

Aug. 30, 1955

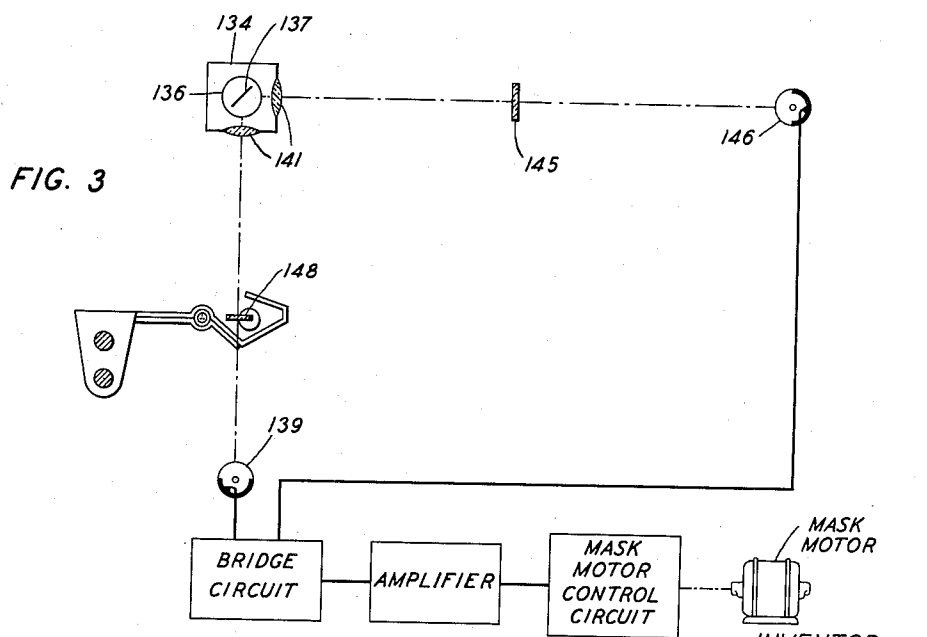
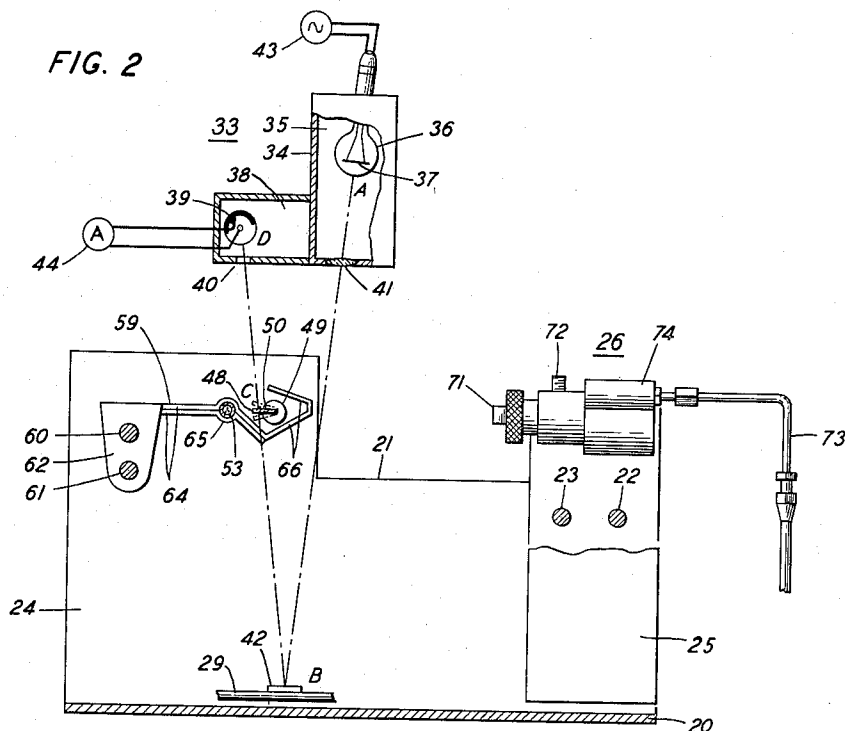
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2,716,622

METHOD AND APPARATUS FOR SPRAY COATING ARTICLES

Filed Oct. 6, 1952

3 Sheets-Sheet 2



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3 Sheets-Sheet 3

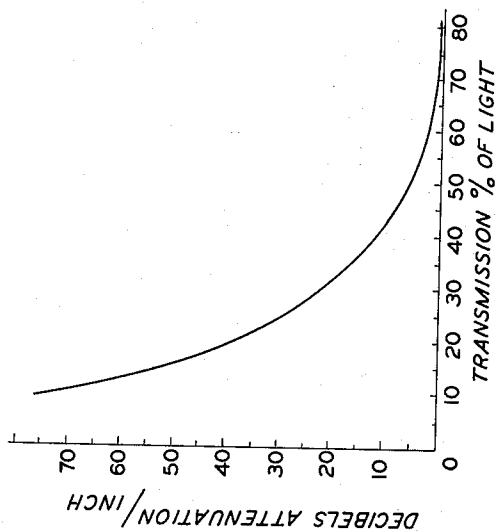


FIG. 5

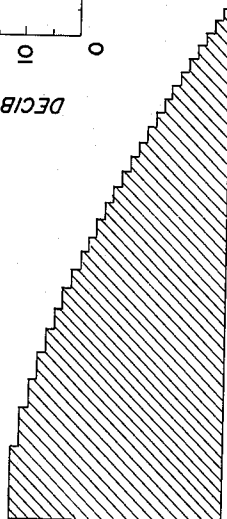


FIG. 4A

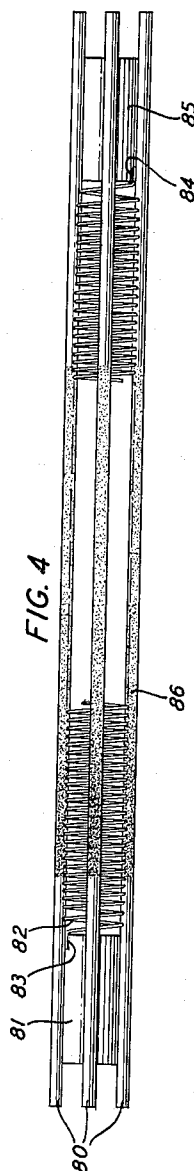


FIG. 4

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METHOD AND APPARATUS FOR SPRAY COATING ARTICLES

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Application October 6, 1952, Serial No. 313,297

12 Claims. (Cl. 117—201)

This relates to methods and apparatus for manufacturing electron discharge devices of the type known as traveling wave tubes and, more particularly, to methods and apparatus for placing electrical attenuating material upon the helices of such devices.

In traveling wave tubes, it has been shown as in application Serial No. 168,202, filed June 15, 1950, of C. C. Cutler, that the introduction of glossy or attenuating material to the surface of the helical electrode and its supports, known generally as the helix, is desirable to obtain maximum power and efficiency, while avoiding instability and undesirable impedance effects.

It is also disclosed in the above-mentioned application that the attenuation may be applied in prescribed patterns of density varying with the distance along the helix from its input end. Typical of patterns designed for maximum stability in the device is one including a comparatively high density of attenuation adjacent the input end of the helix and decreasing in density gradually toward its output end. The attenuation tends to absorb any reflected radio frequency signal wave which would otherwise degrade the tube gain.

In the past, this attenuation has been introduced onto helices by spraying a colloidal solution of carbon in water, commonly known as aquadag, upon the surface of the helix and its supports. The spraying has been accomplished by apparatus which includes a pair of centers for supporting and rotating a helix about its axis at a constant rate, a spray gun mounted upon a carriage which moves in a repetitive path in front of the rotating helix, electrical memory means for counting the number of passes of the spray gun and stop means for limiting the travel of the carriage in accordance with a prescribed number of passes indicated by the memory means. Such apparatus is described in detail in the application, Serial No. 313,229, filed October 6, 1952, of H. A. Schneider, now Patent No. 2,659,337, issued November 17, 1953.

In apparatus which reproduces predetermined patterns in attenuation density by regulating the number of passes of the spraying or coating means, the assumption must be made that the attenuation deposit varies in quantity directly with the number of passes of the spray gun by a certain point. It has been found, however, that due to uncontrollable clogging and spurting of the spray gun, a constant quantity of spray does not issue from the nozzle per unit of time. Consequently, variations in the quantity of attenuation applied to the helix appear apart from the prescribed pattern.

An object of this invention is to improve the manufacture of electron discharge devices and, more particularly, to improve the spraying of traveling wave tube helices with attenuation.

Another object of this invention is to eliminate unwanted variations in the quantity of attenuation upon traveling wave tube helices.

A further object of this invention is to realize continuous monitoring of attenuation deposit.

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Still another object is to enable and facilitate automatic operation in the attenuation coating process.

In one embodiment of this invention, a helix is mounted for axial rotation, as between the centers of a lathe or similar device. A spray gun is mounted on a carriage which automatically traverses a path back and forth in front of the helix with the spray gun directed toward the helix. Two shields, one of which is movable, cover the helix as it is coated with the desired quantity of attenuation. A glass slide of length approximating that of the helix is located edgewise to the spray between the spray gun nozzle and the helix. The slide is adapted to flutter continuously to sample the quantity of spray directed toward the helix. A photoelectric cell and an associated optical system and light source are arranged so that light from the source is transmitted through the slide and then to the photoelectric cell. The slide becomes increasingly opaque as it is coated with attenuating material and the photoelectric cell current will vary inversely with the quantity of attenuating material upon the slide. The photoelectric cell optical system and light source are mounted to travel with the spray gun to monitor the attenuation deposit upon the entire length of the helix. The movable mask or shield may be interposed in the spray path when the photoelectric cell current falls to a predetermined level at any point along the helix length corresponding to the desired attenuation.

In another embodiment of this invention, a single light source is employed with two photoelectric cells, one of which receives the light passing through the monitoring slide between the helix and the spraying means, and the other of which receives light through a precoated reference slide which corresponds in coating thickness to the desired attenuation upon the helix. The two photoelectric cells are connected in a bridge circuit from which any differential current constitutes the input to an amplifier. The amplified differential current actuates relay devices to move the mask automatically to cover each portion of the helix as it receives the proper quantity of attenuation.

A feature of this invention involves the continuous monitoring of spray directed towards the helix by a moving transparent slide.

Another feature involves photometric means for continuous attenuation quantity measurement.

Another feature of this invention relates to interposing masking devices in front of the helix upon actuation by the monitoring means.

Another feature involves the application of light transmission characteristics of the deposited material to measure the attenuation deposit.

A further feature of this invention involves the use of a pair of photoelectric cells energized proportionately to the light transmission through the monitoring slide and a reference slide.

A more complete understanding of this invention may be had from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is a perspective view of apparatus illustrative of one embodiment of this invention;

Fig. 2 is a side view of the apparatus of Fig. 1, partly in section, showing the spacial relationship of helix, slide and photometric system;

Fig. 3 is a schematic view of another embodiment of this invention including a control circuit for automatically shielding the helix after completion of the spraying of each portion of its length;

Fig. 4 is a perspective view of a helix coated with attenuation according to this invention;

Fig. 4A is a diagrammatic representation of the variation in attenuation thickness along the length of the helix; and

Fig. 5 is a graphical representation of the variation in decibels signal attenuation per unit length along the helix with respect to the percentage change in light transmission through the monitor slide.

Referring now to Fig. 1, the apparatus there illustrated comprises a frame 20 including a motor mount box 21. At the front of the frame 20 are a fixed rod 22 and a drive screw 23 which extend between the two sides 24 of the frame 20. A carriage 25 mounting a spray gun 26 rides upon the rod 22 and drive screw 23 either to the right or left depending upon the direction of rotation of the screw 23. Slideably attached to the rod 22 are reversing switches 27 for a drive screw motor, not shown but located in the motor mount box 21. The reversing switches 27 allow the carriage 25 and spray gun 26 to traverse a repetitive path of length equal to the distance between the switches 27. Also riding with carriage 25 is an angular support 28 comprising a pair of shaped rods 29 welded to the carriage and extending toward the rear of the frame 20.

Mounted at an apex 32 of the support 28 is a photometric assembly 33, including a lamp 36 and a photosensitive device 39 such as a photoelectric cell. A mirror 42 is affixed to support 28 opposite the apex 32 to reflect light from lamp 36 toward the photoelectric cell 39.

The light is supplied by current source 43 and the photoelectric cell 39 is connected to a current indicating device 44 such as a microammeter. The light in traversing the path from the lamp 36 to the mirror 42 and to the photoelectric cell 39 passes through a transparent glass slide 48 which extends between slotted studs 49. The slide lies in the slot portions 50 of each of the studs 49 so that it may be fluttered about one edge as they are rotationally oscillated by a crank and arm assembly and a motor all contained within motor mounting box 21 and not shown.

Lying adjacent the movable edge of the slide 48 is the helix 53 mounted for rotation between resilient centers 54, including rubber bushings 55. One of the centers 54 is held in chuck 56 to be rotated at a constant rate by a third motor contained within the motor mounting box 21. At the end of the helix 53 opposite the chuck 56 is a tube 57 coaxial with the helix 53 and acting as a mask for that portion of the helix 53.

Surrounding the helix 53 and adapted to be moved along its length is a movable mask 59 mounted by tabs 62 upon a guide rod 60 and a lead screw 61, the latter of which is actuated manually by crank 63 at one end of the frame 20. The mask 59 comprises a pair of metal plates 64 forming a cylindrical portion 65 surrounding the helix. One of the plates 64 extends beyond the helix 53 to mask the slide 48. The slide masking portion 66 of the mask 53 is V-shaped to shield the slide 48 while allowing for its fluttering movement.

Spray gun 26, slide 48 and helix 53 are aligned so that the spray issuing from a nozzle 71 of spray gun will pass the slide 48 and be deposited upon the helix 53. The movement of the slide 48 is controlled by a different motor from that which drives the helix 53 so that the oscillation frequency is independent of the speed of helix rotation, insuring a random deposit of the material upon the helix.

Referring now to Fig. 2, the apparatus of Fig. 1 is shown with portions broken away or removed for clarity. Alignment of the spray gun 26, helix 53 and the intervening transparent slide 48 is apparent, as well as the movement of the slide 48 which is shown by dotted lines. The movement is in the form of an arc of approximately 20 degrees which is sufficient to sample all the fluent material from the spray gun 26 directed into the vicinity of the helix 53.

The details of the measurement system of the embodiment of the invention shown in Fig. 2 comprise a housing 34 including a rectangular compartment 35 in which a lamp 36 is suspended. Lamp 36 desirably has a linear shaped filament 37 for reasons hereinafter explained. In a smaller adjoining compartment 38 is mounted a photo-

electric cell 39 and each compartment has an opening in the lower side to allow the passage of light rays. A lens 41 is mounted in the opening in compartment 35 to focus the light of lamp 36. The light from lamp 36 is directed along the path marked ABCD toward the mirror 42 and thence through the slide 48 and onto the active surfaces of the photoelectric cell 39.

The accuracy of the light transmission measurement by the photoelectric cell 39 and its associated current indicating means 44 is incumbent upon the presence of a distinct light source. This is furnished by providing a lens 41 which will focus the image of the linear filament 37 upon the surface of the slide 48 and provide a high intensity apparent light source for the photoelectric cell, which varies in intensity indirectly with the quantity of attenuating material deposited upon the slide 48.

The monitoring of attenuation deposit by the slide 48 and the photometric assembly 33 is continuous as the carriage 25, spray gun 26 and assembly 33 move along the length of the helix. With the slide 48 interposed between the spray gun 26 and the helix and continuously oscillated or fluttered, the attenuating material which reaches the helix is that amount which passes the slide 48 due to its motion. The helix 53 and the slide 48 are each moved at a constant rate so the relationship between the quantity deposited upon each is fixed. This relationship is illustrated in Fig. 5 as a curve of variation of the electrical attenuation of a helix with respect to the decrease in photoelectric cell illumination in per cent. Employing such a curve the current indicating device 44 may be directly calibrated in decibels of electrical attenuation. The operator then moves the mask to cover portions of the helix and slide when the device 44 shows that the area adjacent the edge of the mask 59 has reached the desired attenuation level.

Preliminary to the coating process, the movable mask 59 is positioned over a portion of the helix 53 which is to remain uncoated and one edge of the mask 59 is immediately adjacent the area where the coating is to begin. A few drops of the coating solution are deposited in a filler hole 72 in the spray gun 26 which is positioned so that the nozzle 71 is directed at mask 59. The slide actuating and helix motors are started, followed by the drive screw motor, and the spraying begun with the nozzle 71 set to give a fine spray. As the spray gun makes a single pass and return in front of the helix 53, the indicating device 44 will show a decrease in photoelectric cell current corresponding to the attenuating deposit upon the slide and helix. When the decrease corresponds to the desired attenuation at that end of the attenuation pattern, the mask is moved to cover more of the helix during the time in which the spray gun 26 is passing in front of the shielded portion of the helix. By the time that the spray gun 26 and carriage 25 strike the reversing switch 27 and begin the next pass, the mask is in position. The process is repeated and the mask 59 is moved toward the tube 57 each time that the microammeter reading corresponds to the prescribed attenuation reading for that point along the length of the helix until the pattern is completed.

The spray gun used preferably is one of the self-cleaning type which shuts off the supply of spray material periodically as a needle valve probes the orifice of the nozzle to clear it of any fouling. A microswitch control may be employed to clean the spray gun at the end of each pass so that the cleaning operation will not interfere with the helix coating. This periodic cleaning of the spray nozzle without interference with the spraying operation is advantageous due to the fact that the colloidal solution carbon easily fouls the spray nozzle.

A completed helix 53 is shown in Fig. 4 comprising a trio of support rods 80 of ceramic material enclosing a pair of metal tubes 81 and 85 connected by a helical wire 82 at the points 83 and 84 respectively. Attenuation coating 86 covers portions of the helical wire 82 and the

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support rods 80 as applied in accordance with this invention.

Fig. 4A is a pictorial representation of the thickness of attenuation 86 along the length of the helix 53 including the stepped graduations resulting from adjustment of the mask 59 during the application of the attenuation coating.

The apparatus of Figs. 1 and 2 employs manual movement of the mask 59 in accordance with the change of light transmission through the slide 48 as indicated upon the microammeter 44. In order to employ a principle of this invention in the automatic spraying of traveling wave tube helices, the apparatus of Fig. 3 may be used. It comprises a single light source 136 enclosed in enclosure 134 having two openings in adjacent sides. A lens 141 is located in each of the openings and designed to focus the image of the filament 137 upon each of two slides; a monitoring slide 148 interposed in the spray path as in the apparatus of Figs. 1 and 2; and a precoated reference slide 145 having the prescribed pattern deposited upon its surface. A monitoring photoelectric cell 139 is directed toward the monitoring slide 148 while a reference photoelectric cell 146 is directed toward the reference slide 145. The light source and photoelectric cells 139 and 146 are mounted to indicate the quantity of attenuating material immediately adjacent the masked area and move with the mask.

The two photoelectric cells are electrically connected to a bridge circuit, the output voltage of which is proportional to the differential of the two photoelectric cell currents. The bridge output voltage is amplified and impressed upon the grids of a pair of gas tubes or other type of suitable motor control device. When the voltage unbalance is sufficiently large and of proper polarity, the gas tubes ignite to energize the mask motor. The motor in turn moves the mask and the photoelectric assembly to a new light transmission balance at which point the motor stops. A limit switch may be attached to the mask support rods to terminate all operation when the mask covers the entire helix.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of this invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. The method of accurately depositing a small quantity of fluent material upon an article in a predetermined quantity including the steps of continuously directing a quantity of fluent material at the article, interposing a transparent slide directly between the article and fluent material source, oscillating the slide in the path of the fluent material directed toward the article to collect a sample of the material, measuring the light transmission of the sample, and shielding the article from further deposit when the light transmission of the sample falls to a prescribed level.

2. The method of accurately depositing a variable thickness coating of material upon an article including the steps of repeatedly passing a spray source by the object to be coated, oscillating a transparent slide between the article and the spray source over an area at least as large as the area of the article exposed to the spray source to collect a portion of the material directed toward the article while allowing a portion of the material to be deposited upon the article, periodically collecting fluent material directed toward the article upon a transparent support, measuring the light transmissibility of the portion collected upon the slide, and shielding the article from further deposit when the transmissibility of the portion collected falls to a prescribed value.

3. The apparatus for coating articles with a prescribed variable thickness coating comprising spray means for coating the article with fluent material, a transparent slide interposed between the article and the coating means, photometric means for indicating the quantity of

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fluent material deposited upon said slide and means for masking the article in accordance with the quantity of material indicated by the photometric means.

4. The apparatus for coating articles with a prescribed variable thickness coating comprising means for rotating the article, means for coating the article with fluent material, transparent sampling means interposed directly between the article and the coating means, said transparent sampling means mounted to oscillate in the path of fluent material directed toward the article, to allow one portion of the fluent material to be deposited upon the article while collecting the remaining portion of fluent material photometric means for measuring the quantity of material deposited upon said sampling means, said photometric means for determining the quantity of fluent material deposited upon said sampling means comprising a photosensitive device and light source embracing said sampling means, said photosensitive device directed to receive light from said source transmitted through said sampling means, and means indicating the magnitude of the light received by said photosensitive device.

5. The apparatus according to claim 4 including a mask actuatable to shield successive areas of the article from further deposit of fluent material in accordance with the reading of said indicating means.

6. The apparatus for coating articles with a prescribed variable thickness coating comprising means for rotating the article, a spray source directed toward the article and mounted for translation in a repetitive path along the length of the article, a transparent slide interposed directly between the article and the spray source, means for fluttering said slide in the path of the fluent material to obtain a random sample of the fluent material directed toward the article, photometric means for measuring the amount of material deposited upon successive areas of said slide, said photometric means mounted for translation with said spray source and masking means actuatable in accordance with the photometric means measurement to shield successive areas of the article.

7. The apparatus for coating articles with a predetermined variable thickness coating of fluent material including means for rotating a helical article about its axis, spray means for coating the article with a coating of fluent material, a transparent slide of length approximating that of the article, said slide mounted in substantially parallel relationship to the axis of the article and lying between the article and said coating means, means for oscillating said slide in the path of the fluent material to collect an amount of fluent material directly correlated to the amount deposited upon the article, photometric means for measuring the quantity of material upon said slide, both said coating and photometric means mounted to travel parallel to the axis of the article, and means for shielding the article from further deposit when the photometric means indicates a prescribed quantity of material has been deposited upon said slide.

8. The apparatus according to claim 7 including a pair of reversing switches to cause said coating and photometric means to traverse a repetitive path along the axis of the article.

9. The apparatus in accordance with claim 7 wherein the transparent slide is mounted for oscillatory movement over an area at least as great as that of the article exposed to the fluent material to obtain a random sample of all of the material directed at the article.

10. In combination, spray means for coating articles with fluent material, transparent sampling means interposed between the coating means and an article, photometric means for measuring the light transmissibility of said sampling means as the article and slide become coated, an electrical bridge for comparing the transmissibility of the sampling means with that of a reference, and means for shielding successive areas of the article

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when the transmissibility of the sampling means corresponds to that of the reference.

11. In combination, spray means for coating articles with fluent material in a variable thickness coating, a transparent slide interposed between the coating means and an article, first photometric means for measuring the light transmissibility of said slide as the article and slide become coated, second photometric means for measuring the light transmissibility of a reference, an electrical bridge for comparing the light transmissibility of the slide and of the reference at successive points along their respective lengths, and means for shielding successive areas of the article from further coating when the light transmissibility of the slide corresponds to that of the reference.

12. In combination, spray means for coating articles with fluent material in a variable thickness coating, a transparent slide interposed between the coating means and an article, said slide being of length approximating that of the article and mounted to oscil-

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late in the path of material deposited upon the article a first photosensitive device mounted to measure the light transmissibility of said slide as the article and slide become coated, a reference slide, a second photosensitive device mounted to measure the light transmissibility of the reference slide, an electrical bridge for obtaining the differential output of said first and second photosensitive devices, a mask to shield the article from excessive coating, and means moving said mask to shield the article in successive steps in accordance with the differential output of said photoelectric devices.

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