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**Lane et al.**

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[54] **COATED RAZOR BLADE**


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**Related U.S. Application Data**

[63] Continuation of Ser. No. 861,937, Sept. 29, 1969, abandoned.

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[51] **Int. Cl.**[2] ..... **B26B 21/54;** C23C 15/00

[58] **Field of Search** ..... 204/192, 298; 30/346.53, 30/346.54; 29/195, 191, 196.6; 117/132 CF, 69, 106 A, 71 M, 75, 48, 43



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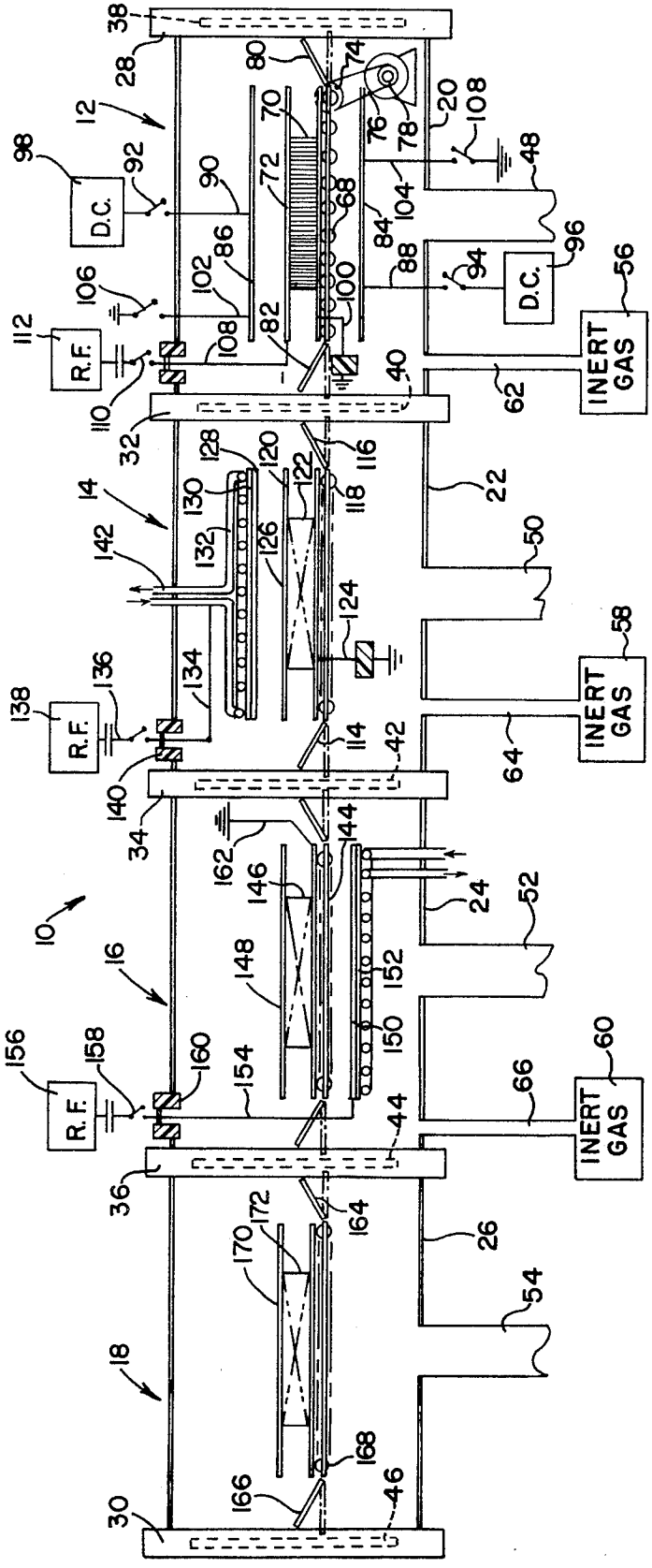


[57] **ABSTRACT**

An apparatus and method for sequentially cleaning and coating articles. The apparatus is in the form of a multi-chamber device, with each chamber being partially defined by valve units which permit passage of articles to be coated therethrough. Each chamber has associated therewith means for drawing a vacuum therein, several chambers include means for leaking a minute quantity of an inert but ionizable gas therein, and at least one chamber further includes at least one electrode, which may be placed in electrical communication with the articles so as to establish, in one of several ways, a direct current bias on the article with respect to another point within the chamber. Coating material to be transferred to the article is placed on one electrode, preferably in the form of a flat plate, in those chambers in which coating is to take place, whereas target material is not present in the cleaning or other non-coating chambers. One chamber is provided to serve as an air lock so that articles may be removed from it into the air while the chamber is sealed off from an adjacent chamber so as to prevent atmospheric contamination of coating material or articles to be coated in a coating chamber.

Means are provided for moving articles successively from one chamber to another so that the articles may be introduced into one chamber, cleaned, coated by passage into one or more succeeding chambers, and then removed through a last, vacuum or air lock chamber. Cleaning occurs by reverse sputtering, sputter etching, or glow discharge, and coating occurs by diode sputtering of a target material from a target electrode onto the substrate or article to be coated.


**2 Claims, 1 Drawing Figure**


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# COATED RAZOR BLADE

This is a continuation of Application Ser. No. 861,937, filed Sept. 29, 1969, now abandoned.

## BACKGROUND OF THE INVENTION

The present invention relates generally to coating apparatus and methods, and more particularly, to an apparatus and method for cleaning the surface of an article while the article is in a region of extreme high vacuum, transferring the article to a second high vacuum region, where a part or all of the article may be coated by cathodic sputtering, moving the article to an adjoining, evacuated chamber for coating at least a part of the remainder of the article, or for adding a second coating to the coating first placed on the article, and removal of the article into a vacuum lock chamber which is provided to prevent atmospheric contamination of the articles or of portions of the coating and cleaning chambers.

The use of cathodic radio frequency induced sputtering using one or two target plates and an electrically biased article as the substrate, and other similar coating methods generally referred to as sputtering methods, have recently been of increasingly great interest to many industries. The reason for the interest taken in such apparatus and methods is that these techniques provide, for the first time on a commercial scale, methods of placing extremely fine, strongly adherent, very uniform coatings in extremely thin layers or films.

For example, it has recently become possible to coat the edge of cutting instruments with desired coating materials, such as refractory metals and alloys, corrosion resisting metals and alloys, plastic coatings for lubrication or other purposes, and the like. Use of sputtering methods to achieve coatings such as these is highly advantageous since the coatings are so thin that it is possible to coat the cutting edge of an instrument after it has been finish ground and honed without perceptibly decreasing the sharpness thereof. Continuous coatings, that is, coatings totally free of voids, "pock marks," inclusions or other discontinuities, may be applied in thicknesses of from 1,000 Angstoms down to as little as 50 Angstroms or less, and typically fall in the range of about 100 Angstroms in the case of coating of metals such as chromium and the like. Coatings of this order of magnitude, that is, of only about one one-hundredth of a micron, add some mechanical strength to the cutting edge of the instrument, and greatly increase corrosion resistance. Cutting edges such as these can then be post-treated with a lubricating material such as tetrafluoroethylene polymer waxes or other lubricous organic coatings.

As an example, razor blades having a pure chromium metal coating overlying their cutting edges have demonstrated noticeably greater useful life than corresponding uncoated edges. As pointed out above, these coatings are extremely thin, and accordingly, the cost of material used to place these coatings on blades is not great. However, as is the case with many coatings of such a thin cross section, uniformity and adhesion are of great importance. Sputtering systems by their very nature tend to produce a very even, continuous film; however, in the event that the substrate or surface of the article to be coated is chemically contaminated or has otherwise undergone significant alteration in texture or makeup after being prepared for application of the sputtered coating, the bond between the sputtered coating material and the article surface or substrate may lack the requisite strength and continuity.



Since, as pointed out above, sharpening cutting edges involves the use of honing the edge with fine grinding wheels and strops, there is significant opportunity for surface contamination, such as inclusion of foreign matter, to occur. In addition, abrasive particles, oils or other lubricants, as well as oxidation from exposure to the atmosphere may also occur on a finish ground or honed blade edge. Besides the sources of contamination referred to above, other airborne contaminants may contact the blade edge after sharpening.

Accordingly, particularly in view of the short time required for oxidation of freshly cut metal edges in the presence of atmospheric oxygen, it is highly desirable to protect cutting edges from the time they are formed until a relatively impervious coating can be applied thereto.

Thus, an apparatus and methods capable of cleaning a previously sharpened edge, and maintaining it in a substantially perfectly clean condition until coating it in the same apparatus would represent a worthwhile advance in the coating art, particularly in the area of quality control and product reliability and uniformity.

Accordingly, an object of the present invention is to provide an improved coating apparatus for cleaning and coating various articles.

A further object is to provide a method of cleaning an article and coating it before it has had an opportunity to become contaminated after being cleaned.

A still further object is to provide an apparatus in which a plurality of articles may be treated at successive treatment stations by cleaning and coating under high vacuum conditions.

Another object is to provide a method of vacuum cleaning and coating an article, by the utilization of high vacuum techniques including glow discharge, reverse sputtering, or sputter etching followed by sputter coating of an article to be coated, all without exposure of the article to the atmosphere intermediate the cleaning and coating steps.

Another object is to provide an apparatus having a plurality of chambers, at least one for cleaning, one for coating and one for serving as a vacuum lock so that articles may be transferred successively from one chamber to another without being contaminated during cleaning and coating.

A still further object is to provide an apparatus having a plurality of chambers, at least one for cleaning and one for coating, in which each chamber has separate means associated therewith for evacuating such chamber and in which several of the chambers have associated therewith means for leaking inert gas into a region across which a high frequency alternating potential or a direct current potential exists within the chambers.

Another object is to provide an apparatus having a plurality of adjacent chambers, at least one for cleaning and one or more for coating, in which the chambers are connected by gate or valve mechanisms allowing each chamber to be isolated from the other in one operational mode, and allowing spatial communication between at least two of the chambers in another operational mode.

Another object is to provide an apparatus as set forth above which is useful in cleaning and coating by different but related methods, and which can be made to perform a variety of different operations merely by alter-

ation of the external vacuum and electrical circuitry associated therewith.

A still further object is to provide a cleaning and coating apparatus making possible higher volume production of cleaned and coated articles.

Another object is to provide a method of cleaning and coating an article which includes a glow discharge, sputter etching, or reverse sputtering cleaning step in one chamber, movement of the article through a valve to a second chamber which is then isolated from the first chamber and wherein at least a part of a coating is applied to the article, and subsequent removal of the coated article from the coating chamber through a vacuum lock for isolating the coating chamber from the atmosphere.

The present invention achieves these and other of its objects by providing a multi-chamber apparatus including valve means for isolating one chamber from another, means for permitting movement of articles between chambers, means for establishing a vacuum in each chamber and means for establishing an electrical connection between an outside power source and one or more electrodes within certain of the chambers; and by providing a method which includes placing articles in a first chamber, evacuating the chamber, cleaning the articles by glow discharge, reverse sputtering or sputter etching, moving the articles successively to one or more adjacent chambers for coating without exposing the articles to the atmosphere intermediate the cleaning and one or more of the coating steps, and removing the coated articles through a vacuum lock. The exact manner in which the invention achieves these objects will become more clear when reference is made to the following detailed description, to the appended claims, and to the accompanying drawings, in which like reference numerals indicate corresponding parts throughout.

## BRIEF DESCRIPTION OF THE DRAWING

The drawing is a side elevational view, partly in section, showing one form of the apparatus of the present invention and illustrating the practice of the method of the invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

Although it will be understood that the present invention is useful in a number of ways, description thereof will be made with reference to an embodiment in which cleaning and coating of only the edge portions of a large plurality of small articles takes place, such as treating an array of razor blades which have the edge portions thereof completely finish ground and honed before undergoing cleaning and coating treatment.

Referring now in greater detail to the drawing, the cleaning and coating apparatus **10** of the invention is shown to include a cleaning chamber **12**, an adjacently disposed first coating chamber **14**, a second coating chamber **16** disposed adjacent the first coating chamber **14**, and a vacuum lock or article removal chamber **18**. A portion of each of the chambers **12, 14, 16, 18** is defined respectively by a plurality of air tight, cylindrical or other continuously extending side walls **20, 22, 24, 26**, which may be circular in vertical cross section for adequate strength with minimum thickness.

The end chambers **12, 18** each include respective end wall portions **28, 30**, while intermediate walls **32, 34, 36**, respectively, form dividers between adjacent pairs of chambers **12** and **14, 14** and **16**, and **16** and **18**, respectively. Movable valve elements schematically illustrated at **38, 40, 42, 44, 46** are associated with each of the respective walls **28, 30, 32, 34, 36.** In use, these valves or valve elements establish spatial communication between a region lying outside each of the chambers partially defined by the walls and the region within the chambers when the valves are opened, and serve to isolate the chambers from one another and from the atmosphere when the valves **38, 40, 42, 44, 46** are closed. Conduits **48, 50, 52, 54** are provided for establishing spatial communication with the interior of each of the chambers **12, 14, 16, 18,** respectively and vacuum sources (not shown), so that a vacuum may be established and maintained in each of the chambers.

In the embodiment shown, three inert gas sources **56, 58, 60** are provided, each having an associated inert gas conduit **62, 64, 66** communicating with the interior of the respective chambers **12, 14, 16.**

Thus, it will be seen that all of the chambers include means for establishing vacuum therein, and certain of the chambers further include means for permitting the entry of inert gas. Each chamber also includes valve means in the form of the movable valve elements **38, 40, 42, 44, 46** so that articles may be successively moved from one chamber to another, and thus, after being introduced at one end of the apparatus **10,** and moved successively from chamber to chamber, may also be removed from the opposite end thereof.

Referring now in more detail to the chamber **12,** there is shown supporting means in the form of a plurality of rollers **68** for retaining and positioning a plurality of articles **70** contained within a fixture or holder **72** adapted to be moved axially of the apparatus upon rotation of a drive element **74** which is motor driven and connected by a chain or belt **76** to a motor **78.** Ramps **80, 82** are adapted, in the phantom line position thereof shown in FIG. **1,** to permit entrance of the holder **72** thereon and, in the raised or solid line position thereof to permit further movement of the holder **72** over the rollers **68.** A pair of oppositely disposed cleaning electrodes in the form of plates **84, 86,** each including a conductor **88, 90** may be placed in electrical communication through switches **92, 94** with one or more associated DC sources **96, 98.** A lead **100** is adapted to allow connection to be made between ground potential and the holder **72,** and consequently the articles **70** received in the holder **72** may be held at ground potential, if desired.

In addition, a pair of leads **102, 104** are provided, one for grounding each plate **84, 86** upon closing of an associated switch **106,108,** as will be described further herein. Means in the form of a lead **109** is provided for connecting the holder **72** and the articles **70** held thereon through a switch **110** to a radio frequency source **112,** for impressing a radio frequency alternating potential on the holder **72** and any articles **70** received thereon.

Referring now to chamber **14,** ramps **114, 116** are provided as are rollers **118** for receiving another holder **120** for another array of articles **122,** the holder **120** containing, in the operation of the process, a previously inserted group of articles **122.** A line **124** is provided to serve as a ground for the holder and articles **120, 122.** Disposed in an oppositely facing relation to the upper margins or edge surfaces **126** of the articles **122** is a target plate **128** overlying and being in direct electrical connection with an electrode plate **130,** which includes

cooling means in the form of a plurality of tubes **132** attached thereto for the passage of a coolant such as water therethrough. A radio frequency alternating electrical potential is supplied to the electrode **130** and to the target **128** associated therewith, through the line **134** which is connected through switch **136** and a coupling capacitor **139** to a radio frequency source **138.** A suitable insulator assembly **140** is provided for isolating the high energy emanating from the RF source from the chamber, while the ends **142** of the tubes **132** extend outside the chamber **14** and are adapted for connection to a cooling fluid source such as a water tap (not shown).

The chamber **16** is similar to chamber **14** except that an opposite margin or edge **144** of the articles **146** in a holder **148** is disposed opposite a target **150,** which is attached to the electrode plate **152.** Energy is supplied to the electrode plate **152** through a line **154** connected to another radio frequency source **156** through a coupling capacitor **157** and a switch **158,** by a line **154** passing through an insulator assembly **160.** Means in the form of a connector **162** are provided for grounding the articles **146** held in the frame **148.**

The chamber **18** also includes a pair of ramps, shown at **164, 166,** and rollers shown at **168** for supporting a holder **170** which includes the articles **172,** but the chamber **18** includes only the vacuum conduit **54** for communication with a vacuum source, and does not include an inert gas source or any electrical connections. The valve or air lock formed by the movable valve element **46** allows the articles **172** disposed within the holder **170** to be removed from an axial end portion of the chamber **18,** ordinarily when the valve element **44** is in the closed position.

As pointed out above, and as is apparent from the claims, the present invention is capable of use in a number of operational modes, and therefore, a description will first be given as to the operation of the unit in one preferred mode thereof.

## EXAMPLE 1

In a typical use of the apparatus **10** of the invention, a plurality of articles **70** such as razor blades or the like are disposed on a carrier **72** which is moved into position on the supporting rollers **68** after having traversed the ramp **80** through which entry to the interior of the chamber **12** was made when the valve element **38** was opened. With the holder **72** in position, the valve **38** is closed, and one or more vacuum pumps (not shown), such as a mechanical roughing pump and an oil diffusion pump in series, or a so-called turbomolecular pump is operated so as to extract air through the conduit **48** from the interior of the chamber **12,** until an absolute pressure of about $1 \times 10^{-6}$ millimeters (mm.) of mercury (Torr) results. This pressure is referred to herein, and in the vacuum coating art, as a background pressure, and represents the degree of vacuum or pressure present in the chamber in the absence of intentionally added gaseous material, as will be described more fully herein.

Next, a potential from about 500 to about 3000 volts DC, and preferably about 1000 volts, is impressed on the plates **84, 86** by operating the switches **92, 94,** thereby connecting lines **88, 90** to a suitable direct current source **112.** Thereupon, an inert gas such as argon is leaked through the conduit **62** from the source **56,** until a total gas pressure of about $1 \times 10^{-2}$ to $1 \times 10^{-3}$ Torr is reached. Under these conditions, a current of about 500 milliamperes (ma) will be developed, and the resulting glow discharge will cause ionization of the argon atoms and, because of the DC bias or relative potential difference between the plates **84, 86** and the blades **70,** ionized argon atoms will be drawn to the blade edges. Impingement of the atoms onto the edges of the articles or blades **70** will remove surface contaminants, particularly organic material, such as oils or greases and adsorbed gases. This operation may be carried out at ambient temperature, or, in the alternative, heater units (not shown) may be provided to accelerate the desorption of volatile materials. After a cleaning period of a suitable length, such as for example, three to six minutes, the valve controlling the supply of argon into the chamber **12** is turned off and the pressure is allowed to fall to or near the previous background level, namely $1 \times 10^{-6}$ Torr. The connections between the DC source **112** and the plates **84, 86** are then broken, by opening the switches **92, 94.**

During this cleaning time or therebefore, but in any event, before opening the valve element **40,** the chamber **14** is evacuated to the $1 \times 10^{-6}$ Torr background pressure by means of a pump (not shown) drawing gases through conduit **50.** At this point, with the valve element **42** closed, valve element **40** is opened, and as the ramps **82, 116** fall into position with their adjacent ends abutting, the fixture **72** is moved into the chamber **14.** Since a continuous process is illustrated, however, the drawing shows that a preceding fixture **120** of a series of fixtures or holders **120, 148, 170** is positioned within the chamber **14,** it being understood that fixture **72,** in the operation of the process, would next occupy chamber **14.** After the holder **120** is in the desired position on the rollers **118,** argon gas is leaked through the conduit **64** from the source **58** until a pressure of approximately **6** to $9 \times 10^{-4}$ Torr is reached. At this level, a radio frequency alternating current is supplied to the electrode plate **130** and to the associated target plate **128** upon closing of the switch **136,** which controls current flow through the line **134** passing from the RF source **138** through the insulator **140** to the tubes **132.** These tubes **132** are in physical and electrical contact with the plates **128, 130.** In a typical embodiment, a 13.56 megahertz (mhz) radio frequency is used, this frequency being supplied by a crystal controlled oscillator and an amplifier of any well known type. A line **124** insures that the holder **120** and the articles **122** contained thereon are at ground potential. As the radio frequency alternating voltage is applied to the plates **128, 130,** to which it is capacitively coupled by capacitor **139,** a large DC bias is built up on the plate **128,** and consequently, atoms of argon struck by the high frequency electrons within the alternating voltage field are attracted to the target plate **128** with great force, thereupon striking the plate **128** and sputtering surface atoms therefrom. The sputtered atoms are deposited on the exposed edges lying along the upper surface **126** of the array of blades or other articles **122.** Typically, the coating material used is a pure metallic chromium which has been electrolytically deposited on the plate **128.** According to known practice, the plate **128** is removably associated with the electrode plate **130** so that the coating on the target may be renewed periodically as it is depleted.

Only the capacitor **139** proper has been shown as a means of coupling the RF source **138** to the plates **128, 130,** since the drawing is somewhat schematic, but it will be understood that the actual coupling may take

place by means of a so-called pi matching network or matching box which tunes a group of inductors and capacitors so that the total impedance of the target portion of the circuit matches the output impedance of the oscillator and amplifier or output circuit. Thus, typically, the effective impedance of the target plate circuit might be about 50 ohms at the selected frequency, although of course the target circuit, being basically a circuit without positive connections at either end, has practically infinite DC resistance.

Coating of the blade edges typically takes place over a period of two to five minutes, following which the switch **136** is opened and the supply of inert gas is shut off, allowing the chamber **14** again to reach its background pressure of $1 \times 10^{-6}$ Torr.

Assuming that the chamber **16** has been evacuated to the same background level at or before this time, the gate or valve element **42** may be opened to place the chambers **14, 16** in spatial communication with each other, following which the holder **120** is moved into position within the chamber **16.**

However, since the operation is assumed to be continuous, the drawing shows still another holder **148** having a supply of articles such as blades **146** thereon already in position with the second coating chamber **16.** The basic function of the second coating chamber **16** is identical to that of chamber **14,** and structurally, the only difference is that the target **150** and its associated electrode plate **152** are on the opposite side of the article **146.** Thus, assuming that double edge razor blades are the articles **146** to be coated, the chamber **16** provides means for coating the edges thereof which are disposed opposite the edges coated in the chamber **14.**

With the ground line **162** serving to keep the articles at a grounded potential, the same sequence of operations is performed in chamber **16** as was performed in chamber **14,** including addition of inert gas to the same pressure, closing the switch **158,** and, while supplying RF current to the electrode plate **152** and its associated target plate **150,** allowing the capacitatively coupled plate **150** to become self-biased, whereupon coating of the edges of the article by cathodic sputtering takes place in the manner set forth above.

Referring again to the drawing, it is also shown that still another holder **170** having articles **172** therein is positioned by rollers **168** within the vacuum or air lock chamber **18.** The conduit **54** is likewise connected to a vacuum source, and prior to entry of articles into this chamber **18** from the adjacent chamber **16,** a $1 \times 10^{-6}$ Torr vacuum is drawn thereon, so that, as the articles are moved from the last coating chamber **16** to the air lock chamber **18,** substantially no air can pass into the second coating chamber **16.** Passage of air into the chamber **16** would not only present a problem of surface oxidation of the articles previously cleaned and being coated, but would also present a problem of contaminating the surface of the target **150,** with the consequent risk that the coating material sputtered from this surface would not be a pure material, but would be contaminated or oxidized, even if only in part. After the valve element **44** is closed, the holder **170** bearing the articles **172** may be removed through the valve **46** into the atmosphere. Thereupon, valve **46** is again closed and a vacuum is again drawn on the interior of chamber **18** prior to opening of the valve **44** for passage of another holder into the vacuum or air lock chamber **18.** Removal of each successive holder takes place in the same manner.

Operation of the apparatus in this sequence thus provides a means for cleaning the articles, and for preventing any contamination of the articles or the targets **128, 150** until the articles are coated and are ready to be withdrawn from the apparatus.

This arrangement does away with the need for providing an intermittent operation wherein the surface of the target must be cleaned in a vacuum by a preliminary sputtering or like operation before the surface atoms of the target are allowed to be directed onto the intended substrate or article.

This embodiment of the invention has been described with respect to an operation in which the chromium coating is applied first to one edge of a double edge razor blade and then another edge. However, it will be understood that any number of coating chambers, such as the chambers **14, 16** might be provided in series. As an example, two additional, similar or identical chambers might be provided, differing in that each might have a target of an aluminum oxide ($Al_2O_3$) material, which would be adapted to be placed over the chromium. Likewise, an additional pair of chambers might be provided for placing a lubricous fluorocarbon coating onto the edge, and likewise, in this case, the only difference would be the composition of the surface on the targets.

## EXAMPLE 2

Referring again to the drawing, an operation will be described which is identical to the above described operation set forth in Example 1, except that the mechanics of the cleaning step are somewhat different.

Once the articles **70** held in the fixture or holder **72** are in place within the chamber **12,** and the appropriate background pressure has been established, argon is leaked into the chamber **12** until a pressure of from about **1** to about $3 \times 10^{-3}$ Torr is attained. Electrical connections are established between the articles **70** and the RF source **112** by closing the switch **110.** At this time, or before, the switches **106, 108** are closed so that the plates **84, 86** are grounded. The RF source, which may be 13.56 megacycle supply source, and which is coupled to the articles **70** through the capacitor **113,** is regulated to a power setting of about 50 ma, causing a DC bias of up to about 3000 volts to be built up between the articles and the plates. The ionized argon atoms are attracted to the blade edges because of this charge, and the cleaning carried out according to this method is characterized as a reverse sputtering, that is, in this mode of operation, the article or substrate which will be coated in an adjoining chamber is used as the target in the cleaning chamber. The effect of using the edges as the target is to completely clean the edges, and to a certain extent, remove not only the contaminants from the surface but a portion of the surface itself. After cleaning, the argon leak valve is turned off, the background vacuum is restored to its previous level, and the reverse sputter cleaned articles are ready for subsequent coating in the same manner as described in connection with Example 1.

## EXAMPLE 3

Cleaning of the articles may also be accomplished by a method characterized as sputter etching. This operation differs from the reverse sputtering operation just described only in that the power and vacuum settings

and the physical disposition of the plates in respect to the articles may be somewhat different. For example, the background pressure is initially the same, but argon may be added until a pressure of about 6 to $9 \times 10^{-4}$ Torr is reached. The plates **84, 86** are preferably situated physically a greater distance apart from the article **70,** and with approximately 100 watts of 13.56 mhz. power supplied to the articles, the DC bias thereon may reach about 4000 to 5000 volts. An operation of this sort, using somewhat less inert gas and higher voltages, is sometimes characterized as a sputter etching operation, and provides a very effective cleaning method, particularly for certain types of articles. Following cleaning by the sputter etching method just described, the valve controlling entry of the inert gas to the chamber **12** is turned off, and the electrical switches are opened so as to allow conditions within the chamber **12,** including vacuum conditions, to return to their previous state. After cleaning as set forth above, the articles and holder are adapted to be moved to an adjoining chamber for coating operations carried out in the manner described in connection with Example 1, above.

As pointed out above, although in some cases, it is preferred to change the spacing between the electrodes or plates and the articles when different forms of cleaning are utilized, this is not strictly necessary, and accordingly, it is possible to provide a single apparatus which is useful in a number of operational modes and depends for this operation only on connection or external circuitry. Such an apparatus, by reason of the plural chambers and the functional relations therebetween, is adapted to permit high volume, low cost, high quality production free of many of the disadvantages of prior known production sputtering systems.

It will thus be seen, that the present invention provides an improved coating apparatus and method having a number of advantages and characteristics including those pointed out herein and others which are inherent in the invention.

We claim:

**1.** A razor blade comprising at least one cutting edge, a chromium coating on said cutting edge, and an aluminum oxide coating on said chromium coating.

**2.** The razor blade of claim **1** further comprising a fluorocarbon polymer coating on said aluminum oxide coating.

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