Nov. 18, 1958 J. H. RICE ET AL 2,860,599

ELECTROSTATIC COATING DEVICE WITH RESTRICTED FLUID PASSAGEWAY OPENING ADJACENT SHARP DISCHARGE EDGE

Filed Aug. 13, 1954 2 Sheets-Sheet 1

FIG. 1.

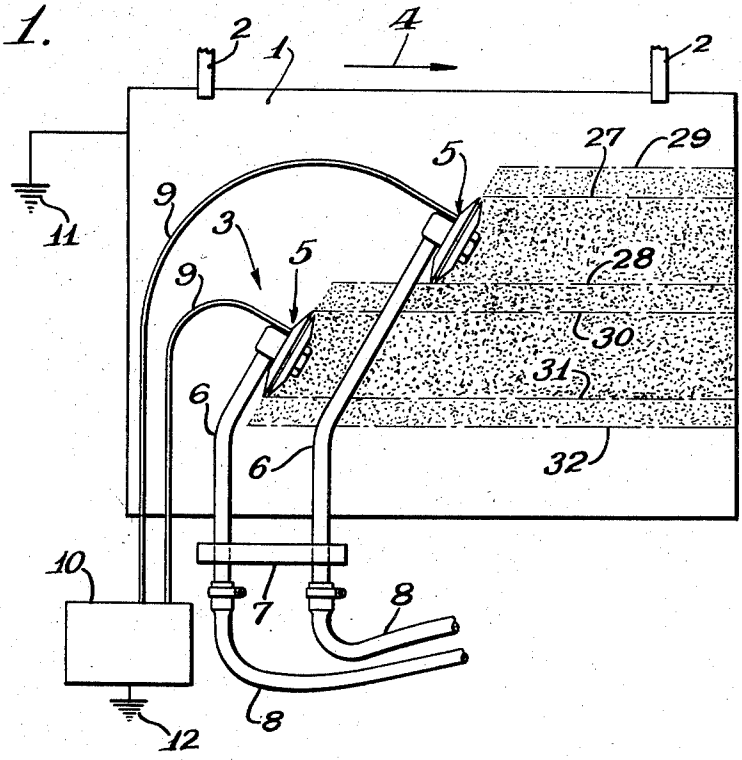


FIG. 2.

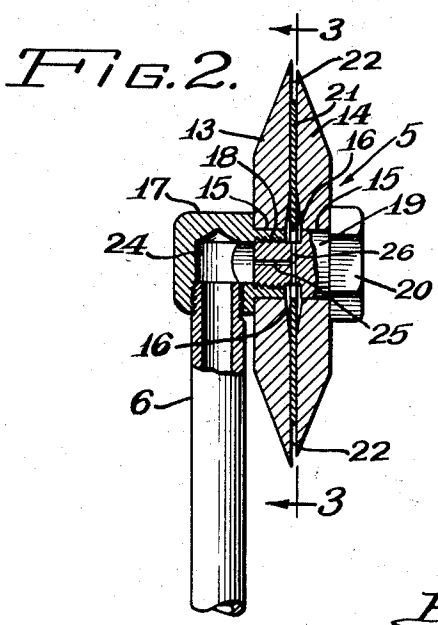
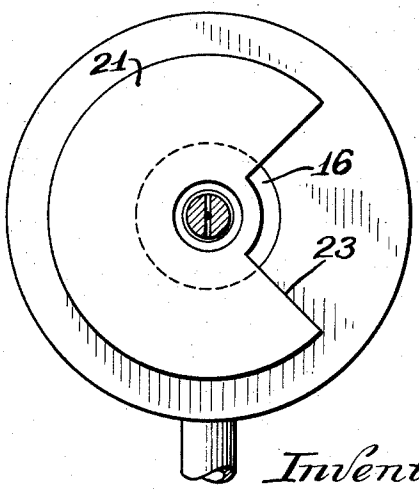


FIG. 3.



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2 Sheets-Sheet 2

FIG. 4.

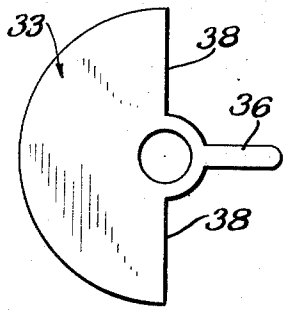


FIG. 5.

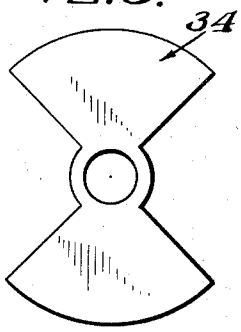


FIG. 6.

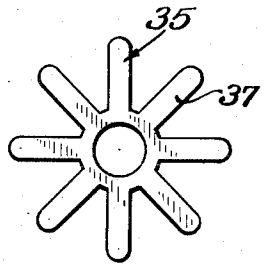


FIG. 7.

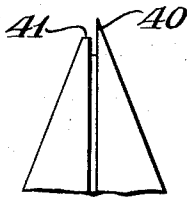


FIG. 8.

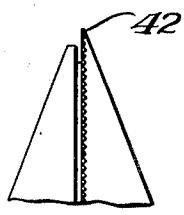


FIG. 9.

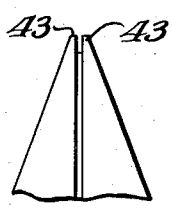


FIG. 10.

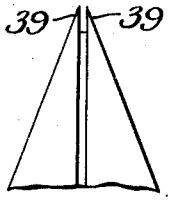


FIG. 11

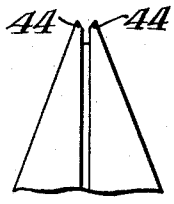


FIG. 12.

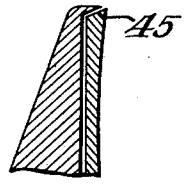


FIG. 13.

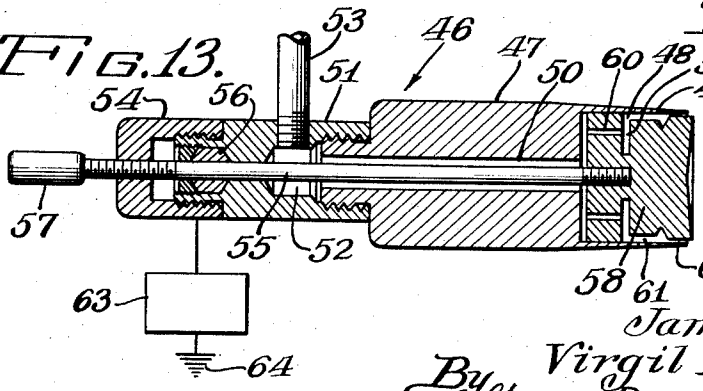
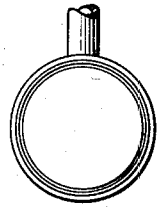


FIG. 14.



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2,860,599

ELECTROSTATIC COATING DEVICE WITH RESTRICTED FLUID PASSAGEWAY OPENING ADJACENT SHARP DISCHARGE EDGE

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Application August 13, 1954, Serial No. 449,697

3 Claims. (Cl. 118—626)

This invention relates to improvements in a device for electrostatically atomizing and spraying coating materials such as paints, enamels, lacquers and the like, and refers particularly to a device for directing and controlling the flow of the coating material to and through a zone wherein the material is acted upon by the electrostatic forces which atomize the material and direct the passage of the atomized material to the surface of an object to be coated.

It is known that liquids such as paints, enamels, lacquers and the like can be atomized when under predetermined conditions the material is subjected to an electric field of sufficiently high voltage. To take advantage of this phenomena for spray coating, however, introduces many difficult problems. One of the most difficult of the problems encountered resides in the requirement that the material must be introduced into the actuating electric field or the zone where the material can be effectively acted upon by the electric field, in a uniform, controlled manner and in a form related to the electrode such that uniform and continuous atomization will take place, and that the atomized particles be so produced and directed that they will uniformly coat the surface of an object.

The present invention relates to a device which may take a number of different physical forms, but which embodies several important features which, regardless of the overall form taken by the device, must be present. One of the important features of the device resides in the provision of an electrode which has a relatively sharp point, a relatively sharp edge, or relatively sharp points or edges at which the electrostatic charge may be accumulated in a most intense form, that is, the charge is concentrated over a relatively small area of the electrode. A second important feature resides in the shape or configuration of the electrode whereby an adequate area of a body to be coated may be uniformly and adequately coated when the electrode is juxtaposed in spaced relationship to the surface to be coated. A third important feature resides in the physical association of the electrode with other directing or confining agencies or surfaces whereby the material to be atomized and sprayed may be brought continuously and uniformly into the vicinity of the electrode in a form such that the electric field can efficiently atomize the material into charged particles.

As to the first feature of the device, hereinbefore specified, the electrode may take the form of a sharply pointed member or a plurality of sharply pointed members disposed in a desired alignment, or the electrode may take the form of an elongated curved or straight member having a relatively sharp edge, or the electrode may partake of both of these forms, such as a relatively elongated curved or straight member having a relatively sharp serrated edge.

As to the second feature of the device, hereinbefore specified, the electrode should be of a shape or configuration and should be capable of being so positioned with respect to the article to be coated, that a desired

spray pattern of desired area may be projected upon the surface of the article.

As to the third feature of the device, hereinbefore specified, the coating material must be brought to the electrode in such fashion and at such rate that the electric field can thoroughly atomize the material and charge the atomized particles. In order to accomplish this function most efficiently, the electrode comprises guiding or confining surfaces so related to each other that a relatively restricted zone is provided for the passage of the coating material to and through the electrode whereby the material brought to the electrode is in a relatively thin film or in a body of relatively small cross-section so that the entire volume of the material may be acted upon by the disrupting or atomizing force of the electric field and a finely divided spray will be formed comprising uniformly small particles.

For purposes of illustrating the invention several different forms of the device are shown and described including the preferred form thereof.

In the drawing,

Fig. 1 is a diagrammatic front elevational view of the improved spray device in operative position with respect to a surface to be sprayed.

Fig. 2 is an enlarged sectional view of one of the electrodes illustrated in Fig. 1.

Fig. 3 is a sectional view taken on line 3—3 of Fig. 2, showing particularly the pattern-forming spacer interposed between the plate of the spray electrodes.

Figs. 4, 5 and 6 are detailed views of different pattern-forming spacers which may be used, Fig. 4 showing a spacer for spraying a 180° pattern, Fig. 5 illustrating a spacer for spraying a double opposed 90° pattern, and Fig. 6 showing a spacer for spraying a 360° pattern.

Figs. 7 to 12 inclusive are greatly enlarged fragmentary detailed views of various types of spray electrode edges which may be employed.

Fig. 13 is a sectional view of a modified form of spray electrode.

Fig. 14 is an end view of the device shown in Fig. 13.

Referring in detail to the drawings, 1 indicates an object to be coated which may conveniently be carried by supports 2. The supports 2 may comprise a portion of a traveling conveyor (not shown) whereby the object 1 may be moved at a desired speed past a spraying device 3 in the direction of the arrow 4.

The device 3 may comprise one or more spray electrodes 5, two being illustrated, and each spray electrode may be supported by a pipe 6 which, in turn, may be carried by a suitable support 7 to hold the spray electrode at a desired distance from the plane of movement of the object 1. Flexible tubes 8 may connect into pipes 6 whereby a supply of paint, lacquer or other liquid coating material may be passed under desired pressure from a source of such coating material (not shown) to the spray electrodes.

The spray electrodes 5 are constructed of an electrically conductive material, preferably, metal, and each electrode is connected, by a conductor 9, to a source of high voltage direct current, shown diagrammatically at 10. The spray heads 5 are preferably maintained as the high potential positive side of the system and, hence, the object 1 is grounded, as at 11, and the power source 10 is also grounded, as at 12. If desired, however, the object 1 may be connected to the high potential side of the power source 10 and the spray electrodes may be grounded.

With the spray electrodes maintained at high potential, the conduits 8 are constructed of an insulating material such as polyethylene or the like, and if desired, the pipes 6 may also be constructed of insulating ma-

terial. Of course, the support 7 is adequately insulated from ground by conventional means (not shown).

The spray electrodes 5 comprise a pair of plates 13 and 14 each of which is substantially flat on one side and the opposite side adjacent the peripheral edge is tapered to a relatively sharp edge. Each of the plates is provided with a central aperture 15 and adjacent said aperture upon the flat face of each plate a shallow annular recess 16 is provided. A fitting 17 carries an internally threaded tubular extension 18 which is adapted to be positioned in recess 15 of plate 13 and a screw 19 having a hexagonal head 20 is adapted to extend through aperture 15 in plate 14 and threadedly engage the tubular extension 18. Thus, means is provided for fastening the plates 13 and 14 together.

A pattern-forming spacer 21 comprising a relatively thin metal disc is positioned between the flat faces of the plates 13 and 14. The disc 21 is of lesser diameter than either of the plates 13 and 14, and, hence, an annular space 22 is provided between the plates adjacent their peripheral edges. Disc 21 is provided with a substantially segmental notch 23, the inner portion of said notch overlapping an outer portion of each of the shallow recesses 16 provided in the plates.

The fitting 17 is provided with a hollow interior 24 and pipe 6 connects into said fitting, said pipe being in communication with the hollow interior 24. The shank of screw 19 is provided with a relatively restricted bore 25 which is disposed substantially axially in said screw. The bore 25 connects with a diametral transverse bore 26, the opposite ends of which connect into the space provided by the shallow recesses 16 in the plates 13 and 14. Thus, paint, lacquer or other liquid coating material employed in the device can be delivered through pipe 6 to the space within the spray electrode 5 provided by the shallow recesses 16.

In view of the fact that the segmental notch 23 overlaps the outer portion of the space provided by the recesses 16, the coating material delivered into said shallow recess can flow outwardly between the flat surfaces of the plates 13 and 14 through the space defined by the segmental notch 23.

In employing the spray electrode 5 the liquid coating material introduced thereto is maintained at a sufficient pressure to fill the volume of the space defined by the segmental notch 23 and the flat faces of the plates 13 and 14. As will be hereinafter more fully described, as the coating material moves through said segmental space it moves toward the outer peripheral edges of the plates 13 and 14. In view of the fact that said plates are tapered and terminate in a relatively sharp edge the electrical charge imparted to the spray electrode is concentrated at and adjacent said sharp edges. This concentration of the electric field tends to disrupt and atomize the liquid which moves outwardly through the segmental space and hence said atomized material leaves the edges of the plates as an extremely finely divided spray or mist. The pressure of the liquid flowing to the spray electrode is maintained such that it replenishes the liquid volume carried in the segmental space as said material is atomized and sprayed from the spray head.

The spray heads 5 are maintained at a predetermined distance from the plane of movement of the object 1 to be coated. Since the spray heads are maintained at a relatively high potential and since the object to be coated is grounded, an electric field is established between the spray heads and the object to be coated. The coating material which moves through the segmental space to the edges of the plates 13 and 14 and which is atomized adjacent the sharp edges of said plates, is acted upon by the electric field and the finely divided spray particles tend to move from the spray electrodes to the surface of the object to be coated.

By virtue of the sape of the segmental notch 23 a substantially fan-shaped spray discharge moves from the spray electrodes to the surface of the object 1. Employing the pattern forming disc 21 illustrated in Figs. 2 and 3, a fan-shaped spray of about 90° leaves the spray electrode. As will be hereinafter more fully described, the spray pattern which leaves the spray electrode can be changed by employing pattern forming spacers having different shaped cut-away portions corresponding to the segmental notch 23.

In employing the spray forming disc 21 it has been found that the density of the spray emitted from the edges of the plates 13 and 14 decreases from the central portion of the segmental notch to the angular defining edges of said notch. This change in spray density is not uniform but falls off relatively rapidly adjacent the angular defining eges of the notch.

This phenomena is employed to advantage in utilizing multiple spray electrodes since the spray pattern upon the object to be coated diminishes in density adjacent the edges of the pattern. For instance, in Fig. 1 the spray pattern of the upper spray electrode 5 is relatively dense between approximately the lines 27 and 28, and between the lines 28 and 30 the density falls off. When employing multiple spray electrodes, a second electrode may be positioned in offset relationship to the first electrode. For instance, in Fig. 1 the spray density of the lower spray electrode between the lines 30 and 31 will be relatively great whereas the spray density between the lines 28 and 30 formed by the lower spray electrode will be less dense and the density of the spray between the lines 31 and 32 will be less dense.

Accordingly, by employing multiple electrodes the thickness of the coating to be sprayed upon the object 1 can be made relatively uniform by overlapping the less dense spray areas from the offset spray electrodes. Of course, there is no sharp line of demarcation corresponding to lines 27, 28, 30 and 31. These lines are shown arbitrarily to illustrate the manner in which the restricted density spray patterns may be overlapped to make the entire spray area of uniform coated thickness.

Of course, the present invention broadly contemplates the use of one or more spray electrodes depending upon the area of the object 1 to be sprayed.

Referring particularly to Fig. 4 a different pattern forming spacer 33 is illustrated. The spacer 33 is of relatively flat disc construction but has a notch of substantially 180°.

In Fig. 5 a pattern forming spacer 34 is shown which is of disc construction but is provided with two substantially 90° notches.

In Fig. 6 a substantially cruciform pattern forming spacer 35 is illustrated wherein the notches aggregate substantially 360°. The relatively restricted arms 36 and 37 carried by the spacers 33 and 35 do not materially effect the spray density and said arms are merely used for the mechanical purpose of uniformly spacing the plates between which the spacers 33 and 35 are positioned. In other words, the spray pattern emitted from a spray electrode wherein the spacer 33 is employed will substantially span 180° and the pattern emitted from a spray electrode carrying the spacer 35 would be substantially 360° and the spray density in both cases would be substantially uniform throughout the angles.

The nature of the outer peripheral edges of the plates 13 and 14 are found to be of material importance. In the form of the invention illustrated in Figs. 2 and 3 it will be noted that the peripheral edges of the plates 13 and 14 are relatively sharp. It has been found that in general the sharper said edges are the less voltage is required to disrupt or atomize the liquid coating material. Although the precise phenomena which is involved is not thoroughly understood, it is believed that the disruption or atomization which takes place adjacent the peripheral edges of the spray electrode depends upon the concentrated intense electric field which is established adjacent the edges of the plates. When said edges are relatively

sharp a relatively high intensity field can be established with a lower operating voltage than would be the case were the edges relatively blunt. However, to accommodate the use of the device to paints, lacquers and liquid coating materials of various characteristics, different types of emitting edges may be employed upon the peripheries of the plates.

It has been found that with certain types of paints, peripheral edges such as illustrated in Fig. 2 are most adapted. Employing other types of paints or lacquers, peripheral edges such as illustrated at 39 in Fig. 10 appear to be most suitable, that is, where the diameters of the plates 13 and 14 would be equal and one edge would not be radially offset relative to its companion edge. Other conditions of operation may dictate the use of an edge arrangement as illustrated in Fig. 7 wherein the edge 40 is relatively sharp and the edge 41 is relatively blunt. As a modification of the form shown in Fig. 7 the relatively sharp edge 42 may be serrated or, as illustrated in Fig. 9, both edges may be radially flush and relatively blunt as illustrated at 43. Other uses may dictate arrangements such as illustrated at 44 in Fig. 11 or at 45 in Fig. 12.

In all cases, however, the nature of the emitting edges of the plates 13 and 14 have been found to be of importance with regard to the disruption or atomization of the coating material which seeps between said edges.

As has been hereinbefore described, the pressure of the coating material delivered to the spray electrode is so controlled that the space between the plates will always remain substantially filled with the liquid. The pressure is not maintained sufficiently high to deliver an excess of material to this space since it would tend to drip off and would be delivered to the edges of the electrodes at a rate faster than it could be atomized. In other words, the ideal condition is that the liquid be delivered to the edges at the same rate that said edges are capable of atomizing it while still maintaining the volume or space between the electrodes completely filled with liquid. The voltage which may be applied to the spray electrodes may range between 25,000 and 100,000 volts, the voltage depending upon the nature of the paint, lacquer or coating material and also depending upon the rate at which the coating material is delivered to the spray electrodes. Voltages higher than 100,000 volts may be employed, but to develop and control such higher voltages is in most instances economically unjustifiable. The distance that the object to be coated is maintained from the spray electrodes is also variable and will depend upon the voltage, the nature of the paint, lacquer or coating material, the nature of the object being coated and the area to be coated.

As an example of the present invention a pair of spray electrodes similar to the spray electrodes 5 were employed to coat a relatively flat metal plate. The plate was moved by a conventional conveyor past the spray electrodes at a rate of about 10 feet per minute and said plate was spaced from said electrodes at 12 inches. The electrodes were disposed in the fashion illustrated in Fig. 1 and the plates 13 and 14 were provided with peripheral edges similar to the plates illustrated in Fig. 2. The larger plate had a diameter of 4.000 inches and the smaller plate had a diameter of 3.960 inches. A pattern-forming spacer 21 having a notch angle of 90° was employed, said spacer having a thickness of .007 inch. The voltage maintained upon the spray electrodes was 90,000 volts and it was found that with a single pass of the object sprayed a relatively uniform spray coat of .001 inch was obtained. In this example paint having the following characteristics was employed: A white synthetic baking enamel with a viscosity of 25 seconds on a Zahn No. 2 cup.

As has been hereinbefore explained, the present invention may take a number of forms. However, to operate satisfactorily all forms must have predetermined common features. For instance, the spray electrode must have a sharp point, sharp points or a sharp edge whereupon the intensity of the electric field may be concentrated and the spray electrode must also be such that the paint, lacquer or other liquid coating may be fed to the vicinity of the sharp point or points or sharp edge in a uniform manner and in such physical form that it can be readily disrupted or atomized by the electric field.

As an example of another form which the invention may take, reference is made to Figs. 13 and 14. The reference numeral 46 indicates generally the modified spray electrode. The spray electrode 46 comprises a cylindrical member 47 which at one end is provided with a relatively large diameter recess 48 defined by a relatively thin tubular wall 49 which terminates outwardly in a relatively sharp circular edge. The member 47 is provided with an axial bore 50 which at one end connects with recess 48. A connecting piece 51 is threadedly connected to the rear end of the member 47 and is provided with a recess 52 into which paint supply pipe 53 connects.

A tail piece 54 threadedly connects with the rear end of the connecting piece 51 and a control rod 55 is threadedly mounted in the tail piece 54 and extends through the connecting piece and through the bore 50 and into recess 48. A packing ring 56 circumscribes rod 55 and seals the rear end of rod 55 to prevent passage of coating material from recess 52. A manipulating knob 57 is carried on the protruding end of rod 55 whereby said rod may be rotated to axially move it toward or away from recess 48.

A control plug 58 is immovably carried upon the forward end of rod 55 and is positioned in recess 48. The control plug is provided with a relatively deep annular groove 59 intermediate its length and the rear portion of the plug is provided with a plurality of bores 60 which connect into said groove. The rear portion of the plug is of an outer diameter which permits a snug slidable fit with the wall 49. Thus, the bores 60 permit communication between bore 50 and the forward portion of the recess 48. The forward portion of plug 58 is of a diameter such as to leave an annular space 61 between plug 58 and wall 49 and at the extreme forward end of the plug a relatively restricted annular space 62 is provided between the plug and the forward end portion of wall 49.

In operation, paint, lacquer or other coating material may be introduced into the spray electrode 46 through pipe 53 from a suitable source of supply under pressure (not shown). The coating material thus delivered is passed through the bore 50 and passes through the bores 60 in the plug 58 and moves through the annular spaces 61 and 62. The device 46 is connected to the high potential side of a power pack 63 which is grounded, as at 64. Accordingly, when the coating material moves into the restricted annular space 62 said coating material is subjected to the disrupting electrostatic force which atomizes the coating material. It can readily be seen that the wall 49 is drawn to a relatively sharp edge which is disposed adjacent the outlet of the coating material through the annular space 62. Hence, the coating material in passing through the space 62 is subjected to the high intensity electric field which is concentrated at the sharp circular edge of the wall 49.

The spray electrode 46 is employed in the same fashion as has been hereinbefore described with regard to the spray electrodes 5, that is, the object to be sprayed is spaced from the forward end of the spray electrode 46 and may be moved past said electrode by a suitable conventional conveyor. The object to be sprayed is grounded and hence an electrostatic field is established between the forward end of the spray electrode 46 and the grounded object to be coated. The atomized particles which leave the space 62 are thus drawn or forced toward the object to be coated. In the form of the invention illustrated in Figs. 13 and 14, the spray pattern emitted from the spray electrode 46 is substantially cylindrical in shape, con-

forming more or less to the circular annular space 62. By the manipulation of the knob 57 to axially move the control rod 55 the plug 58 may be moved inwardly or outwardly relative to the recess 48. Such movement will have an effect upon the spray pattern and may also be resorted to when coating materials of different physical characteristics are employed.

It will be noted that the spray electrode 46 partakes of all of the essential features of the spray electrode 5, that is, a sharp edge is provided for the establishment of a high intensity electric field, the edge being disposed adjacent a restricted space through which the coating liquid must pass whereby substantially all of the coating liquid is uniformly and thoroughly atomized. In employing the spray electrode 46, the pressure upon the coating liquid is adjusted and so correlated with respect to the voltage employed that the spaces 61 and 62 will always be completely filled with coating liquid but the coating liquid will not be discharged through said spaces at a rate which exceeds the capacity of the electric field to atomize the coating material.

It can readily be seen that many forms of the coating device may be devised by those skilled in the art and hence it is not intended that the present invention be limited to the specific forms illustrated.

We claim as our invention:

1. A spray electrode for electrostatically spraying an object with liquid coating material which comprises, a pair of stationary disc-shaped members of substantially the same diameter at least one of which has a relatively sharp arcuate outer peripheral edge, substantially segmental disc-shaped means interposed between said members to space said members from each other and provide a relatively flat passageway of restricted thickness between said members for the passage of liquid coating material, means for connecting said passageway to a source of coating material under pressure whereby said coating material is passed to the vicinity of said sharp peripheral edge, and means for connecting said discs to a source of electric potential higher than that of said object to be coated to atomize said coating material adjacent said sharp edge and charge the atomized particles.

2. A spray electrode for electrostatically spraying an object with liquid coating material which comprises, a pair of stationary disc-shaped members at least one of which has a relatively sharp arcuate outer peripheral edge, disc-shaped substantially segmental means of relatively restricted thickness interposed between said members to space said members from each other, said spacing means being provided with a segmental notch to provide a segmental relatively flat passageway between said members which opens adjacent said sharp arcuate peripheral edge for the passage of liquid coating material, stationary means within said disc-shaped members for connecting said passageway to a source of coating material under pressure whereby said coating material is passed uniformly and continuously to the vicinity of said sharp peripheral edge, and means for connecting said discs to a source of electric potential higher than that of said object to be coated to atomize said coating material adjacent said sharp edge and charge the atomized particles.

3. An electrostatic spray device for coating the surface of an object with a liquid coating material which comprises, a stationary spray electrode comprising a pair of opposed substantially disc-shaped members one of which has an arcuate relatively sharp discharge edge portion, said spray electrode being adapted to be disposed in spaced relationship to said surface to be coated, a spacer member of lesser area than the area of either of said disc members being disposed between said disc members to provide a restricted passageway which opens adjacent to said sharp discharge edge portion of the electrode, stationary means for connecting said entire passageway to a source of liquid coating material under pressure whereby coating material is fed uninterruptedly through said passageway to the sharp discharge edge portion of the electrode, means for maintaining the surface to be coated at a predetermined electrical potential, means for connecting said sharp discharge edge portion of the electrode to a source of electrical potential sufficiently different from that of said surface to be coated to disrupt the coating material emerging from said passageway and to reduce it to finely divided charged particles whereby said particles are carried by the electric field established between said electrode and the surface to be coated to said surface to uniformly coat said surface.

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