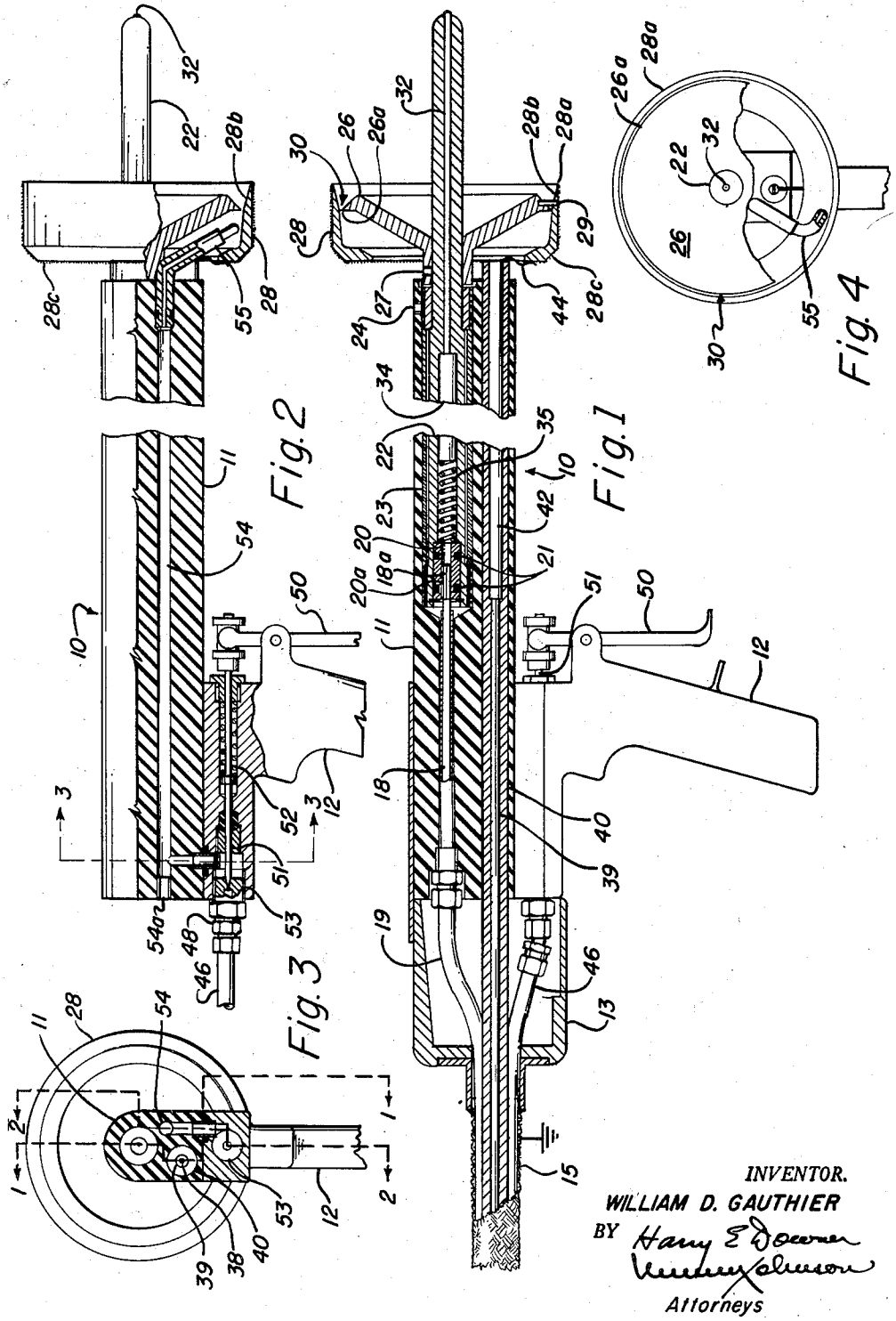
Feb. 23, 1960 W. D. GAUTHIER 2,926,106

APPARATUS AND METHODS FOR ELECTROSTATIC COATING UTILIZING AN INNER ELECTRODE TO SUBSTANTIALLY REDUCE THE CENTRAL VOID OF THE ANNULAR SPRAY PATTERN

Filed July 16, 1956 2 Sheets-Sheet 1



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2 Sheets-Sheet 2

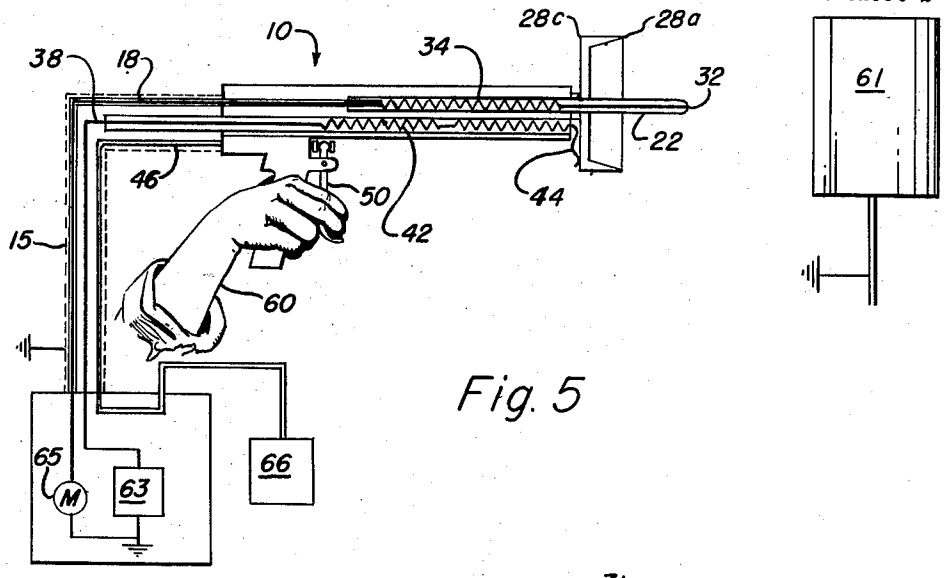


Fig. 5

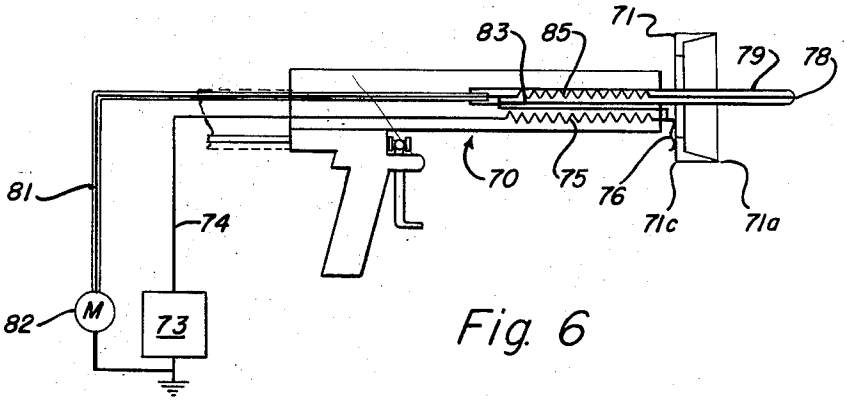


Fig. 6

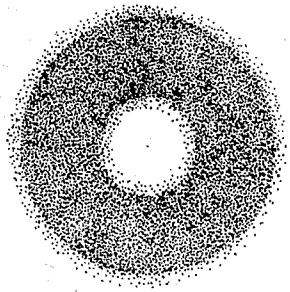


Fig. 7

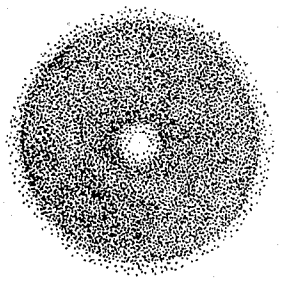


Fig. 8

INVENTOR.
WILLIAM D. GAUTHIER
BY Harry E Dawson
Attorneys

United States Patent Office 2,926,106
Patented Feb. 23, 1960

2,926,106

APPARATUS AND METHODS FOR ELECTROSTATIC COATING UTILIZING AN INNER ELECTRODE TO SUBSTANTIALLY REDUCE THE CENTRAL VOID OF THE ANNULAR SPRAY PATTERN

William D. Gauthier, Indianapolis, Ind., assignor to Ransburg-Electro-Coating Corp., Indianapolis, Ind., a corporation of Indiana

Application July 16, 1956, Serial No. 598,168

9 Claims. (Cl. 117—93)

My invention relates to improvements in apparatus and methods for electrostatically coating articles.

This application relates to a portable, manually operable airless electrostatic spray gun which produces a spray of electrically charged, finely divided paint particles in an annular or "doughnut-shaped" pattern, that is, a circular pattern having a void central portion which is substantially devoid of spray particles. Such an annular pattern has, in some instances, certain advantages. But in most hand spray operations, especially where the operator is acustomed to a conventional spray gun which does not produce a spray pattern having a void central portion, elimination or substantial reduction in the size of the void central portion of the spray is to be desired.

The use of a secondary electrostatic field to control the pattern of a charged spray of liquid coating material is broadly taught in U.S. Patent 2,658,009 to E. M. Ransburg. Surrounding an annular, hollow-centered charged spray with a similarly charged secondary electrostatic field in an attempt to compress the spray and thereby eliminate its void central portion has been suggested, but a surrounding secondary field entails the disadvantage of bulky apparatus for a hand spray gun and also to some degree at least causes deterioration in the quality of the electrostatic atomization of the liquid coating material.

I have discovered that it is possible to eliminate or substantially reduce the central void of a spray of liquid coating material issuing from an atomizing device in a pattern at least initially having a central portion substantially devoid of spray particles by maintaining a zone of particle-attracting electrical potential spaced from both the article to be coated and the atomizing device. Preferably this particle-attracting zone is maintained at a potential intermediate between the potentials of the atomizing device, normally at high potential, and the article, normally at ground, and the zone is located within the void central portion of the spray to divert inwardly into the central void substantial numbers of spray particles initially surrounding the central void. Also, I have discovered a novel electrical circuit for connecting an electrode in an electrostatic coating system.

It is an object of my invention to provide improvements in apparatus and methods for electrostatic coating with a spray of liquid coating material projected in a pattern having a void central portion in order to effect an improved, more efficient spray pattern.

A further object is the provision of a simple, inexpensive and compact atomizing device for the electrostatic spray coating of articles.

Another object of the invention is to provide an auxiliary electrode or other member in electrostatic coating apparatus at a desired potential intermediate that of the spray charging electrode and the article by connection through a high resistance to a point at a substantially different potential from that of the charging electrode.

The foregoing and further objects of my invention will be readily ascertained from the following detailed

description of the invention and by reference to the accompanying drawings, in which:

Fig. 1 is a detailed side elevational view, partially broken away, of electrostatic hand spray gun utilizing my invention;

Fig. 2 is a further partial view of the hand spray gun of Fig. 1 showing in detail the liquid feeding system;

Fig. 3 is a rear cross-sectional view of the hand spray gun;

Fig. 4 is a front view, partially broken away, showing the rotatable atomizing head of the hand spray gun;

Fig. 5 is a somewhat diagrammatic view of a coating system employing the apparatus illustrated in Figs. 1–4 and showing the electrical connections within the hand spray gun;

Fig. 6 is a diagrammatic view of alternative electrical connections for utilizing my invention with a hand spray gun;

Fig. 7 is an illustration of a typical spray pattern deposited on a flat sheet by the spray gun shown in Figs. 1–5 when used without my invention; and

Fig. 8 is an illustration of a typical improved spray pattern deposited on a flat sheet by the spray gun in Figs. 1–5 utilizing my invention.

Turning first to Figs. 1–4 the hand spray gun is identified in general as **10** and includes a housing of insulating material **11** such as nylon and a handle assembly **12** of metal connected to housing **11**. A rear cover **13**, also of metal, is mounted over the rear of housing **11** and connected to handle assembly **12** with screws. Flexible lines including a rotary power transmission line, a high voltage line and a liquid coating material feed line are contained within a grounded flexible protective sheath **15**, preferably of braided metal, which terminates within rear cover **13**.

The rotary power transmission line consists of a flexible shaft **18**, preferably of metal wire construction and electrically grounded as later described, extending from a source of rotary power not shown and running within a tube **19** of insulating material. The end of the flexible shaft includes a lug **18***a* which fits into a longitudinal slot **20***a* in a metal bushing **20** which is securely fitted by means of O-rings **21** into a shaft **22** of insulating material. Shaft **22** is journaled for rotation within a sleeve **23** which is secured within housing **11** by means of a plastic set screw **24**.

An atomizer support **26**, sometimes called a baffle ring is mounted for rotation onto the forward end of shaft **22** by a set screw **27**. A ring-like atomizer **28** having a forward liquid-discharge or atomizing edge **28***a* preferably of knife-like sharpness is rotatably supported concentrically about shaft **22** and spaced from atomizer support **26** by means of a plurality of pins **29** in order to provide an annular opening **30** between the outer edge **26***a* of the support and the inner or liquid-guiding surface **28***b* of the atomizer. Support **26**, screw **27**, atomizer **28** and pins **29** are all constructed of suitable insulating material such as nylon and the rotation of flexible shaft **18** is transmitted through bushing **20**, shaft **22** and support **26** to rotate the atomizer **28** concentrically about the axis of shaft **22** at a speed preferably in the order of 900 revolutions per minute.

A metal electrode **32** preferably of .080 diameter wire and having an exposed hemispherical tip extending beyond the forward end of the shaft is supported by shaft **22** with the electrode tip about 3 inches in front of edge **28***a*. The rear end of electrode **32** is connected directly or by a wire to a high resistance **34** of predetermined value, for example in the order of 1500 megohms. The resistance **34** may be held in contact with the electrode wire by a spring **35** which also provides an electrical connection between the rear end of high resistance **34** and

bushing 20. The bushing is maintained at ground potential by its connection to the grounded flexible shaft 18.

The high voltage line consists of a metal wire 38 encased in an insulating covering 39 which is protected by a length of insulating tubing 40 extending the length of housing 11 and rear cover 13 and somewhat rearwardly thereof. High voltage is conducted to the hand gun from a source hereinafter described through wire 38 whose forward end is connected to a high resistance 42 of predetermined value, for example, in the order of 1000 megohms. The forward end of high resistance 42 is electrically connected to a small metal wire spring 44 which makes "brush" contact with a permanently applied resistive coating 28c on the exterior surface of atomizer 28.

Resistive coatings, having high chemical and physical resistance to the ingredients of liquid coating materials used in hand spray gun 10 as well as predetermined desired high electrical resistance characteristics are known. Such a coating material preferably has finely divided carbon in a thermosetting synthetic resin. A preferred resin that has proved particularly useful is a mixed alkyd resin and phenolic resin. Once these resins have been set to an irreversible state by heating, they are not attacked by the coating material flowing over them, and because of the presence of the finely divided electrically conducted solid, the carbon black, the resistivity can be controlled to a desired value. The total resistance of resistive coating 28c, as measured from spring 44 to a conducting metal plate placed over the atomizing edge 28a of the atomizer, is at least 20 megohms and preferably in the order of 100 megohms.

Liquid coating material is supplied under positive pressure to hand gun 10 through a liquid coating material feed line 46 which is connected by suitable couplings to a conduit 48 (shown in Fig. 2) in the rear of handle assembly 12. Handle assembly 12 is adapted to be conveniently held by an operator and includes a trigger 50 which controls a needle valve 51 normally maintained by a spring 52 in a position to close off the forward end of conduit 48. When trigger 50 is operated, that is, squeezed toward the handle by an operator, needle valve 51 will move forwardly against spring 52 to open conduit 48 and permit the flow of liquid into a chamber 53 in the handle assembly and from this chamber through a passageway 54 in the gun housing (the rear end of which contains a plug 54a) to a nozzle 55 at the forward end of the gun. Liquid coating material is discharged from nozzle 55 onto the inner surface of rotating atomizer 28 to flow through opening 30 and spread into a thin film on surface 28b of the atomizer moving outwardly toward atomizing edge 28a.

Turning now to Fig. 5 the spray gun just described is shown diagrammatically in an electrostatic coating operation. Gun 10, adapted to be held by an operator whose hand is shown as 60, is maintained in spaced relation to an article 61 to be coated which is normally at ground potential as is the operator. High voltage line 38 from hand gun 10 is connected to a high voltage source 63 supplying voltage in the order of 100 kilovolts. The rotating elements of gun 10 are rotated, preferably at 900 r.p.m., by connecting flexible shaft 18 to a motor 65 which is suitably grounded as shown. Liquid coating material is fed to gun 10 at a rate in the order of 100 cc. per minute through the connection of liquid feed line 46 to a source of liquid coating material under pressure 66 which may be a pressure pot or a pump.

High voltage from a source of 100 kilovolts is applied through line 38, resistance 42, spring 44 and thence through resistive coating 28c to the atomizing edge 28a of the rotating atomizer. Due to the voltage drop across resistance 42 and coating 28c the voltage at atomizer edge 28a will be approximately 85 kilovolts when paint is supplied to the edge and the gun is 12 inches from the grounded article. Assuming, as will normally be the case, that the article 61 to be coated is the closest grounded object and is 12 inches from the gun, an electrostatic field having an average potential gradient of approximately 7,000 volts per inch will be established between edge 28a at high voltage and the grounded article. With gun 10 in coating position the operator squeezes trigger 50 to cause liquid coating material to flow from pressurized source 66 through line 46 and, through the internal liquid supply system best shown in Fig. 2, as a thin film to atomizer edge 28a. Adjacent to edge 28a the liquid is raised substantially to the electrical potential of edge 28a and liquid atomized and introduced as a spray into the electrostatic fields.

An unbroken column of liquid extending between chamber 53 in handle assembly 12 and atomizing edge 28a constitutes an electrical path between edge 28a at high voltage and the grounded handle. If the liquid column were as electrically conductive as copper, it is obvious that it would be impossible to maintain edge 28a at the desired potential of many kilovolts. However, very few, if any, commercial liquid coating materials possess any such degree of conductivity. While the ingredients (including solvents and thinners) used in the formulation of liquid coating materials vary widely in their conductivity, the great majority of commercially used liquid coating mixtures can be classed as relatively poor conductors which exhibit considerable resistance particularly in the form of columns of small diameter and thin films. For example, when a typical pigmented synthetic baking enamel extensively used in coating household appliances and kitchenware was used in gun 10 under the conditions above described, the liquid flowing between the grounded handle and the high voltage atomizing edge results in a voltage drop at the edge at most of one or two kilovolts which was of no consequence in the efficient operation of the coating system described.

An electrical attraction exists between the highly charged, atomized liquid coating material particles and the grounded article causing the spray particles to move toward and be deposited as a liquid coating on the article. Where the article is a substantially flat metal sheet parallel to the atomizing edge and were there no electrode 32 in the hand gun, the pattern of spray particles deposited on the article would be an annulus or "doughnut" having a substantial central portion devoid of spray particles as illustrated in Fig. 7.

Although article 61 is the nearest directly grounded object to edge 28a, electrode 32 is connected to high resistance 34, the readward end of which is grounded through flexible shaft 18. The exposed tip of electrode 32 lies prederably somewhat forwardly of edge 28a and at a point within the electrostatic field between edge 28a and article 61 which, in the absence of the electrode 32, would have a potential of approximately 70 kilovolts. Thus if the exposed portion of electrode 32 were electrically floating, rather than being ultimately connected to ground, it would assume a potential of approximately 70 kilovolts by virtue of its position in the electrostatic field. On the other hand if electrode 32 were connected to ground directly, rather than through high resistance 34, it would serve in the system described as ground terminal of an electrostatic field which would exist primarily between edge 28a and electrode 32 itself since electrode 32 would be considerably closer to edge 28a than is article 61. If grounded, electrode 32 would serve to reduce the voltage at edge 28a and any spray particles atomized therefrom would be attracted to and deposit largely on electrode 32, all of which would normally be undesirable.

I have found, however, that by connecting electrode 32 to ground through a high resistance 34 in the order of 1500 megohms, the tip of electrode 32 will be maintained at a particle-attracting potential in the order of

30 kilovolts which will cause spray particles to be attracted inwardly toward electrode **32** but with insufficient force to actually deposit any appreciable number of spray particles on the electrode or its insulating sheath **22**. Thus a substantial number of spray particles will be deflected from their normal path in the annular pattern and move inwardly and more particularly into the normally void central portion of the pattern to fill in substantially all or a major portion of the void central portion in the spray pattern. In addition, the outer limits of the pattern may be reduced and the spray made more dense, all of which serves to achieve a much more desirable pattern as deposited on the grounded article.

With my invention in the apparatus above described using a 4 inch diameter atomizer and with the forward end of the gun held approximately 12 inches from a grounded flat metal sheet, the spray pattern deposited on the sheet was substantially as shown in Fig. 8. Both the patterns shown in Figs. 7 and 8 were obtained by delivering to the spray gun approximately 100 cubic centimeters per minute of Lilly red synthetic baking enamel thinned with xylene to a viscosity of 20 seconds on a Zahn No. 2 cup. Of course, other patterns with more or less "filling in" of the central void can be obtained by changing the value of resistance **34**, the position of electrode **32** in relation to edge **28***a* and other variables in the system.

While my invention serves to reduce the central void portion of an annular spray pattern, additional unanticipated benefits may be obtained through use of the invention. Such benefits include fine atomization of the liquid coating material at lower operating voltages and, in some instances, increased uniformity in the deposition of spray particles on relatively sharp projecting edge portions of articles and in recessed areas of articles.

In spray coating systems in which the liquid is atomized primarily by electrostatic forces, it has been found that there is an upper as well as a lower limit as to the voltage required for producing the most desirable fineness of atomization, all other conditions remaining constant. This "optimum voltage" so-called for any given set of other conditions can be determined and usually the optimum voltage increases rather sharply as the distance between the atomizing device and the article to be coated is increased. In conveyorized coating operations this close relationship between optimum voltage and atomizer spacing dictates rather close control over the atomizer-to-article distance.

For example, using a conventional 4 inch diameter metal atomizing bell fed with a typical synthetic baking enamel, it was found that with the bell positioned 6 inches from the article to be coated optimum atomization of the liquid occurred with the bell at a potential of 70 kv.; with the bell at 12 inches, optimum atomization required 100 kilovolts; and with the bell at 18", 125 kilovolts were required. However, with the same atomizing bell using a central probe maintained at an intermediate potential substantially as described above, with the bell 6 inches from the article, 65 kilovolts were required for optimum atomization; with the bell at 12 inches, 75 kilovolts were required; and with the bell at 18 inches, only 95 kilovolts were required. All of the foregoing bell edge voltages were determined by direct measurement.

In this regard my invention permits the use of a lower voltage under any set of other conditions leading to the use of less expensive voltage supply mechanisms. Also, changes in atomizer-to-article spacing have less effect on the quality of atomization than with prior systems and effects less variation in the quality of atomization occasioned by changes in atomizer-to-article spacing.

For a given voltage applied to the atomizer the presence of my intermediate electrode increases the potential gradient at the atomizing site and thus may increase the charges on the spray particles. The electrode at the same time serves to reduce the potential gradient in the region between the intermediate electrode and the grounded article. The depositing portion of the electrostatic field, that is, the portion of the field surrounding the article, is thus of a lesser intensity than could otherwise be the case when optimum atomizing gradient is maintained. In a number of instances the invention effects more uniform coating of articles by increased deposition of coating material on sharp edge portions and recessed areas and such results may be due to increased charging of the spray particles and the reduced intensity of the field surrounding the article.

My invention is not limited to a hand operated atomizer, to the type or position of electrode or to the particular circuit above described. The invention as it relates to minimizing the central void portion of an annular pattern can be used with obvious advantage with a stationary, automatically operated atomizer as well as with hand spray operations.

Fig. 6 illustrates a further embodiment of my invention having a modified electrical circuit. A gun indicated generally as **70** is of the same shape and size as hand gun **10** previously described. Gun **70** includes a rotatable bell-shaped atomizer **71** to the atomizing edge **71***a* of which liquid coating material is fed by a liquid supply system not shown but identical to the system employed with gun **10** and shown in Figs. 2 and 6. High voltage is supplied to atomizing edge **71***a* from a high voltage source **73** through line **74**, high resistance **75** (for example, 500 megohms), spring **76** and resistive coating **71***c* on the outer surface of atomizer **71**.

An electrode **78**, all but the forward tip of which is encased in a rotatable shaft **79** of insulating material, is positioned axially of atomizer **71** preferably with the exposed tip of the electrode lying about 3 inches in front of atomizing edge **71***a*. In this embodiment where the electrode is connected to the high voltage source, it is preferred to have a small relatively sharp point on electrode **78**, rather than a hemispherical tip as for electrode **32**. Shaft **79**, similar to shaft **22** previously described, rotates atomizer **71** and is powered by a flexible shaft **81** from a motor **82**.

An electrical connection **83** from the forward end of resistance **75** to the forward end of flexible shaft **81** puts shaft **81** as well as motor **82** at high voltage. Electrode **78** is also maintained at high voltage by means of connection **83** and a further high resistance **85** (for example, 5000 megohms) in series as shown. In this circuit electrode **78** can be maintained at any desired potential intermediate that of the high voltage source **73** and ground by appropriate selection of values for resistances **75** and **85**, rather than having the electrode assume a potential by virtue of its proximity to the atomizing edge and the value of a resistance inserted between ground and the electrode as in the circuit shown in Fig. 5.

While I have shown and described in detail two embodiments of my invention, it should be understood that the invention may be used in many ways in electrostatic coating systems and is capable of numerous modifications. Changes in construction and arrangement may be made without departing from the spirit and scope of the invention.

I claim:

1. In a method of electrostatically spray coating an article by exposing the article to a spray of electrically charged liquid coating material particles issuing from an atomizing device maintained at a predetermined high electrical potential in an annular pattern whose central portion at least initially is substantially devoid of spray particles and maintaining the article to be coated at ground potential, the step of positioning an electrode to create in the region between the atomizing device and the article being coated and within the central void portion of said annular spray a zone at an electrical potential intermediate between said atomizing device and ground and substantially lower than the potential of such region

in the absence of said electrode so as to divert inwardly into said central void portion a substantial number of the spray particles initially surrounding said central void portion.

2. In a method of electrostatically coating an article by maintaining the article at ground potential and exposing the article to a spray of electrically charged coating material particles issuing from a device maintained at a predetermined high electrical potential, the steps of positioning an electrode in electrically influencing relation with said spray particles and adjacent to said device, and inducing on said electrode a predetermined desired potential intermediate between the high potential of the device and ground potential and substantially lower than the potential normally existing at the location of said electrode in the absence thereof by connecting the electrode to ground through a high resistance of predetermined value.

3. In a method of electrostatically spray coating a grounded article using an atomizing device producing a spray of charged liquid coating material particles in a pattern whose central portion at least initially is substantially devoid of spray particles, the step of positioning an electrode to create in the region between the atomizing device and the article being coated and within the central void portion of said spray a zone of electrically particle-attracting potential, said potential being substantially lower than the potential of such region in the absence of said electrode, serving to substantially reduce the central void of said pattern thereby to improve the uniformity of the coating deposited on the article.

4. In a method of electrostatically spray coating an article by exposing the article to a spray of electrically charged liquid coating material particles issuing from an atomizing device in a pattern initially having a void central portion substantially devoid of spray particles and the article being maintained at a particle-attracting electrical potential to cause spray particles to move toward the article, the step of diverting inwardly toward said void central portion by electrostatic forces effective from within said pattern void, and during the movement of spray particles toward the article, at least some of the particles initially surrounding said void central portion.

5. In apparatus for electrostatically spray coating an article, an atomizing device having a discharge portion for producing a spray of liquid coating material particles in a pattern initially having a void central portion substantially devoid of spray particles, means including a source of high voltage connected to the discharge portion of said atomizing device for maintaining said portion at a high electrical potential electrically to charge the spray of liquid coating material particles, an exposed electrode located at a point within the confines of said spray, a support of insulating material connecting the rearward portion of said electrode to the atomizing device, a high resistance of predetermined value, means within said support connecting said electrode to one end of said high resistance, and means connecting the other end of said high resistance to ground thereby to maintain said electrode at an electrical potential intermediate the discharge portion of said atomizing device and ground to establish an electrically particle-attracting potential about said electrode substantially lower than the potential about said point in the absence of said electrode serving to substantially reduce the central void of said spray pattern.

6. In apparatus for electrostatically spray coating an article, an atomizing device for producing a spray of liquid coating material particles in a pattern initially having a void central portion substantially devoid of spray particles, means including a source of high voltage connected to said atomizing device for maintaining said device at a high electrical potential and to charge the spray of liquid coating material particles, an exposed electrode, a support for maintaining said electrode at a point within the confines of said spray, a high resistance of predetermined value, means connecting said electrode to one end of said high resistance, and means connecting the other end of said high resistance to a point at a potential substantially different from that of the atomizing device to maintain said electrode at a potential substantially lower than the potential of such point in the absence of said electrode so as to electrostatically effect spray particles initially surrounding the void central portion of said spray to cause at least some of these spray particles to be attracted inwardly into said void central portion.

7. In apparatus for electrostatically spray coating an article, an atomizing device for producing a spray of liquid coating material particles in a pattern initially having a void central portion substantially devoid of spray particles, means including a source of high voltage connected to said atomizing device for maintaining said device at a high electrical potential and to charge the spray of liquid coating material particles, an exposed electrode, a support for maintaining said electrode at a point within the confines of said spray, a high resistance of predetermined value, means connecting said electrode to one end of said high resistance, and means connecting the other end of said high resistance to said source of high voltage to maintain said electrode at a potential substantially lower than the potential of said point in the absence of said electrode for electrostatically affecting spray particles initially surrounding the void central portion of said spray to cause at least some of these spray particles to be attracted inwardly into said void central portion.

8. In apparatus for electrostatically spray coating an article, an atomizing device for producing a spray of liquid coating material in a pattern initially having a central portion substantially devoid of spray particles, means including a source of high voltage connected to said atomizing device to electrically charge the spray of liquid coating material particles, an exposed electrode positioned at a point along the axis of the central void portion of said spray, and means including a conection to said electrode for maintaining said electrode at a predetermined electrical potential to establish an electrically particle-attracting potential along said axis which is substantially lower than the potential along said axis in the absence of said electrode which serves to substantially reduce the central void portion of said spray pattern.

9. In apparatus for electrostatically spray coating an article, an atomizing device having a discharge portion for producing a spray of liquid coating material particles in a pattern initially having a void central portion substantially devoid of spray particles, means including a source of high voltage conected to the discharge portion of said atomizing device for maintaining said portion at a high electrical potential electrically to charge the spray of liquid coating material particles, an exposed electrode positioned at a point within the confines of said spray, a support of insulating material connecting the rearward portion of said electrode to the atomizing device, a high resistance of predetermined value, means within said support connecting said electrode to one end of said high resistance, and means connecting the other end of said high resistance to said source of high voltage thereby to maintain said electrode at an electrical potential intermediate the discharge portion of said atomizing device and ground to establish an electrically particle-attracting potential about said electrode substantially lower than the potential of said point in the absence of such electrode serving to substantially reduce the central void of said spray pattern.

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