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Lane

[11] **3,784,458**

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[54] **METHOD OF COATING A CONTINUOUS STRIP OF RIBBON RAZOR BLADE MATERIAL**

[75] Inventor: **George C. Lane,** Danbury, Conn.

[73] Assignee: **Warner-Lambert Company,** Morris Plains, N.J.

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[52] **U.S. Cl.** **204/192**

[51] **Int. Cl.** **C23c 15/00**

[58] **Field of Search** 204/192, 298; 118/49

[56] **References Cited**

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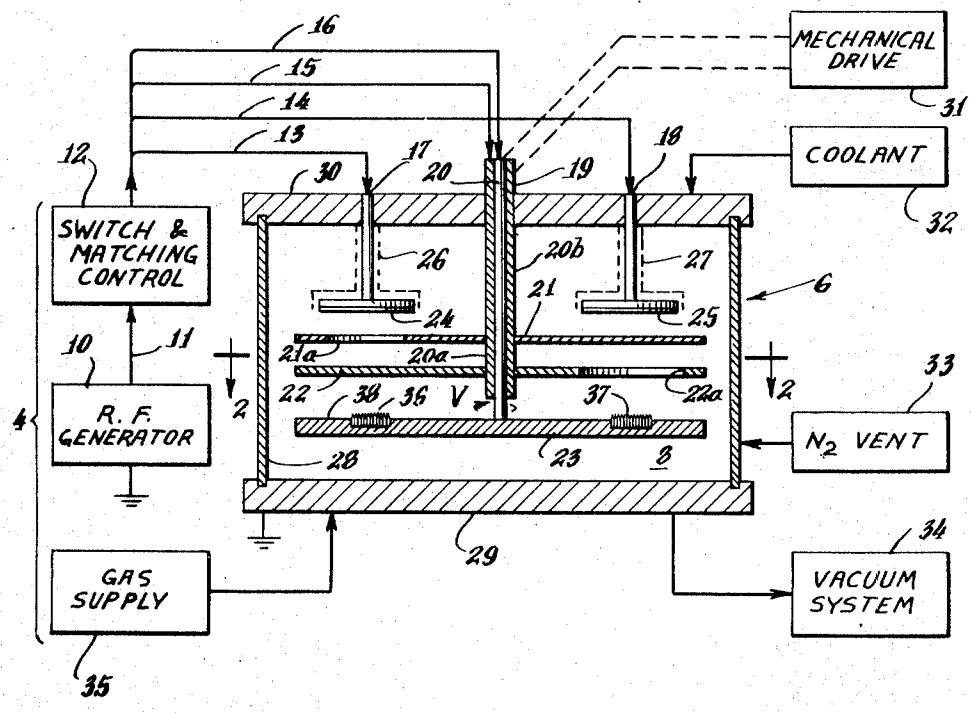
Primary Examiner—John H. Mack
Assistant Examiner—Wayne A. Langel
Attorney—James F. Powers, Jr. and Albert H. Graddis

[57] **ABSTRACT**

A method and apparatus for placing extremely thin finish coatings on previously sharpened coils of band or ribbon type razor blade material prior to cutting such strips into shorter lengths for eventual inclusion in magazine fed ribbon blade safety razors. The method includes winding a relatively great length of ribbon blade into a helix or coil with an open center, fitting the coil within a special fixture, and placing the coil and fixture within an evacuable chamber wherein one or more coating materials are sputtered onto the blade edge in extremely thin layers under carefully controlled conditions. The chamber, in addition to conventional vacuum system components, includes at least one, and sometimes plural electrodes, each adapted to receive thereover a target plate containing a coating of the material to be sputtered therefrom and onto the blade edge. A shutter arrangement is provided to shield the blade edge against contamination during the time the target is being cleaned in vacuo prior to coating, and to protect the target from contamination when the blade edge is being sputter etched in order to clean it before coating. Means are provided for indexing the shutter to desired positions for these operations and for rotating the fixture so as to cause portions of the blade coil to be passed successively adjacent the target in facing relation thereto when the shutter is indexed so as to provide a generally perpendicular line of sight between the target and the portion of the blade coil facing the target. The fixture is preferably in the form of a disc with an annular groove therein for receiving the blade coil and for providing controlled exposure of the edge portion thereof, while the shutter preferably is in the form of one or more rotatably mounted apertured plates. The sputtering process includes the formation of a plasma within the evacuated chamber by the ionization of an otherwise inert or non-reactive gas; the coating materials may be metals or alloys as well as dielectric materials such as organic plastics applied to the edge for imparting lubricity thereto. Coating thicknesses range from about 50 Angstroms or less up to several hundred Angstroms or more, but, in any case, are insufficiently thick to dull the previously sharpened blade edge.

6 Claims, 5 Drawing Figures



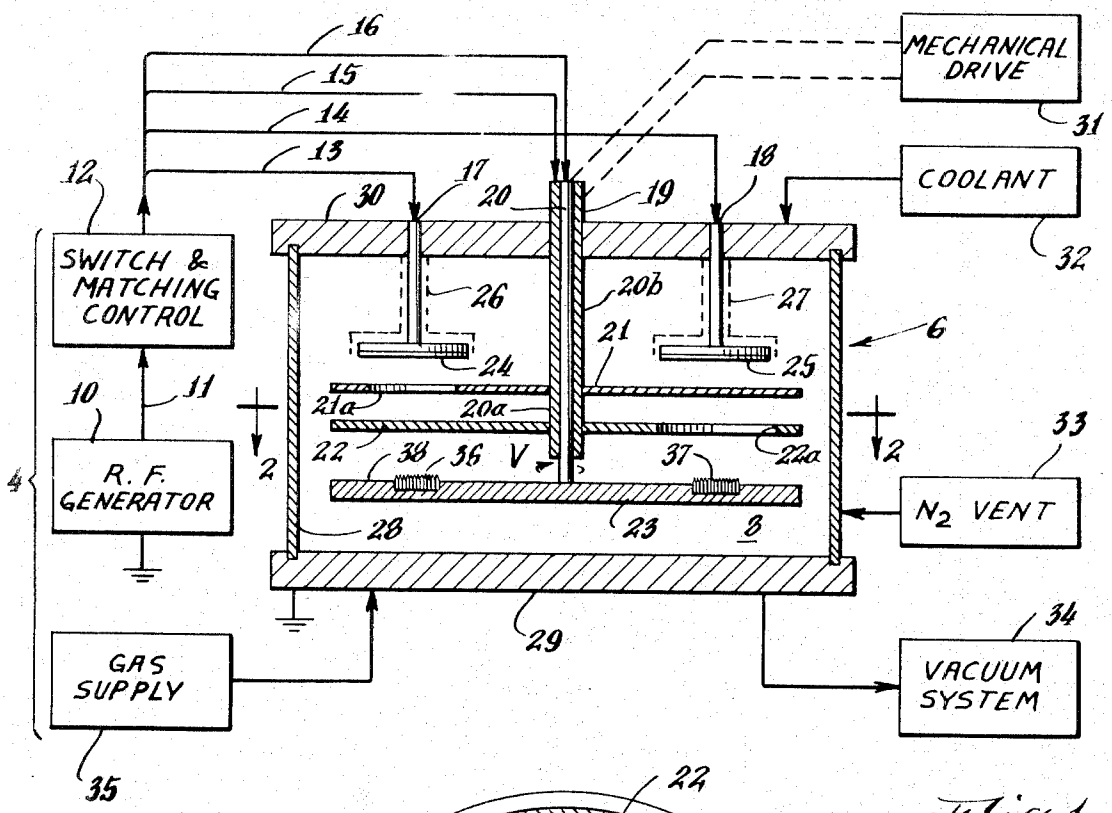

16
15
14
13
12
17
18
30
20
19
MECHANICAL DRIVE
31
COOLANT
32
SWITCH & MATCHING CONTROL
26
20b
27
6
21
24
25
10
11
21a
20a
4
R.F. GENERATOR
2
22
38
36
V
37
22a
2
33
N_2 VENT
28
23
8
29
34
GAS SUPPLY
VACUUM SYSTEM
35

Fig. 1.

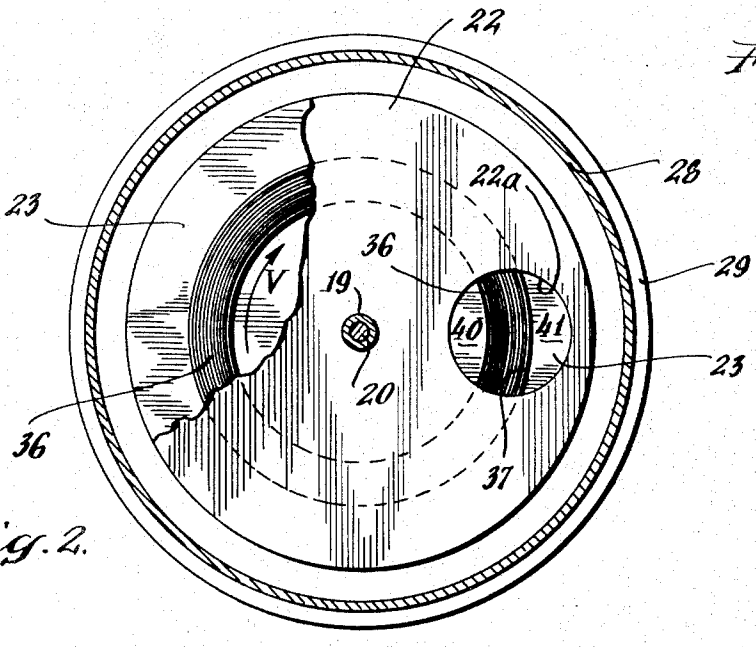
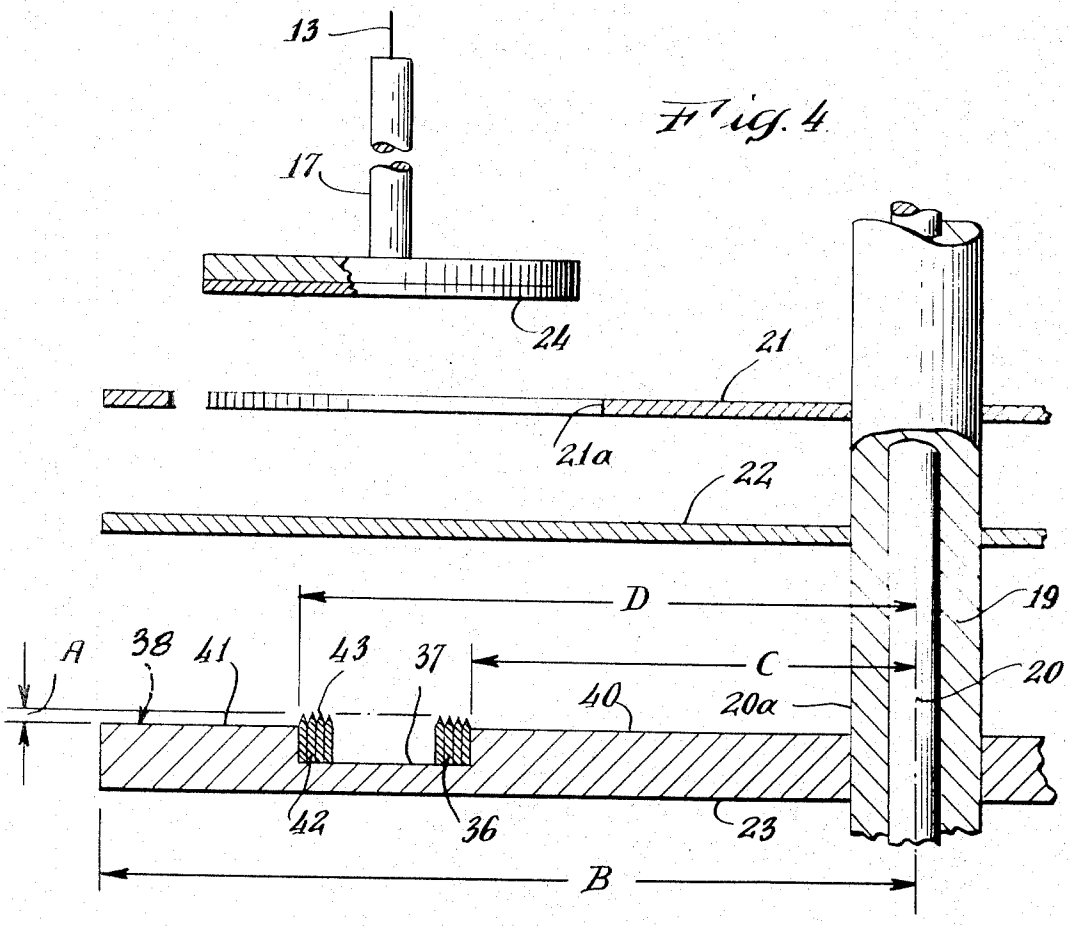

22
22a
28
23
36
V
19
29
40
41
23
20
36
37

Fig. 2.

Fig. 3

SPUTTER ETCH CYCLE	LINE 16 TO R.F. ENERGY LINE 15 TO R.F. GROUND
TARGET ETCH CYCLE	LINE 15 TO R.F. GROUND LINE 13 OR 14 TO R.F. ENERGY
SPUTTER CYCLE	LINE 16 TO R.F. GROUND LINE 13 OR 14 TO R.F. ENERGY

Fig. 4



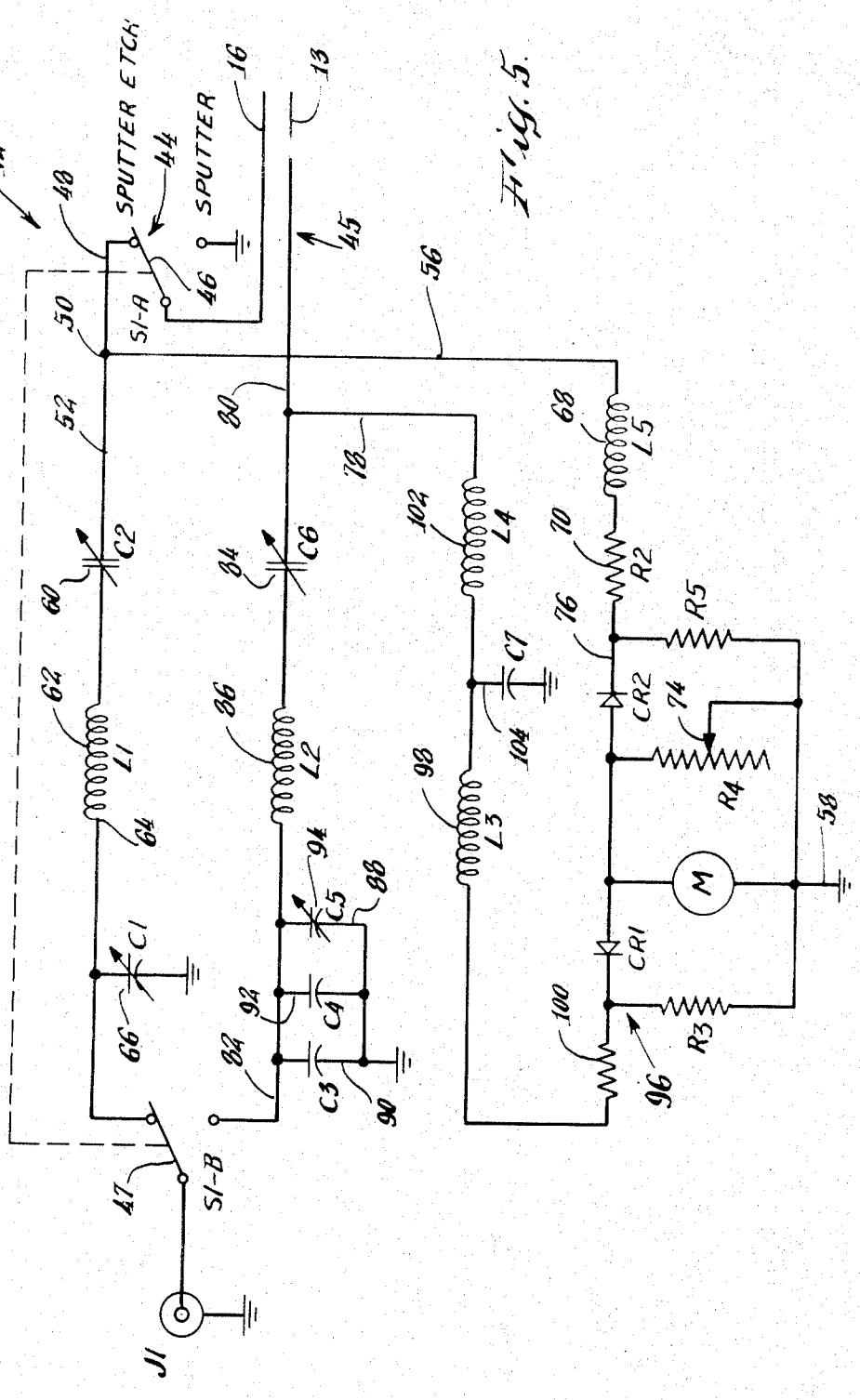

12
48
SPUTTER ETCH
44
SPUTTER
16
13
45
46
S1-A
50
56
52
80
68
L5
78
102
L4
70
R2
R5
60
C2
84
C6
C7
76
62
86
L2
98
L3
104
CR2
74
R4
L1
64
94
C5
88
58
M
C1
92
C4
66
CR1
82
C3
90
100
R3
96
47
S1-B
J1

Fig. 5.

METHOD OF COATING A CONTINUOUS STRIP OF RIBBON RAZOR BLADE MATERIAL

CROSS-REFERENCE TO RELATED APPLICATION

This patent application is a Division of copending U. S. Patent Application Ser. No. 144,510, filed May 18, 1971.

BACKGROUND OF THE INVENTION

The present invention relates generally to methods and apparatus for coating the edge portions of cutting instruments. More particularly, the invention is directed to applying extremely thin coatings of materials over the edges of razor blades and the like in order to increase the longevity of the blades or to impart other desirable characteristics thereto. In particular, the present invention is directed to coating extremely long, continuous strips of sharpened material from which shorter lengths of ribbon type razor blades are subsequently cut for loading into magazine type razors.

Recently, the advantages of applying extremely thin coatings of various materials to the cutting edges of instruments such as razor blades has become a common commercial practice, in view of the improved properties which may be imparted to such blade edges by placing thereover a strongly adherent coating of materials in extremely thin layers after the finished processing has otherwise been completed, or has been completed except for the addition of a lubricating coating.

Thus, it has recently been made possible to place a replicate coating of a corrosion-resistant material such as metallic chromium, over blade edges in thicknesses of 50 to 200 Angstroms by a sputtering process. These coatings are far too thin to affect the sharpness of a previously sharpened blade but quite surprisingly are thick enough to be extremely tenacious and to provide excellent rust and corrosion resistance to the edges. Methods such as those described in U.S. application Ser. No. 680,926, now U.S. Pat. No. 3,632,494 have proved able to provide blades of superior performance under extremely reliable and economical conditions of manufacture with the result that millions of razor blades are manufactured every day using techniques which are the same or similar to those described in this application.

Following the discovery that individual single and double edge blades may advantageously be coated by such methods, a demand arose for a suitable method of coating those continuous strips or ribbon type razor blade material from which shorter lengths are subsequently cut for assembly and incorporation into magazine type razors, since razors of this type are also currently in common use. However, the forms of apparatus used for individual blades or groups of blades have not been readily adaptable to the economical mass production of extreme lengths of continuous blade stock. Accordingly, while there has been a need for ribbon type blades containing coatings of the type obtainable by these processes, the requirement for producing the vacuums necessary for production of sputtered coatings has seemed incompatible with the requirements that such blades be formed, sharpened and treated in continuous lengths of considerable extent in order to obtain satisfactory quality and economy.

In other words, whereas ribbon type blades are necessarily handled in long strips, vacuum coating operations must be carried out, on a practical basis, in small areas or volumes, and such regions are, in a manner of

speaking, spatially inconsistent with existing processing equipment which produces ribbon blade material and which occupies extensive floor space. Although the continuous strips of blade are eventually subdivided into shorter lengths for inspection and assembly, it is not desirable to cut the blades in this manner immediately after sharpening and honing, since it is customary to place a lubricous coating (such as Teflon) on the blades after finishing, and existing equipment and technology is based on performing this operation on extended rather than shortened lengths of blade material. Consequently, where it is desired to place an anti-corrosion coating on the edge, such as a chromium or alloy coating, this step will normally be followed by the application of the fluoropolymer coating, which is advantageously carried out in the continuous, extended lengths. Therefore, the anti-corrosion coating should be applied to the extended, rather than subdivided, lengths of blade to fit properly into this operational sequence and thereby to avoid the necessity of obtaining new equipment or extensively modifying existing equipment.

Accordingly, it is an object of the present invention to provide methods and apparatus for applying thin surface coatings to the edges of continuous lengths of ribbon razor blade stock.

Another object is to provide an improved apparatus and method adapted for use in manipulating continuous lengths of razor blade and like material within an evacuated region.

A further object is to provide an apparatus which includes means for cleaning a substantial length of ribbon razor blade stock, cleaning the surface of the target containing the material which is to be applied to the blade, and thereafter placing one or more thin coatings uniformly on the blade edges, all without removing the blades from the evacuated region within which they are disposed for treatment.

A still further object is to provide a blade treating apparatus wherein the blade stock is required in a special rotatable fixture in a predetermined position in relation to a target, and wherein the fixture is capable of undergoing a predetermined motion sequence to insure uniform application of a layer of coating material, such as a metal, metal alloy or organic coating, for example, to the edge portion of the blade material.

Another object is to provide an apparatus having at least one generally planar holder for a continuous coil of blade, an electrode and an associated target disposed in generally facing relation to one sector of the holder, an apertured, rotatable shutter disposed between the target and the holder, and lying in a generally coplanar relation to the holder, with the shutter being rotatable co-axially with the holder so as to obscure or expose the target upon shutter rotation, with the holder being rotatable so as to permit passage of the blade beneath or otherwise in facing relation to the target when the aperture in the shutter is indexed into a position of registry with the target.

Another object is to provide an apparatus such as that referred to in the immediately foregoing object, but which includes plural electrodes, targets and shutters so that the operations described above may be repeated in respect to plural targets.

Another object is to provide a fixture or holder for a continuous coil of blade wherein the blade is entirely received within an annular groove in the holder with

the annular groove being spaced apart from the center and the outer edge portions of the holder by margins of substantial extent.

A further object is to provide a method of coating continuous strips of ribbon razor blade material which methods include forming a strip of blade material of extended length into a continuous coil having an opening of substantial diameter in the center thereof, placing the coil within an evacuated region which includes an energizable electrode and an operatively associated target, positioning the target in a generally facing relation to one sector of the blade coil, and thereafter applying electrical energy to the target in the presence of a minute amount of an inert gas to create a plasma within the evacuated region and to cause the ions thus formed to strike the target and sputter the coating material disposed thereon from the target and onto the blade edges under carefully controlled conditions.

Another object is to provide a clean vacuum system for the sputter deposition of films.

Another object is to provide a method as generally set forth above which further includes the steps of protecting the target and the blade respectively during cleaning operations carried out prior to coating and thereafter applying a coating of material from a cleaned target surface to the cleaned edge portions of the continuous coil of ribbon blade material, all without removing the coil of blade material from the evacuated region.

A further object is to carry out a coating method within a vacuum which includes manipulating a protective shutter and coil of blade in such a manner as to facilitate cleaning of the target and electrode while protecting them against contamination and thereafter manipulating the shutter and the blade coil in such a way as to advance successive portions of the blade coil past the target in generally facing relation thereto.

Another object is to provide an apparatus which includes plural targets and associated electrodes, at least one generally disc-like, apertured shutter plate lying parallel to the plane of the target, a generally disc-like blade coil holder having a groove therein for receiving a coil of blade, means for evacuating the region in which these elements are disposed, means for applying electrical energy to each of the electrodes and means for rotating the shutter and rotating a holder in desired motion sequences to provide for cleaning of the blade edges and the target and thereafter for applying the coating material by a sputtering operation directly from the target to the blade edge portion of the continuous coil of blade.

These and other objects of the invention are accomplished by providing an apparatus having means for receiving a continuous coil of blade, electrode means and an associated target, and protective means which may be removably interposed between generally facing portions of the target and a portion of the blade coil holder. The objects are also carried out by providing a method wherein the coil of blade is disposed within an evacuated region, and protected against contamination during cleaning, wherein the target associated with at least one electrode is cleaned while the blades are protected, and wherein the blade is thereafter manipulated in relation to the target so as to pass successive portions thereof adjacent the target in generally facing relation thereto under controlled conditions.

The manner in which the foregoing and other objects are achieved may be more clearly understood when reference is made to the accompanying detailed description of the preferred embodiments of the invention and when reference is made to the accompanying drawings, wherein like reference numerals indicate corresponding parts throughout.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a vertical sectional view, partly diagrammatic in nature, showing the principal elements of one form of the apparatus of the invention;

FIG. **2** is a horizontal sectional view of the apparatus of FIG. **1** taken along lines **2—2** thereof;

FIG. **3** is a diagrammatic view of the electrical connections to be made for providing a typical operating sequence undergone by the apparatus of FIGS. **1** and **2** in carrying out the method of the invention;

FIG. **4** is a greatly enlarged, fragmentary view of the portion of the apparatus of FIGS. **1** and **2**; and,

FIG. **5** is a schematic view of one form of electronic circuitry which is useful with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

Although it will be understood that the principles of the invention may be carried into practice in various manners and embodied in a number of different forms of apparatus, the invention will be described with respect to an embodiment wherein one or more electrodes and targets within a single vacuum chamber are used to apply single or plural coatings to a single continuous length of blade in coil form without breaking the vacuum in the apparatus.

Referring now to FIG. **1**, one form of the invention is shown to be embodied in an apparatus shown generally at **4** and including an evacuable chamber **6** with an interior **8** and generally defined by a continuous cylindrical side wall portion **28** extending between a top wall portion **29** and a bottom wall portion **30.** Disposed within the interior **8** are a pair of electrode and target assemblies **26, 27** with targets **24, 25** overlying the face of each electrode **17, 18** and with a shutter **21** being provided for operative association with one electrode assembly **26** and another shutter **22** being provided for association with the other electrode and target assembly **27.** Disposed beneath the shutters **21, 22** is a means in the form of a holder **23** for receiving a tightly wound coil **36** of ribbon blade which, as shown, is of a substantial radial extent so as to include an extended continuous length of blade, but which also has a relatively large opening in the center thereof. Referring again to FIG. **1**, it will be noted that the apparatus **4** also includes a coil rotation and shutter indexing assembly **19** which, in the embodiment shown, comprises three generally cylindrical drive shafts **20, 20*a***, and **20*b***, arranged in concentric relation. The drive shaft **20** terminates adjacent its lower end in a fixed connection with the coil holder **23,** the intermediate drive shaft **20*a*** terminates adjacent its lower end in a fixed connection to the shutter **22,** and the outermost sleeve or drive shaft **20*b***, being similarly associated in operation with the shutter **21,** is attached thereto adjacent the lower end of the shaft **20*b***. Accordingly, rotation of each of the shafts **20, 20*a*, 20*b*** will bring about a corresponding rotation of the part associated with it and lying within the evacuated region **8.**

Means for producing the desired motion sequence of the holder **23** and the shutters **21, 22** are provided in the form of a mechanical drive assembly **31**, which is only schematically represented, further detailed description being omitted since the drive assembly **31** may be of a known, conventional type forming no part of the invention which is necessarily novel per se. It will also be understood that appropriate seals of a known type may be provided to permit relative mechanical motion of the drive shafts **20, 20*a*, 20*b***, and that seals of a known type are also provided for insuring that electrical contact may be established and maintained with various elements lying within the chamber.

Although further detailed reference will be made herein to the electrical connections, it may be seen generally in FIG. **1** that one electrode and target assembly **26** is operatively associated with line **13** which terminates at the base portion of the electrode **17**, that a similar line **14** is joined to a portion of the electrode **18**, and that lines **15** and **16** terminate in the vicinity of the coil rotation and shutter indexing assembly **19**. Opposite ends of the line **13–16** terminate at the switch and matching control assembly **12**, details of which will be described in greater detail herein. FIG. **1** also shows that this assembly **12** permits connections to be made between the appropriate energy sources, or such as the radio frequency generator **10**, a ground potential point, an various elements disposed within the chamber **6**. This assembly **12** is adapted for matching the impedance of the target circuit generally with that of the output circuit of the radio frequency generator **10** which is shown to be associated with the control assembly **12** by line **11**.

The chamber unit **6** is also shown in FIG. **1** to have associated therewith a number of more or less conventional auxiliary elements which are commonly used in sputtering and the like high vacuum operations. For example, a coolant source **32** is provided for ensuring that excessively high temperatures are not developed in the electrode and target assemblies **26, 27**. A nitrogen vent **33** is provided for purging air or other relatively reactive gases from the interior **8** of the chamber **6** prior to and during evacuating thereof and introducing nitrogen gas prior to opening of the chamber **6**. Liquid nitrogen is thus also available fo use in a cold trap associated with the vacuum system schematically indicated at **34**.

Although the type of vacuum system used does not form a necessary part of the invention, it is well known to be advantageous to use a mechanical forepump or "roughing" pump for preliminary chamber evacuation, and a so-called turbomolecular, multi-stage, axial-flow, turbine type high vacuum pump in series therewith and lying upstream thereof. Oil diffusion pumps may also be used. Process requirements for deposition of certain films may require complete absence of hydrocarbon contaminants common to even higher developed diffusion pump systems. The use of molecular sieve cryopumping followed by the use of an ion pump combined with titanium sublimation provides the necessary "clean" vacuum. This novel pumping arrangement has proven of exceptional merit in sputter depositing films of a critical nature on razor blade edges and has reached pressure levels of approximately 10^{-10} Torr. Inasmuch as sputtering will take place in the presence of a plasma wherein electron flow ionizes a minute amount of inert gas admitted to an otherwise highly evacuated interior **8** of the chamber **6**, a gas supply **35** is schematically shown, it being also understood that this unit may include a precision leak valve, and may have an ionization gauge or the like associated therewith for determining the exact vacuum level within the chamber and the amount of inert gas supplied to the chamber. The gases used include argon and other known gases.

Referring now to the interior **8** of the chamber **6**, and specifically to the holder **23**, it will also be noted that a generally annular groove **37** is provided therein for receiving the coil **36** of blade. As shown, it is preferred that only the edge portion of the coil **36** project upwardly of the top surface **38** of the holder **23**.

Referring now to FIG. **2**, the generally concentric relation of the parts shown may be appreciated, and it may also be seen that the opening **21*a*** in the shutter **22** may be of a circular configuration and that it is in a directly overlying relation to one sector of the coil **36** of blade disposed or passing therebeneath. FIG. **2** also illustrates that there is a center section **40** and an outer margin **41** of the holder **23** which define therebetween the groove **37** in which the coil **36** of blade material is received. Accordingly, it will be appreciated that upon rotation of the disc **23** at a selected angular velocity V, successive portions of the blade coil are passed beneath the opening or aperture **22*a*** in the shutter **22**, and beneath a fixed target assembly, such as target assembly **26**, which lies above and in facing relation to the coil **36** in the holder **23**.

Thus, assuming that the aperture **22*a*** is indexed to a position directly beneath the electrode and target assembly **26**, the portion of the coil **36** passing beneath the electrode and target assembly **26** and in facing relation thereto will be exposed to any material sputtered from the target plate **24**, whereas, if the shutter **22** is indexed to a position wherein the aperture **22*a*** is out of registry with the electrode and target assembly **26**, any material sputtered from the face of the target plate **24** will be deposited on the upper surface of the shutter **22** which lies between and generally parallel to the target plate **24** and the holder **23**.

A similar mode of operation exists in respect to the electrode and target assembly **27** and the shutter **21** having the aperture **21a** therein. That is, as long as the opening **21a** is in registry with the electrode and target assembly **27**, material sputtered generally perpendicularly from the surface of the target plate **25** will pass directly downwardly through the aperture **21** and onto that portion of the coil **36** lying therebeneath. On the other hand, when the opening or aperture **21a** is moved out of registry with the assembly **27**, any material sputtered from the target plate **25** will fall on an upwardly directed surface of the shutter **21**. It will also be appreciated that, if two or more electrode and target assemblies such as the assemblies **26** and **27** are present, and if more than one shutter, such as the shutters **21** and **22** are present, both apertures **21*a***, **22*a***, must be registered with each electrode in order to permit flow of the sputtered material from either of the targets **24, 25** onto the edges of the blade coil **36** lying therebeneath and in oppositely facing relation thereto.

Referring now to FIG. **4**, an enlarged view is shown of some of the elements within the chamber **6** and their relation. By reference to FIG. **4**, it may be seen that the individual segments or turns **42** of the blade are in tightly packed relation with the adjacent sides thereof abutting one another. It will also be noted that the edge

portions **43** lie only a slight distance above the upper surface **38** of the holder **23**, this dimension being shown at A in FIG. **4**. The importance of this feature will be set forth elsewhere herein. FIG. **4**, also shows the overall radius of the holder **23** to be indicated by dimension B, and that the inner and outer walls forming the groove **37** are shown to fall on radii having dimensions C and D respectively. It will also be noted that the aperture **21***a* in the shutter **21** is indexed so as to fall beneath the target plate **24** which overlies electrode **17**.

In a preferred form of the invention, the radius (C) of the center section **40** of the holder **23** may be approximately 7 inches, the width of the coil (dimension D minus dimension C) is preferably about 2 inches, and the width of the margin **41** lying radially outwardly thereof is at least 1 inch. In such an embodiment, bearing in mind that the thickness of the typical stock comprising the coil **36** of the blade is only about 0.0015 inches, it will be appreciated that about 1,200 to 1,400 turns of blade per inch of coil thickness are provided, and that, accordingly, a blade coil about 2 inches thick, and having a mean diameter of 15 inches would contain about 10,000 feet of blade stock, that is, about 2 miles thereof. Preferably, the edges **43** rise above the surface **38** of the holder **23** only about 0.005 inches. In this connection, it will be realized that the sizes and shapes of the individual turns **42** of the blade coil **36** are not shown to scale, but are shown greatly enlarged for clarity of illustration.

Referring now to FIG. **5**, a simplified schematic drawing of certain portions of the switch and matching control unit **12** is shown. Inasmuch as an object of the invention is the provision of an apparatus **4** capable of use in various modes, FIG. **5** shows a blade etching circuit **44** and a sputtering circuit **45** for use in the sputter etch or blade etching a cleaning mode, it will be assumed that line **16** is connected within the unit **12** to a source of radio frequency energy, and that switches **46** and **47**, which are ganged for simultaneous operation, are in the position shown in solid lines in FIG. **5**. In this mode, radio frequency energy present in line **16** will also appear in line **48**, which includes a divider **50** having one line **52** thereof forming a part of a tunable, inductance-capacitance circuit. A second line **56** extends from the divider **50** to an inductance-resistance circuit having one terminal **58** thereof at ground potential.

In the illustrated form, tunable capacitor **60** is placed in series with the principal inductor **62**, which has the other terminal **64** thereof connected to switch **47** and to a second tunable capacitor **66** which is disposed parallel to the switch **47** and which has one terminal **54** thereof at ground potential. Accordingly, the signal in line **52** may be turned for the desired resonant condition by adjustment of the capacitors **60** and **66**, it being generally desirable, as will be pointed out herein, to obtain a certain forward power and a certain reflected power within the evacuated chamber **8** in order to provide the desired sputtering rate. The second line **56**, which is parallel to the tunable portion of the circuit **44**, includes an inductance of fixed value **68**, a series resistor **70**, and parallel resistors **72**, **74** each having a ground potential terminal and having the opposite terminals thereof connected to each other and to the series resistor **70** by diode **76**. The resistance **74** is preferably in the form of the potentiometer shown to permit adjustment of this portion of the circuit. In use, the switches **44**, **46** being in the position shown, the radio frequency current will be supplied to the blades, causing the blades to serve as the target in the sense that the surfaces thereof will be bombarded by the ions created in the plasma, thus bringing about a slight surface etching thereof. In this mode, the shutters **21**, **22** are placed at the R.F. ground potential.

Moving the ganged switches **46**, **47** to the other position shown in FIG. **5**, associates line **13** to the circuit **45**, which is functionally similar to circuit **44** but which differs therefrom in detail only.

Thus, this circuit **45** also includes a tuning capacitor **84**, a principal inductor **86** and a tunable capacitance circuit **88** parallel with line **82**. However, in this instance, capacitance circuit **88** includes two fixed capacitors **90**, **92** and one adjustable capacitor **94** to bring about fine tuning. Similarly, line **78** is analagous to line **56**, except that in addition to the grounded, divided resistance network **96**, and the inductor **98** and resistor **100** in series relation, an additional inductor **102** and grounded capacitor **104** are provided as shown. In use, the circuit **45** operates such that a signal in line **13** is supplied to the electrode and target assembly **26**, which receives a correctly matched signal. Sputtering therefore takes place in respect to target **24**, which has the R.F. signal applies thereto. Accordingly, in this mode, once the plasma is formed by the admission of a minor amount of inert gas into the evacuated area **8**, sputtering will commence as long as the plasma is maintained.

It will be understood, in connection with the foregoing illustrative description, that the elements of circuits **44** and **45** were described merely for purposes of indicating a typical form of circuit and that the illustrated circuit does not form a necessary part of the invention. Although it is conventinal and well known to form the switch and matching networks in a number of different ways, it is preferred that, for most effective operation, a matching box circuit should possess the ability to be tuned so as to closely match the impedances of the output circuit and the target load portion of the circuit.

Referring now to FIG. **3**, it is diagrammatically shown that three cycles or operational modes are typically able to be provided by the apparatus **4**, and that the connections made within the switch unit **12** between the leads **13–16** and the R.F. generator **10** will determine the mode of operation.

Thus, since it is customary first to etch the blade edges, the switch and matching control unit **12** is manipulated so as to establish an operative connection between line **16** and the R.F. energy source, thereby furnishing radio frequency energy to the holder **23** and the coil **36** of blades associated therewith. Line **15** is then operatively associated with the radio frequency ground, and accordingly, one or both shutters **21**, **22** assume a ground potential with respect to the holder **23**, it being understood that the shutters **21**, **22** and the holder **23** are all electrically isolated from each other. Accordingly, the ionized atoms will be attracted within the plasma to the exposed edges **32** of the individual blade segments **42** and the lower surfaces of the shutters **21**, **22** will receive a coating of whatever small amount of material is sputter etched or removed from the edge **43**. For this operation, the shutters **21**, **22** are indexed so as to avoid direct exposure of either target plate **24**, **25** to the coil **36**. Thereafter, the blade edges having been cleaned, any surface contamination is next

removed from the targets **24, 25** by operation of the apparatus in the target etch mode or cycle. In this mode, the line **15** is operatively associated with the radio frequency ground, thereby again grounding the shutters **21, 22.** Depending upon which electrode **17** or **18** is to be activated for etching of its associated target **24, 25,** the appropriate line **13** or **14** is connected to the R.F. energy source. In this mode, the surface of the target is etched or cleaned by a sputtering operation, but deposition of material from the targets **24, 25** onto the edges **43** of the blade coil **36** is prevented by assuring that the shutters **21, 22** remain indexed in positions such that their apertures **21***a*, **22***a* are out of registry with the electrode and target assemblies **26, 27.** Furthermore, since the shutters **21, 22** are at R.F. ground potential, the upper surfaces thereof serve to collect the material sputtered from the surfaces of the targets **24, 25.**

After the target has been etched to insure presentation of a totally clean surface thereof, the shutters **21, 22** are indexed to the proper positions so that the apertures **21***a*, **22***a* therein lie beneath the assembly which will be energized and from which it is desired to remove the material for deposition onto the coil **36,** and the apparatus is then operated in the ordinary sputter coating mode. In this mode, the radio frequency energy is again supplied to either electrode and target assembly **26, 27,** while line **16** is connected to a radio frequency ground, thereby grounding the coil **36** of blades and causing the sputtered material to be attracted to the edges **43** of the blade coil **36.**

In a typical operation of the apparatus **4,** the holder **23** is loaded with a coil **36** of blade material and sputter etching thereof is carried out by reducing the vacuum level to an approximate order of 5×10^{-6} Torr, and, while maintaining this background pressure, leaking argon into the chamber interior **8** from source **35** until the plasma starts, and thereafter quickly reducing the leak rate thereof. Preferably, the pressure of the system is maintained at about 2.5×10^{-3} Torr. A 1,000 volt direct current bias between the blades and a ground potential point is allowed to build up, and a forward power setting of about 750 watts is maintained with a reflected power level of 250 watts or less. The frequency preferred is 13.56 MHz operating the apparatus for about 5 minutes at an angular velocity V of one to three revolutions of the holder per minute, will serve to clean the blades effectively. Thereafter, the argon or other inert gas inflow is stopped, and the argon supply is discontinued and the background pressure is reduced to 5×10^{-6} Torr. Thereupon, with the shutters **21, 22** remaining in the same position, the controls may be actuated to etch the target, which is carried out in a similar manner, a pressure of 5×10^{-3} Torr being common, for example, the DC bias between the shutters and the target may be 2 KV in this mode, while power settings remain approximately the same. After this operation, the shutters **21, 22** may be indexed to the desired position, that is, with their apertures disposed directly beneath the target to which the R.F. energy is suplied. With a target-to-blade bias of about 2 KV and with 750 watts forward bias and a reflected power rating of less than 250 watts, the holder **23** may again to rotated in a similar manner. Approximately **6** minutes of sputtering will ordinarily serve to coat a material such as chromium onto the blade edges in a desired thickness, that is, a thickness of from about 25 to 50 Angstroms up to about 200 or more Angstroms.

In any case, a coating of this thickness is a substantially replicate coating of great tenacity and uniformity, and has proved to increase greatly the durability of the blades in use without in any respect dulling them. After coating with the metallic material such as a chromium, or an alloy such as an alloy of chromium and platinum or a composite material such as iron carbide, chromium oxide, or the like, the coil **36** may be removed from the fixture **23** for continued processing on conventional equipment. On the other hand, it may be desired to coat the lubricous material onto the coil **36** while allowing the coil **36** to remain in the chamber **6.** In such a case, the second target **25** may have disposed thereon a coating of a lubricous material such as a polymer of tetrafluoroethylene or the like. Sputtering of this material from the target **25** may be carried out as described in U.S. application Ser. No. 680,794, now U.S. Pat. No. 3,635,811.

The illustrated embodiment of the apparatus of the invention contains two targets **24** and **25,** and a pair of shutters **21** and **22.** It will be appreciated, however, that only a single electrode and target assembly need be provided to obtain most or all of the advantages of the invention, and that it is possible to carry out the invention using only a single shutter even though two targets are used. It is also within the scope of the invention to arrange shutters and targets so that sputtering could take place simultaneously from two targets, if this were desired for some reason. Other variations will also be apparent to those skilled in the art, it being understood that the description herein was made for the purpose of illustrating an embodiment suitable for the solution of a particular problem in a particular environment.

Referring now to one feature of the invention, although the reason therefor is not clearly understood, it has been discovered that significantly improved coatings may be placed on the coil of blade material when the edge portion **43** thereof is either planar with surface **41** or projects only slightly above the surface, in any case less than 0.2 inches. Accordingly, it is preferred that the depth of the groove **37** be only a few thousandths of an inch shallower than the total height of the blade stock.

It will thus be seen that the present invention provides a new and improved coating apparatus and method for coating the edges of a coil of blade material, and that this method provides a number of advantages and characteristics including those expressly pointed out herein and others which are inherent in the invention. Since it is believed that a number of modifications and variations of the apparatus and method disclosed in detail herein will occur to those skilled in the art, it is anticipated that such changes and modifications may be made without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. A method of coating the edge portions of strip material, said method comprising forming a continuous length of strip material into a coil having the edge thereof lying in a given plane, disposing said coil within an evacuable region with a sector of the plane of said edge lying exposed in opposed facing relation to a target comprised of a coating material and disposed in closely overlying relation to an electrode, disposing a shutter between said edges and said target, evacuating

said region, admitting a minute quality of an ionizable gas into said region, applying a voltage gradient between said electrode, said coil and said shutter, establishing a plasma within said region, sputtering material from said target and said edge of said coil while said shutter is interposed between said target and said blade, and thereafter removing said shutter from between said blade and said target and re-establishing said plasma by applying a voltage gradient between said target and said edge to cause coating material to be removed from said target and deposited onto said edge portion of said coil, said coil being moved past said target at a predetermined rate both during sputter removal of material and sputter deposition of material providing for a uniform removal of material from and deposition of material on said coil.

2. A method as defined in claim **1** wherein said voltage gradient is applied between said target and said shutter, to clean said target prior to sputtering material therefrom onto said coil.

3. A method as defined in claim **1** wherein said voltage gradient is established between said coil and said shutter to clean said coil edge prior to reception thereon of said coating material.

4. A method of applying a coating material to a strip of razor blade material having a cutting edge formed on at least one side thereof comprising:

forming said strip material into a coil,

positioning said coil in an annular recess of a holder apparatus within an evacuatable chamber with said cutting edge upwardly exposed, and with said coil concentrically aligned about a vertical axis of said holder apparatus,

positioning at least one electrode having the coating material thereon radially outwardly from said axis and in opposing facing relation to a sector of said coil,

establishing a voltage gradient between said electrode and said coil,

admitting minute amounts of an ionizable gas into said chamber under controlled conditions to establish a plasma in said chamber for sputtering the coating material from said electrode to said cutting edge, and

rotating said holder apparatus about said axis during sputtering.

5. The method of claim **4** wherein said holder apparatus comprises a generally flat upper surface having said recess formed therein, and wherein said recess is dimensioned to position said cutting edge in a plane defined by said upper surface.

6. The method of claim **4** wherein said holder apparatus comprises a generally flat upper surface having said recess formed therein, and wherein said recess is dimensioned to position said cutting edge in a plane between said upper surface and about 0.005 inch above said upper surface.

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