from edge **54** increases.

In representative on-line, high volume razor blade test production runs including abrading stations **16** and **18** described above, a blade strip was fed through the stations at a speed of about 160 feet per minute. Wheels **20** and **22** were rotated in opposite directions at speeds of about 4500 rpm and wheels **120** and **122** were rotated in opposite directions at speeds of about 3600 rpm to contact the blade edge **12** from opposite sides in a downward direction. Representative average production rates were about 76,800 blades per hour. Moreover, blades of consistently uniform high quality were continuously produced at the high production rates over extended periods of time without interruption of the run for equipment maintenance or adjustments such as retruing of the wheels. The average continuous time of operation for a series of test runs was about 8 hours but some test runs were run continuously without interruption for 8 hours or more without effect on the high quality of the blades. Based on the test runs, the invention presents to the art relatively simple but extremely efficient, highly cost effective processes and apparatus for the high speed, mass volume production of razor blades having an excellent combination of performance characteristics.

The above description of the invention has been directed to an embodiment providing a cutting surface **50** including rough honed facets **56** and cutting edge facets **52** on opposed surfaces of top edge **12** of strip **10**. However, the invention can also provide a similar cutting surface on bottom edge **12*a*** to provide double edge razor blades. In on-line test production runs for producing double edge razor blades in accordance with the invention, two juxtaposed, inter-connecting wheels substantially identical to wheels **20** and **22** of station **16** (FIGS. **2**, **3** and **10**) were arranged in abrading relationship with bottom edge **12*a*** in substantially the same manner as described before for the arrangement of wheels **20** and **22** with top edge **12**. However, the plane of the axes of the wheels arranged for abrading edge **12*a*** was reversed. In other words, edge **12*a*** was subjected to substantially the same abrading action applied to edge **12** by wheels **20** and **22**. However, the plane of the axes of the wheels for abrading edge **12*a*** was inclined upwardly toward the path of edge **12*a*** (i.e., plane **14**) to provide the same tilt angle achieved by declining the plane of axes **24** and **24*a*** of wheels **20** and **22** toward the path of edge **12** as shown in FIGS. **3** and **10**. In on-line test production runs, two juxtaposed inter-connecting wheels substantially identical to wheels **120** and **122** (FIG. **10**) were positioned after station **18** to provide edge facets **52** on surface **12*a***. The wheels were arranged in substantially the same abrading relationship with edge **12a** as described for wheels **120** and **122**. However, the plane of the axes of the wheels abrading surface **12a** was inclined downwardly away from the plane of path of edge **12a** to provide the same tilt angle achieved by inclining the plane of axes **124** upwardly away from the path of edge **12** as shown in FIG. **10**. Average production rates of double edge razors in on-line test production runs were about 36,000 blades per hour.

From the above description it should be apparent that the processes and apparatus of the invention provide distinctive and unexpected advantages. The combination of the reverse tilt angle with the capability of the abrading means to abrade the edge of a blade stock concurrently with progressively decreasing degrees of coarseness at progressively increasing included angles of abrading effectively combines the grind and rough honed facet operations into a single operation. The use of the helical wheels provides completely balanced metal removal and balanced wheel wear. Moreover, the helical wheels provide a tighter nip which contributes to more rapid removal of metal and high blade speeds and the tighter nip reduces the effects of wheel wear. These features cooperate with the reverse tilt angle and the abrading capability to provide an abrading action which is extremely reliable and efficient and eliminates the need for the automatic control means presently used to monitor and control the grind and rough honed facet operations. Additionally, the abrading action achieved in the present invention is designed so that the coarser abrading action removes the major portion of the metal in a direction into the strip edge while the finer abrading action removes the lesser portion of the metal and is also directed into the edge. This abrading action provides an extremely efficient removal of metal at increased high speeds. Accordingly, the processes and apparatus of the present invention provide unexpected advantages over

processes and apparatus known to the art at the time the present invention was made.

I claim:

1. A razor blade comprising a cutting surface defined by opposed surfaces terminating at an edge, each opposed surface carrying a cutting edge facet portion and a convex, rough honed facet portion in which the included angle of the rough honed facet portion progressively decreases in the direction from the edge, said rough honed facet portion extending in the direction from the edge for a distance between about 0.010 to about 0.025 inches with the cutting edge facet portion extending in the direction from the edge to the rough honed facet portion for a distance between about 0.0006 to about 0.008 inches.

2. A razor blade of claim **1** where the included angle of the rough honed facet portion progressively decreases in a substantially continuous fashion.

3. A razor blade of claim **2** where the cutting edge facet portion is convex and the included angle of the cutting edge facet portion progressively decreases in the direction from the edge in a substantially continuous fashion.

4. A razor blade of claim **1** where the cutting edge facet portion is convex and the included angle of the cutting edge facet portion progressively decreases in the direction from the edge.

5. A razor blade stock comprising a thin metal strip having a cutting surface defined by opposed surfaces terminating at an edge, each opposed surface carrying a convex rough honed facet extending in the direction from the edge for a distance between about 0.010 to about 0.025 inches and where the included angle of each surface progressively decreases in the direction from the edge.

6. A razor blade stock of claim **5** where the included angle of each surface progressively decreases in a substantially continuous fashion.

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