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Tamny

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[54] **ELECTROSTATIC SPRAY APPARATUS AND METHOD**

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[51] **Int. Cl.** **B05b 5/00**; F23d 11/28

[58] **Field of Search** 118/621, 627, 629; 239/3, 239/15; 117/93.4

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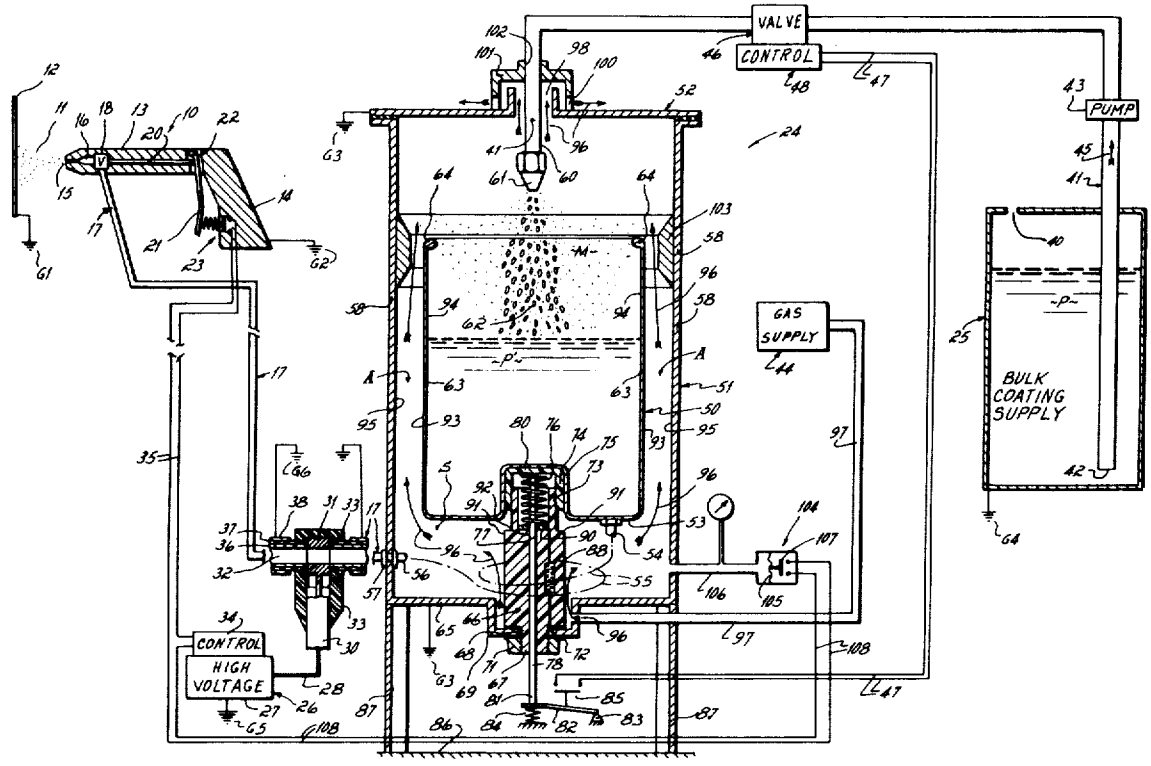
Primary Examiner—Ronald Feldbaum

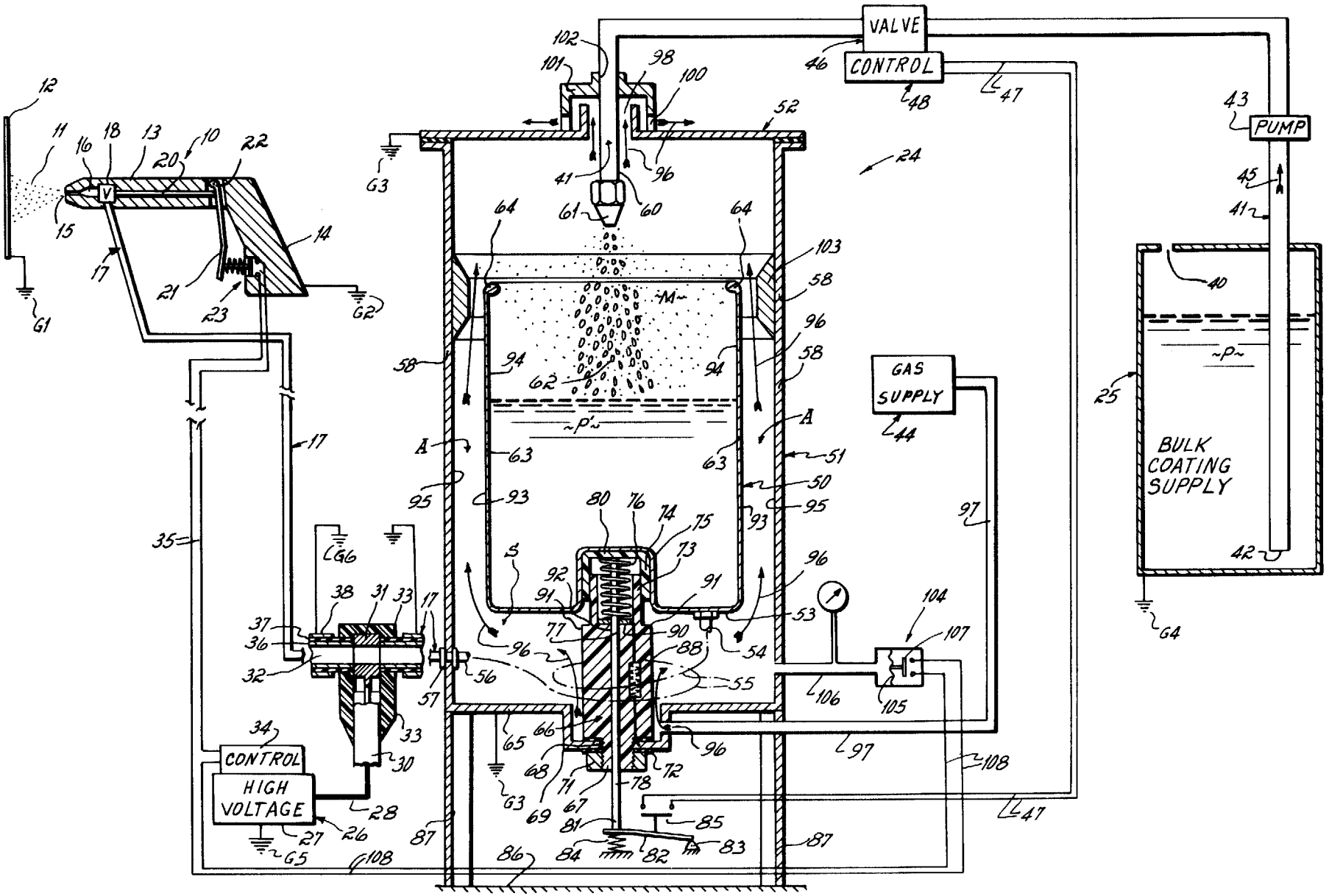
Attorney, Agent, or Firm—Wood, Herron & Evans

[57] **ABSTRACT**

An electrostatic spray apparatus and method for spraying electrically conductive coating materials on a continuous basis from an electrically grounded bulk coating supply. Included is a spray gun from which electrostatically charged coating material is emitted toward an electrically grounded object to be coated; a high voltage source for electrostatically charging the coating material emitted from the gun; an electrically grounded bulk coating storage tank; and an intermediate tank assembly including (a) an inner tank for continuously supplying coating to the gun via a hose, which inner tank is automatically and periodically replenished with coating material from the grounded bulk supply tank without establishing an electrically conductive path between the electrically grounded bulk storage tank and the inner tank which contains coating material electrostatically charged via the column of conductive coating material in the gun hose, (b) an electrically grounded outer housing or container completely enclosing the inner tank, and (c) an insulative support electrically isolating the inner tank from the outer grounded container, which support is subjected to a gaseous stream to prevent build-up thereon of a conductive film of coating material which, if permitted to occur, would shortcircuit the grounded outer container to the electrostatically charged coating material stored in the inner tank and thereby destroy the electrical isolation between the inner tank and the grounded outer container.

22 Claims, 1 Drawing Figure




VALVE
CONTROL
PUMP
GAS SUPPLY
BULK COATING SUPPLY
CONTROL HIGH VOLTAGE
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18
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10
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G1
G2
G3
G4
G5
G6
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ELECTROSTATIC SPRAY APPARATUS AND METHOD

This invention relates to electrostatic spray coating and more particularly to an apparatus and method for electrostatically spray coating electrically conductive coating materials on a continuous basis which permits all exposed elements of the spraying apparatus to be electrically grounded, thereby avoiding shock and ignition hazards occasioned by inadvertent contact by operating personnel with, and/or accidental grounding of, any exposed portion of the system.

Coating materials sprayed on objects to be coated can be categorized, from the standpoint of their electrical conductivity, as falling into one of three categories, namely, low intermediate or moderate, and high conductivity coatings. Coating resistivities in the general range of 2×10^5 ohm-centimeters to 10^6 ohm-centimeters are considered to be in the intermediate or moderate conductivity range, while coating materials having electrical resistivities below and above this range are viewed as falling in the high and low conductivity categories, respectively. While specific resistivity values have been used to define low, intermediate and high conductivity range, it is understood that these resistivity values are arbitrary and relative, and employed only for the purpose of illustration. Accordingly, a coating material having a resistivity above or below the range of 2×10^5–10^6 ohm-centimeters could conceivably be considered as an intermediate or moderate conductivity coating material, notwithstanding that it falls without, although near, the specific numerical range noted. Similarly, a coating material with a resistivity between 2×10^5 ohm-centimeters and 10^6 ohm-centimeters, near one of the other of these limits, may possibly be considered as either a high or low conductivity coating depending on the end of the intermediate range to which it is closest. As used herein, the term "electrically conductive coating material" refers to coating materials of both the intermediate and high conductivity types.

Heretofore there has been no commercially feasible method or apparatus for spraying, on a continuous basis (vis-a-vis-batching operations), an electrostatically charged flow of conductive coating material in which all elements of the spray coating system exposed to the environment are electrically grounded, thereby permitting an operator to contact any exposed portion of the entire spray equipment system without risk of electrical shock and/or accommodating accidental grounding of any exposed portion of the system without risk of ignition hazards should the equipment be located in an explosive environment as is the case when petrochemical solvent-based paints are being sprayed.

In one spray system proposed in German Pat. No. 2,019,466 designed for coating articles with electrically conductive paint, which is not susceptive of continuous operation, the paint supply tank, which is connected to the gun via a hose, is located on an electrically nonconductive stand or platform spaced above the floor (which is at ground potential) a distance sufficient to avoid arcing or dielectric breakdown of the air between the tank and floor. This is necessary as a consequence of the fact that the contents of the tank are at the charging potential by reason of the conductive column of paint in the hose which interconnects the spray gun electrode and the tank contents. With such an arrangement, and assuming the tank is fabricated of electrically conductive material which is not uncommon, the exposed surface of the tank is electrostatically charged at the operating potential. An operator inadvertently contacting the tank risks serious electrical shock. Additionally, should a grounded object accidentally contact the tank, there is presented a significant ignition hazard where the conductive paint is of the petrochemical solvent-based type, since the environment is likely to be explosive.

Of course, the foregoing shock and ignition hazards can be minimized by limiting access to the tank by, for example, placing the tank in an area which is fenced off. However, this is inconvenient, adds to the cost of the system, and does not permit the tank to be conveniently moved when the spray equipment is utilized at different locations within the plant.

In accordance with the proposal of German Pat. No. 2,128,455 also directed to a batch-type operation, the ignition and shock hazards attendant operator contact and/or accidental grounding of the electrostatically charged paint tank are considered to be overcome by completely encasing the electrostatically charged paint tank within an insulative housing, such as a tank fabricated of nonconductive material of much larger size within which the electrostatically charged paint tank can be placed.

However, a distinct disadvantage of each of the foregoing proposals is that they permit only batch type, and not continuous, spraying by reason of the fact that the amount of spraying which can be done during any given interval is limited by the size of the tank. Once the contents of the tank have been consumed it is necessary to interrupt the spraying operation, de-energize the electrostatic generator, electrically ground the tank to discharge any electrostatic charge which accumulated on it during the spraying operation, open the tank and replenish the tank supply from a bulk storage paint supply such as from a large drum or the like. After all this has been done, and then only, can the tank be closed and the electrostatic spray coating operation resumed. This kind of operation is known as "batch-type" spraying, vis-a-vis "continuous" spraying.

Furthermore, a large nonconductive enclosure immediately surrounding a high voltage electrostatic source, as in the second of the foregoing proposals, tends to accumulate charge inbalance on its inner and outer surfaces leading to a secondary shock hazard upon contact by an operator.

In accordance with a further proposal described in U.S. Pat. No. 3,122,320, it is suggested that a system for coating with electrically conductive paint on a continuous basis (non-batch) from a first electrostatically charged tank which feeds the gun can be provided by replenishing the conductive paint in the first tank from a second grounded bulk supply tank which sprays the paint into the first tank thereby presumably avoiding electrical continuity between the bulk supply tank which is grounded and the tank connected to the gun which is charged. While this proposal might conceivably permit conductive paint to be electrostatically sprayed on a continuous basis, it does not overcome the shock and ignition hazards which attend inadvertent contact of the exposed electrostatically charged portions of the system by an operator and/or grounded object.

Accordingly, it has been objective of this invention to provide an apparatus and method for electrostatically spraying conductive paint on a continuous (non-batch) basis free of shock and ignition hazards occasioned by inadvertent contact of exposed portions of the apparatus by an operator and/or other grounded article. This objective has been accomplished in accordance with certain of the principles of this invention by supplying, via a hose, electrically conductive paint to a gun from a paint tank which is enclosed within and spaced from an outer electrically grounded tank-enclosing container, the spaced relation being provided by an insulative support member physically contacting both the inner tank and outer container and over which a gas flow is directed to prevent deposition thereon of an electrically conductive paint film which if permitted to accumulate would provide a conductive path between the electrostatically charged inner tank and the outer electrically grounded container; and by further providing an electrically grounded source of bulk coating material and material conveying means interconnecting the bulk source and the inner tank for transferring material therebetween without establishing an electrically conductive path between the bulk source and the inner tank.

In accordance with a preferred embodiment of the invention the inner tank is open at the top and spaced from the outer grounded container by means of an insulative support extending between the spaced superimposed bases thereof, with the uncharged conductive coating material from the electrically grounded bulk supply tank being introduced in a discontinuous fashion into the inner tank from a hose passing through the top of the outer container. As a consequence of supplying conductive coating material to the inner tank from the electrically grounded bulk supply without establishing an electrically conductive path between the bulk source and the electrostatically charged material stored in the inner tank, continuous (non-batch) spray coating is possible utilizing an electrically grounded bulk paint supply.

Additionally, and by reason of directing a gas stream over the insulative support which spaces the inner tank from the electrically grounded outer container, an electrically conductive film of coating material originating from, for example, vaporized paint within the open-topped inner tank, is not permitted to accumulate on the tank support structure, which support structure constitutes the only direct physical link between the electrostatically charged inner container and the electrically grounded outer container, thereby preventing the creation of a short-circuit path between the inner electrostatically charged tank and the grounded outer container. A further advantage, attributable to placement at the bottom of the open-topped inner tank of the insulative support which spaces the inner tank from the outer grounded container, is that the distance between (a) the open top of the inner tank whereat conductive coating vapors concentrate and (b) the support which constitutes the only potential short-circuit path between the inner and outer tanks, is maximized to further reduce the possibility of a conductive film accumulating on the support and short-circuiting the inner and outer tanks.

In accordance with a further aspect of the invention, the gas flow, in addition to being directed over the insulative support which spaces the inner and outer tanks, is also directed vertically upwardly in the annular region between the inner and outer tanks with a velocity which exceeds the downwardly directed terminal velocity of vaporized coating particles or droplets tending to move downwardly toward the insulative tank support under the force of gravity. This further enhances the likelihood that an electrically conductive film will not be deposited on the support linking the inner and outer tanks.

In a preferred form of the invention an area restrictor in the form of a nonconductive circular ring is mounted in the annular flow region between the inner and outer tanks proximate the upper edge of the inner tank. Such an area restrictor, when positioned in the manner indicated, increases the local upward velocity of the gas stream in the region of the inner tank opening, whereat particles or droplets of conductive coating from the mist located above the stored coating in the inner tank would tend to enter the annular flow region between the tanks in the course of moving downwardly toward the tank support.

In accordance with a further feature of the invention, the gas stream is provided from a pressurized source of low moisture content gas via a suitable hose or the like. This has the dual advantage of pressurizing the contents of the inner tank to provide a pressurized flow of coating to the spray gun and promoting evaporation of any coating which might condense on the inner tank support.

Assuming the gas utilized to sweep the tank support and provide pressurized coating flow is also non-toxic and nonexplosive, very simple means can be utilized to exhaust the gas from the outer container. Specifically, such gas flow exhaust means can take the form of a simple vent provided in the top of the outer container above the inner tank through which the gas is vented, which is introduced at the bottom of the container, exhausts to the atmosphere. Such a gas exhaust arrangement does not create environmental pollution hazards nor does it create ignition hazards.

These and other advantages and objectives of the invention will become more readily apparent from a detailed description of the drawing in which the FIGURE is a schematic diagram of a preferred embodiment of a coating material spray system incorporating the principles of this invention.

The preferred embodiment, as shown in the FIGURE, includes a spray device **10**, preferably in the form of a hand-held spray gun, for emitting electrostatically charged coating material **11**, e.g., electrically conductive water-based paint, toward an object **12** to be coated which is maintained at an electrical potential substantially different from that of the charged coating material emitted from the spray gun. In practice, the coating material **11** as emitted from the gun **10** is in atomized droplet or particulate form as is well known in the electrostatic coating field, such atomization or the like being accomplished in accordance with conventional airless spray, air spray, or electrostatic atomization principles. The emitted material **11** is typically electrostatically charged to a potential in the range of 50 kv – **100** kv, although potentials outside this range are possible, while the article **12** to be coated is typically maintained at zero or ground potential as indicated by ground connection **G1**.

While the advantages provided by the instant invention are perhaps greatest when a spray device of the

manually held variety is used, it is to be understood that the invention can also be used with stationary spray devices secured to a fixed stationary support, as well as movable spray devices used in automatic spray systems in which the spray device is mounted on a movable support which reciprocates vertically and/or horizontally in response to control signals generated by a suitable position controller.

The gun **10** includes an elongated barrel **13** fabricated of electrically insulative material and a handle **14** fabricated of electrically conductive material. The spray gun handle **14** is customarily electrically grounded as shown by ground connection G2. The longitudinal length of the insulative barrel **13**, which establishes the distance between the emission point or nozzle **15**, whereat the electrostatically charged material **11** leaves the gun, and the electrically conductive handle **14**, should be selected to provide an "electrical standoff," i.e., avoid arcing, Corona discharge, undesirable electrical shunt current levels and the like, between the handle and the nozzle. Located within the gun is a conduit **16** through which paint, supplied to the gun via a hose **17** from a remote source to be described, flows to the nozzle **15**. Connected in the conduit **16** is a paint flow valve **18** having an actuating plunger **20** which reciprocates under the action of a movable finger-operated trigger **21** pivoted to the gun at **22**. Inward and outward movement of the trigger **21** reciprocates the plunger **20** to open and close the flow valve **18** respectively, regulating the flow of paint from the gun is a manner to be described. Also operated by the trigger **21** is a normally open-circuited electrical switch **23** which, when the trigger **21** is depressed, is placed in a closed-circuit condition to initiate the application of an electrostatic charging potential to the paint in a manner also to be described hereafter.

To provide the capability of supplying the gun **10**, via the hose or conduit **17**, with electrically conductive paint on a continuous basis, an intermittently refillable intermediate tank assembly **24** and a bulk coating supply tank **25**, both of which are grounded, as indicated by ground connections G3 and G4, are provided. The supply of electrically conductive paint to the gun **10** on a "continuous" basis from an electrically grounded paint supply, as is possible with the apparatus and method of this invention, is to be distinguished from what is known as "batch-type" operation. In such operation the tank directly supplying paint to the gun via an interconnecting hose supplies the gun with paint only until the contents of the tank are depleted, at which time it is necessary to stop the painting operation, electrically discharge the tank, open the tank and refill it with a new supply of paint, following which the tank is closed and the spraying of electrostatically charged paint resumed. The significance of the fact that electrically conductive paint is supplied via hose **17** to the gun **10** on a continuous basis from tanks **24** and **25** which are electrically grounded will become apparent hereafter. It is sufficient at this point to note only that by utilizing electrically grounded tanks **24** and **25** electrically conductive paint can be supplied continuously by hose **17** to the gun **10** without need for locating the tanks **24** and **25** on specially constructed dielectric platforms in areas which have been fenced off or otherwise made inaccessible for the purpose of avoiding electrical shock and ignition hazards which attend exposure of high voltage equipment to operating personnel and/or inadvertent grounding.

A high voltage electrostatic generator **26** of conventional design, having a housing **27** electrically grounded as shown schematically by ground connection G5, provides at its output conductor **28** an electrostatic potential sufficient in magnitude to charge the paint **11** emitted from nozzle **15** to the desired level. In a preferred form the high voltage output **28** is electrically connected via an insulated element **30** to an electrically conductive electrode in the form of a ring **31** located within the bore **32** of the paint hose **17** such that paint flowing through the hose is electrostatically charged at the voltage output from the generator **26** on line **28**. Since the paint flowing through the hose **17** is electrically conductive, the coating material **11** emitted from the nozzle **15** will be electrostatically charged to essentially the potential of the ring **31** via the electrically conductive paint column in the hose **17** between the electrode ring **31** and the nozzle **15**. A suitable electrically insulative fitting **33** surrounds and seals the insulated element **30** and the hose **17** in the region of the charging electrode ring **31**. A suitable control **34** is operatively connected to the high voltage generator **26** for controlling the ON and OFF state of the generator in response to actuation of the trigger **21** via electrical control wires **35**, as will become more apparent hereafter.

While electrostatic charging of the emitted electrically conductive coating material **11** is accomplished in the preferred embodiment by charging the electrically conductive paint as it moves through the hose **17**, other methods are possible. For example, the emitted coating material **11** can be electrostatically charged in the region of the nozzle **15** by mounting an electrode (not shown) in the vicinity of the nozzle, which electrode is electrically connected to the high voltage generator output line **28** via a suitable insulated cable (not shown). However, such an arrangement has the disadvantage of requiring that a cable, insulated for high voltage, be connected to the gun, making the gun more cumbersome to handle and increasing electrical shock and ignition hazards occasioned by the added electrical energy capacitively stored in the cable. However, this disadvantage of a gun-mounted high voltage electrode can be overcome by mounting the high voltage generator within the gun as disclosed and claimed in Senay U.S. Pat. No. 3,731,145, assigned to the assignee of this application. A still further alternative method of electrostatically charging the electrically conductive material **11** emitted from the gun **10** is to connect the output **28** from the high voltage generator **26** to the tank containing the paint which feeds hose **17** such that it makes electrical contact with the coating material therein, as described, for example, in U.S. Pat. No. 3,794,243, assigned to the assignee of this application.

The hose **17**, which transports electrostatically charged paint within its bore **32** from the intermediate tank assembly **24** to the gun **10**, preferably has an interior layer or zone **36** which is impermeable and chemically inert with respect to the electrically conductive paint flowing through the bore **32**, an intermediate insulative layer **37** which, in combination with the layer **36**, has a dielectric strength sufficient to prevent dielectric breakdown when subjected to the charging potential by the electrostatically charged conductive paint flowing in the bore **32**. Preferably surrounding and in

physical contact with the intermediate layer **37** is an electrically conductive element **38** which is grounded as schematically shown by ground connection **G6.** The grounded element **38** prevents the accumulation of electrical charge on the exterior of the hose **17** occasioned by minor current leakage radially through the hose from the electrostatically charged paint flowing therethrough. Accumulation of leakage charge on the exterior of the hose **17,** which might otherwise occur were the electrically grounded conductive element **38** not provided, presents an ignition and/or electrical shock hazards should it accidentally become grounded in an explosive environment and/or contact an operator.

The bulk coating supply tank **25** which as noted previously is grounded at G4 can be fabricated of any suitable material and be shaped in any suitable form. Preferably the tank **25** has a large storage capacity, for example, 100 gallons or more. Located within tank **25,** in which is stored a large quantity of electrically conductive paint P, is a paint circulating pump **43** having a suction end **42** located in the bottom region of the tank. The pump **43** provides a pressurized flow of paint in the tube **41** in the direction of arrow **45.** Interconnected in the paint hose **41** is a suitable flow control valve **46** for regulating the flow of paint in hose **41** in response to a control input on lines **47** to an associated electrical control **48,** such as a solenoid, derived in a manner to become apparent hereafter. The paint P can be replenished as needed through opening **40.**

The intermediate tank assembly **24** is supplied with coating material from the bulk supply **25** under the control of valve **46** when the coating supply in tank assembly **24** reaches a predetermined depletion level. Intermediate tank assembly **24** includes an inner coating material container or tank **50,** and an outer container, enclosure or tank **51** which encloses the inner tank. The outer tank **51** is preferably constructed of electrically conductive material, and as previously noted is electrically grounded as shown schematically at G3. The interior of the outer tank **51** is accessible from the outside for assembly and maintenance purposes via an opening in the top thereof wich is normally closed with a selectively removable cover **52** which passes the paint transporting hose **41** from bulk supply **25.** The inner tank **50,** which holds or stores a supply of electrically conductive paint P', is preferably fabricated of electrically conductive material. Extending from the bottom **53** of the tank **50** and communicating with the tank interior is one end **54** of an insulative helical paint conveying tube or hose **55,** the other end **56** of which connects to the end of the paint hose **17** passing through a suitable located sealing grommet **57** positioned in an opening in the lower section of wall **58** of the outer tank **51.** The helical tube **55** transports electrostatically charged paint from the interior of container **50** to the hose **17** for transmission to the gun **10.** Since the electrically conductive paint within the bore **32** of the tube **17** is electrically charged at the potential of the output **28** of high voltage generator **26,** the paint P' within the tank **50** is also at the electrostatic charging potential by reason of the electrically conductive paint column in hose **55** which interconnects the hose **17** with the interior of the inner tank **50.**

To facilitate replenishing the supply of paint in inner tank **50** (which is at the electrostatic charging potential) from the bulk coating supply tank **25** (which is at grounded potential) via the hose **41** without placing the contents P of bulk coating supply tank **25,** and in turn the tank **25** itself, at the electrostatic charging potential, the transfer of paint from the end **60** of the tube **41** to the inner tank **50** must be accomplished without establishing an electrically conductive path between the paint issuing from hose end **60** and the electrostatically charged paint P' located in the inner tank **50.** To accomplish this, in accordance with a preferred embodiment of the invention, a nozzle **61** secured to the end **60** of the hose **41** is provided to divide the flow of paint issuing from hose **60** into an electrically discontinuous spray of particulate or droplet form, as shown schematically by the discrete particles **62.** If electrical discontinuity is to be obtained between the paint issuing from hose end **60** and the paint P' in the inner container **50** by use of a spray nozzle **61,** a coarse spray is preferable to a fine spray or mist.

Alternatively, electrical discontinuity between the material flowing through hose end **60** and the paint P' in the inner container **50** can be obtained without use of a spray nozzle **61** by discharging the paint from the hose end **60** in timed, spaced, successive discrete quantities or pulses. Such could be accomplished by operating the control **48,** which actuates the valve **46,** in a pulsating mode in accordance with techniques well-known in the art.

To avoid arcing, Corona discharge and the like between the paint issuing from hose end **60** (or nozzle **61**) which is at electrical ground potential and the paint P' in the inner container **50** which is at the electrostatic charging potential, it is necessary to position the hose end **60** (or nozzle **61**) a distance from the maximum contemplated level of the paint P' sufficient to provide a suitable electrical standoff. Similarly, to avoid arcing, etc. between the ground potential paint issuing from hose end **60** (or nozzle **61**) and the inner container **50** which is in contact with the electrostatically charged paint P', the shortest distance between the vertical side wall **63** and/or the upper edge **64** of the inner container **50** and the hose end **60** (or nozzle **61**) must be sufficient to provide an electrical standoff. It is also essential to space the upper edge **64** of the inner container **50** which is at high electrostatic potential from the electrically grounded side wall **58** and cover **52** of the outer container **51** a sufficient distance to provide an electrical standoff condition.

To further reduce the possibility of arcing, Corona discharge and the like between the inner container edge **64** which is electrostatically charged and the ground potential outer container wall **58** and cover **52,** the upper edge **64** should be smoothly contoured to avoid sharp edges which increase the concentration of the electrostatic field thereat.

It is also desirable to space the electrostatically charged vertical side wall **63** and the grounded outer container wall **58** from each other a distance sufficient to avoid arcing, Corona discharge and the like. Similarly, the electrostatically charged inner container bottom **53** and the grounded outer container bottom **65** should be spaced apart a distance sufficient to provide a suitable electrical standoff.

For example, at a typical electrostatic potential of 75 kv a standoff of approximately 6 inches between the conductive surfaces of the inner tank **50** and outer tank **51** may be expected to limit the average leakage current from tank **50** to tank **51** to less than 25 micro-

amps. Efficient electrostatic coating requires that the power supply provide both a high potential to establish the necessary electrostatic field between the gun and work, as well as a current flow sufficient to electrically charge paint particles emitted from the spray gun. A further demand is imposed on the power supply by current leakage from the charged system to earth grounds other than the work piece. The power supply therefore must, if efficient coating is to be achieved, have sufficient capability to meet each of the foregoing demands. There is, however, a practical limit on power supply capability due to personnel hazards which are created as the power supply capability is increased beyond safe limits. To minimize this safety hazard, without deteriorating coating efficiency, current leakage must be held to a minimum.

To support and locate the inner container **50** relative to the outer container **51** as desired, a support structure **66** in the form of a vertically disposed column of insulative material is secured in fixed rigid relation to the outer container bottom **65**. The lower end **67** of the insulative support column **66** preferably takes the form of a threaded stub which extends downwardly through an opening **68** provided in a cup-shaped central section **69** of the outer tank bottom **65**. A nut **71** threads on the projecting portion of the stub **67** to lock the column **66** in its desired upright position. A grommet **72** disposed between the opening **68** and the threaded stub **67** seals the opening when the stub is locked in place with the threaded nut **71**.

The upper end of the column **66** is provided with a tubular section **73** which telescopes within an inverted cup **74**, preferably fabricated of conductive material, which snugly fits within an inverted recessed section **75** formed in the bottom **53** of the inner tank **50**. A conductive compression spring **76** positioned within the tubular section **73** of the vertical support **66**, for reasons to become apparent hereafter, applies an upward force to the bottom **53** of the inner tank **50**.

Positioned within a vertical axially disposed bore **77** provided in the support column **66** is a longitudinal insulative element or rod **78**, the upper end of which contacts the uppermost section **80** of the inverted cup **74**. The bottom end **81** of the rod **78** contacts a lever **82** pivotally mounted at **83** which is upwardly biased by a compression spring **84**. Mounted on the lever **82** is a switch **85**.

When the supply of paint P' in the inner container **50** reaches some predetermined depletion or low level and the inner container **50** has risen upwardly under the action of spring **76** to a specified point, the lever **82** biased by spring **84** pivots clockwise about spatially fixed point **83** causing switch **85** to complete a circuit through wires **47**. This, in turn, causes the control **48** to open the valve **46**, whereupon ground potential paint from the grounded bulk coating supply tank **25** is supplied via the hose **41** to the interior of the inner tank **50** to replenish electrostatically charged paint supply P'. As described previously, replenishment of tank **50** from bulk supply **25** is accomplished in an electrically discontinuous manner via the nozzle **61** which converts what could be an electrically continuous paint stream issuing from hose end **60** into an electrically discontinuous coarse spray **62**.

By techniques commonly known, the actuation of switch **85** is provided with a dead band such that the inner tank **50** drops to a predetermined lower level as a consequence of being replenished with paint from the bulk supply **25** before switch **85** is disengaged to effect the closing of valve **46**.

The detector or sensor for determining when it is necessary to replenish the supply of paint in the inner tank **50** may take a variety of forms other than the rod **78** movable with the inner tank **50** and switch arrangement **82, 83, 84** and **85**. For example, level detectors or sensors operating on pneumatic, magnetic, optical and like principles well-known to those skilled in the art could be employed. The particular detecting or sensing scheme shown in the FIGURE and described herein is illustrative only.

To space the bottom **65** of the outer container **51** from the floor **86** or the like, the outer tank **51** is provided with a downwardly extending enclosure **87** which provides an accommodation space between the outer container bottom **65** and the floor **86** for the projecting end **81** of the movable actuating rod **78** and the switch **82, 83, 84** and **85**. Of course, if the sensor used to detect the level of paint in the inner tank **50** were contained within outer container **51**, or located other than below the bottom **65** of outer tank **51**, outer tank **51** could be placed directly on floor **86**, dispensing with the need for enclosure **87**.

To provide a controlled bleed to ground potential of electrical charge accumulated on inner tank **50**, and in the electrically charged paint P' when the high voltage generator **26** is de-energized, a bleed resistor **88** is provided. Preferred resistance values for said bleed resistor would be in the range of 10g–30g ohms, although a somewhat wider range would be acceptable. Resistor **88** is connected between the grounded outer container **51** and an electrically conductive washer **90** disposed between the bottom of the compression spring and the bottom of the tubular extension **73** of the support column **66**. The bleed resistor **88** preferably is embedded within and completely surrounded by the insulative support column **66**, although this is not necessary. Alternatively, the bleed resistor **88** could be directly connected between the grounded outer container **51** and the inner container **50** at any point along the bottom **53** or side walls **63** thereof. Of course, such an alternative resistor connection must avoid surface short-circuiting and should provide suitable accommodation for relative movement between the inner and outer containers **50** and **51** as occurs in the preferred embodiment wherein the inner container moves up and down depending upon the quantity of paint P' stored therein at any given time.

Since any electrically conductive paint stored in the inner container **50** has a certain degree of volatility, a paint mist M will exist in the space above the stored paint P' due to volatization or evaporation of the stored paint P' in tank **50**. This mist M will produce an electrically conductive paint film if allowed to deposit on the exterior surface **91** of column **66** or the interface **92** between column **66** and rod **78** which collectively space the inner and outer tanks, which surfaces are adjacent to the space S which communicates with the mist of conductive paint above the level of the paint P' via annular path A between vertical tank walls **63** and **58**. This electrically conductive paint film can complete an electrically conductive path between the outer tank **51** which is grounded and the electrically charged paint P' stored in the inner tank. Such an electrically conductive path between the electrically charged paint P'

stored in the inner container **50** and the electrically grounded outer tank **51**, if permitted to exist, would prevent electrical isolation of the electrostatically charged paint P' from the grounded outer tank **51**, resulting in an excessive current drain from the electrostatically charged portion of the system.

To avoid the above-described electrical path between the electrostatically charged paint P' in tank **50** and the outer tank **51** established by deposition of an electrically conductive film of paint on the surfaces **91** and **92**, a flow of gas in an upward direction is indicated by arrow **96** is established in the space S between tank bottoms **53** and **65**, and in the annular flow path A established by the vertical side wall **63** of inner tank **50** and the side wall **58** of outer tank **51**. This upwardly directed gas flow **96** sweeps over tank support surface **91** and through the annular path A, preventing the accumulation of an electrically conductive paint film of the type described which, if permitted to occur, would electrically short-circuit the electrically grounded outer tank **51** to the electrically charged paint P' stored in the inner tank **50**.

To provide gas flow **96**, the supply **44** of gas is connected via a tube **97** to the space S between the inner and outer tank bottoms **53** and **65**. Preferably the gas supply tube **97** is connected to the interior of the outer tank **51** at a point adjacent the bottom of the outer tank such that the entire exposed surface **91** of the tank support element **66** is subjected to the air flow **96**. This maximizes the likelihood that an electrically conductive film of paint originating with the paint mist M existing in the inner container **50** above the level of the charged paint P' will not deposit an electrically conductive film on surfaces **91** and **92** and thereby not establish a short-circuit path between the outer tank **51** and the electrically charged stored paint P' in the inner tank.

The gas flow **96** is exhausted from the interior of the outer tank **51** at the top thereof via an exhaust path defined by an oversized bore **98** formed in the cover **52** loosely surrounding the downwardly extending paint hose **41** and lateral vent holes **100** formed in a fitting **101** mounted to the upper surface of the cover. A bore **102** in the fitting **101** snugly embraces the exterior of the paint hose **41**.

The upward velocity of the gas stream **96** in the region of the edge **64** of the inner tank **50** is preferably selected to exceed the downward terminal velocity of paint particles from mist M entering the annular path A between the confronting walls **58** and **63** of the outer and inner tanks **51** and **50**. This, in addition to the gas flow oversurface **91**, insures that a paint particle entering the annular cavity A from mist M at a point proximate the edge **64** will not reach the bottom region or space S between the tank bottoms **65** and **53** to deposit on the surfaces **91** and **92**. To increase the local velocity of the gas flow **96** in the annular flow path A proximate the edge **64**, a nonconductive flow area restrictor **103** in the form of a circular ring having upper and lower beveled edges is secured to the wall **58** of the outer tank **51** opposite the upper edge **64** of the inner tank **50**. The restrictor ring **103** produces a localized reduction in the area of annular flow path A proximate inner tank edge **64**, thereby increasing the local velocity of the upwardly moving gas stream in the region of the edge **64**.

Preferably the gas introduced into the space S and annular path A to establish the gas flow **96** is relatively moisture-free. This promotes evaporation of any paint film which could conceivably be deposited on the surfaces **91** and **92**.

A sensor **104**, in the form of a pressure responsive switch having a movable diaphragm **105** which communicates with the space S via a hose **106** is provided. A normally open electrical switch **107** closes to connect wires **108** when the pressure in the space S reaches a level correlated to the desired gas flow **96**. Electrical bridging of wires **108** by the pressure-responsive switch **104**, in series combination with electrical bridging of wires **35** by the trigger-actuated switch **23** occurring when the operator desires to paint the article **12**, actuates the control **34** to energize the high voltage generator **26** and in turn electrostatically charge the paint passing through the hose **17** via the ring electrode **31**. Thus, in the preferred embodiment electrostatic charging of the electrically conductive paint in the hose **17** which, as indicated, also electrostatically charges the stored paint P' via the paint column in hoses **17** and **55**, can only occur when both the finger-actuated trigger **21** has been depressed and the gas supply **44** is operative to provide the gas flow **96**.

In the event that cover **52** of outer tank **51** is opened, providing access to the electrostatically charged portion of the system, the pressure in the space S is immediately reduced, opening the pressure-responsive switch **104** and de-energizing the high voltage generator **26**. The accumulated electrostatic charge is then quickly bled off to ground through bleed resistor **88**.

The gas source **44**, in addition to establishing a gas flow **96** in the container **51** via hose **97**, additionally functions to pressurize the paint P' stored within inner tank **50** such that paint flows under pressure to the gun via hoses **55** and **17**. Of course, as an alternative to pressurizing the flow, or as a supplement to it, a fluid pump (not shown) mounted to the bottom **53** of the inner tank **50** could be interconnected in the hose **55** adjacent the hose end **54** for pumping the charged paint from the inner tank **50** to the gun via hoses **55** and **17**.

Significantly, the tank support structure **66** which, if coated with a film of conductive paint, would establish a short-circuit between the electrically grounded outer tank **51** and the electrically charged paint P', is located between the bottoms **53** and **65** of the inner and outer tanks **50** and **51**. This maximizes the distance between (a) the potential short-circuit conductive paint film on surfaces **91** and **92** and (b) the mist M of conductive paint existing in the interior of the inner tank **50** above the level of the electrostatically charged paint P', which mist constitutes the source of the conductive paint film on surfaces **91** and **92**. Maximization of this distance between the location of the mist M of electrically conductive paint and the potential short-circuit path creatable by the paint film on surfaces **91** and **92** minimizes the likelihood that the mist M will deposit on the surfaces **91** and **92** a film of conductive paint, in turn minimizing the likelihood that a short-circuit will occur between electrically grounded tank **51** and the electrostatically charged paint P' in the inner tank **50**.

The helical shape of paint hose **55** between the bottom **53** of the vertically movable inner tank **50** and the stationary paint hose **17** enables the inner tank **50** to freely shift in a vertical direction as the level of the

paint P' stored in the inner container **50** varies during use between replenishments of the inner tank via the valve-controlled bulk coating supply tank **25.**

While the invention has been described in connection with a preferred form of telescoping support **66, 74** for spacing and electrically isolating the inner and outer tanks **50** and **51,** while simultaneously permitting relative movement therebetween to accommodate the paint level sensing function, other insulative support arrangements can be utilized to electrically isolate the inner and outer tanks. Additionally, while the tank isolating support in the preferred embodiment is located between the bottoms **53** and **65** of the inner and outer tanks **50** and **51,** the support may likewise be positioned elsewhere.

The preferred embodiment of the invention has utilized means in the form of an air sweep for volatilizing conductive liquid material, e.g., condensed moisture and/or coating material, which may be deposited on the exposed surfaces of the insulative support which spaces the inner and outer tanks. Other volatilizing conductive devices may, of course, also be used. For example, the auxiliary volatilizing means could take the form of a heater embedded in the support. The heater would elevate the temperature of the exposed surfaces of the support sufficiently to volatilize liquid material deposited thereon. This in turn would prevent build-up of an electrically conductive film of material on the exposed surfaces of the support which, if permitted to occur, could electrically connect the inner and outer tanks.

Having described the invention, it is claimed:

1. An electrostatic coating system operable on a continuous basis for coating articles with electrically conductive material supplied from an electrically grounded bulk coating source comprising:

a material spray device for emitting electrostatically charged coating material for application to an article maintained at an electrostatic potential different from that of said emitted coating material,

an electrically grounded source of uncharged bulk coating material,

an inner container for storing coating material within the interior thereof, said inner container having an outer wall,

coating material transmission means for transferring uncharged coating material from said bulk source to said inner container without establishing an electrically conductive path between said bulk source and said inner container,

an electrically grounded outer container enclosing said inner container and spaced therefrom to provide a gas flow path between the inner wall thereof and said outer wall of said inner container, said gas flow path communicating with said interior of said inner container,

a conduit interconnecting said inner container and said spray device for conveying coating material from said inner container to said spray device, said conduit being constructed of insulative material sufficient to withstand dielectric breakdown when conveying electrostatically charged coating material,

a high voltage source having an output connected for electrostatically charging said coating material emitted by said spray device,

an electrically nonconductive support structure physically contacting both said inner and outer containers for supporting said inner container in electrically isolated relation relative to said outer container, and

a source of gas connected to said gas flow path for providing a gas flow in said flow path to prevent deposition of a film of coating material on said support structure sufficient to conduct a substantial level of electrical current from said inner container to said outer container.

2. The system of claim **1** further including a detector responsive to the quantity of coating material in said inner container for actuating said transmission means to transfer uncharged coating material from said bulk source to said inner container when the quantity of coating material in said inner container is less than a specified amount.

3. The system of claim **2** wherein said support includes resilient means which permit movement of said inner container relative to said outer container to a degree correlated to the quantity of coating material in said inner container, and wherein said detector is responsive to a specified degree of movement of said inner container to effect said transfer of uncharged coating material from said bulk source to said inner container when the quantity of coating material in said inner container is less than said specified amount.

4. The system of claim **3** wherein said detector includes an element movable with said inner container and an element sensor immovable relative to said outer container for sensing movement of said inner container relative to said outer container for effecting said transmission of uncharged material from said bulk source to said inner container when the quantity of coating material in said inner container is less than said specified amount.

5. The system of claim **4** wherein said element is housed within said support and thereby unexposed to said interior of said inner container to prevent deposition of coating material thereon.

6. The system of claim **1** further including an electrically conductive outer member surrounding and physically contacting at least a portion of said insulative conduit, said outer member being electrically grounded to avoid accumulation of electrical charge on the exterior of said insulative conduit.

7. The system of claim **1** wherein said uncharged coating material transmission means includes means to emit uncharged coating material to the said interior of said inner container in a physically discontinuous flow.

8. The system of claim **7** wherein said uncharged coating material emitter is constructed to emit uncharged coating material in spray form to said interior of said inner container.

9. The system of claim **7** wherein said uncharged coating material emitter is constructed to emit uncharged coating material in sequential discrete bursts which are spaced in time to avoid electrical continuity between successive discrete bursts.

10. The system of claim **1** further including an electrical resistor electrically connected between said inner container and said grounded outer container to bleed electrical charge at a controlled rate from said inner container to said outer container.

11. The apparatus of claim **1** wherein said inner container has an opening in the upper region thereof communicating with said gas flow path through which coating material passes downwardly into said inner con-

tainer interior from said coating material transmission means located thereabove, and wherein said support structure physically contacts said inner container in the lower region thereof, and wherein said gas source connects to said gas flow path proximate said lower region of said inner container.

12. The apparatus of claim **11** further including an area restriction located in said gas flow path to increase the velocity of said gas sufficiently to prevent downward movement of coating material from said inner container opening to said support.

13. The apparatus of claim **11** wherein said opening in said upper region of said inner container is defined by a smoothly contoured margin of said inner container wall free of sharp edges to minimize electrical discharge when said inner container is subjected to said electrostatic charging potential.

14. The apparatus of claim **1** wherein said inner and outer containers are spaced apart a distance sufficient to avoid electrical corona discharge therebetween when said inner container is subjected to said electrostatic charging potential.

15. The system of claim **1** wherein said gas source provides substantially moisture-free gas to said gas flow path to enhance evaporation of coating material located in said gas flow path.

16. The system of claim **1** wherein said outer container further includes gas exhaust means for exhausting gas from the interior of said outer container following passage through said gas flow path.

17. The system of claim **1** further including a sensor communicating with said gas flow path for preventing energization of said high voltage source in the absence of said gas flow in said gas flow path.

18. The apparatus of claim **1** wherein said gas source provides a pressurized gas to said gas flow path to pressurize the interior of said outer container and promote pressure flow of coating material to said spray device via said conduit.

19. An electrostatic coating system operable on a continuous basis for coating articles with electrically conductive liquid material supplied from an electrically grounded bulk coating source comprising:

a material spray device for emitting electrostatically charged coating material for application to an article maintained at an electrostatic potential different from that of said emitted coating material,

an electrically grounded source of uncharged bulk coating material,

an inner container for storing coating material within the interior thereof, said inner container having an opening in the upper region thereof communicating with the interior of the container, an outer wall, and a bottom,

coating material transmission means for transferring uncharged coating material from said bulk source to said inner container via said opening without establishing an electrically conductive path between said bulk source and said inner container,

an electrically grounded outer container enclosing said inner container and spaced therefrom to provide a gaseous region between the inner wall thereof and said outer wall of said inner container, said gaseous region communicating with said interior of said inner container via said opening,

a conduit interconnecting said inner container and said spray device for conveying coating material from said inner container to said spray device, said conduit being constructed of insulative material sufficient to withstand dielectric breakdown when conveying electrostatically charged coating material,

a high voltage source having an output connected for electrostatically charging coating material emitted by said spray device, and

an electrically nonconductive support structure exposed to said gaseous region and physically contacting both said inner and outer containers proximate said bottom of said inner container for supporting said inner container in electrically isolated relation relative to said outer container at a point remote from said opening in said inner container to maximize the distance within said gaseous region between said support and said inner container opening.

20. The apparatus of claim **19** further including means associated with said support to volatilize liquid material deposited on said support to thereby prevent accumulation of a conductive surface film on said support structure sufficient to conduct a hazardous level of electrical current from said inner container to said outer container.

21. The apparatus of claim **19** further including means for establishing in said gaseous region a barrier which does not physically contact said inner container to impede migration of liquid material, and wherein said barrier means is located between said support and said inner container opening.

22. An electrostatic coating system operable on a continuous basis for coating articles with electrically conductive material supplied from an electrically grounded bulk coating source comprising:

a material spray device for emitting electrostatically charged coating material for application to an article maintained at an electrostatic potential different from that of said emitted coating material,

an inner container for storing coating material within the interior thereof, said inner container having an outer wall,

coating material transmission means for transferring uncharged coating material from said bulk source to said inner container without establishing an electrically conductive path between said bulk source and said inner container,

an electrically grounded outer container enclosing said inner container and spaced therefrom, to provide a gaseous region between the inner wall thereof and said outer wall of said inner container, said gaseous region communicating with said interior of said inner container,

a conduit interconnecting said inner container and said spray device for conveying coating material from said inner container to said spray device, said conduit being constructed of insulative material sufficient to withstand dielectric breakdown when conveying electrostatically charged coating material,

a high voltage source having an output connected for electrostatically charging coating material emitted by said spray device,

an electrically nonconductive support structure physically contacting both said inner and outer containers for supporting said inner container in electrically isolated relation relative to said outer con-

tainer, said support structure exposed to said gaseous region, and

means associated with said support to volatilize liquid material deposited on said support to thereby prevent accumulation of a conductive surface film on said support structure sufficient to conduct a hazardous level of electrical current from said inner container to said outer container.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,892,357

DATED : July 1, 1975

INVENTOR(S) : Simon Z. Tamny

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, line 30, "is" should be --in--.

Column 7, line 44, insert the word "through" after "cover 52".

Signed and Sealed this

fourteenth Day of *October 1975*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks