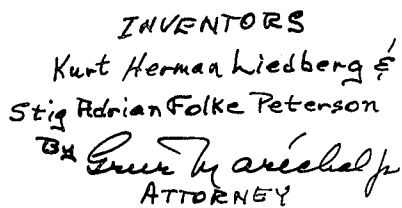


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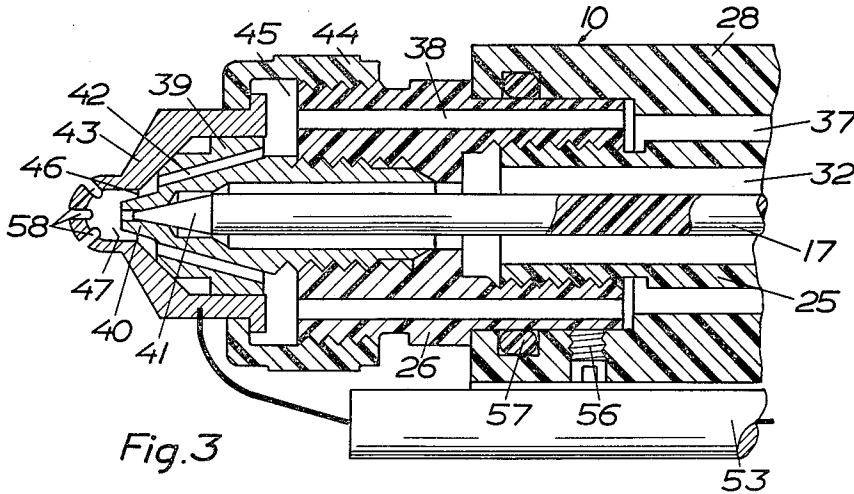
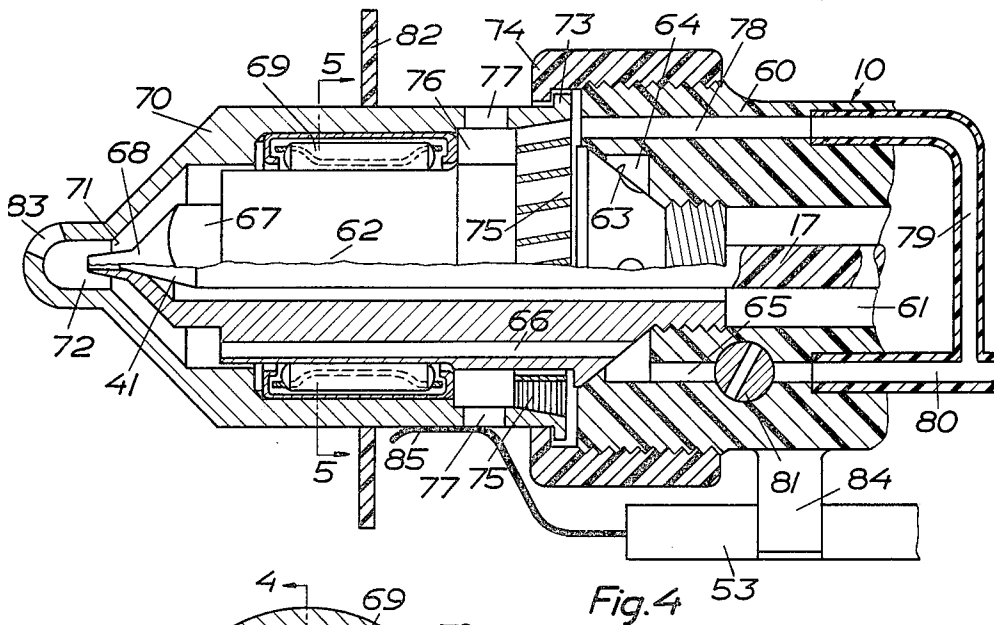
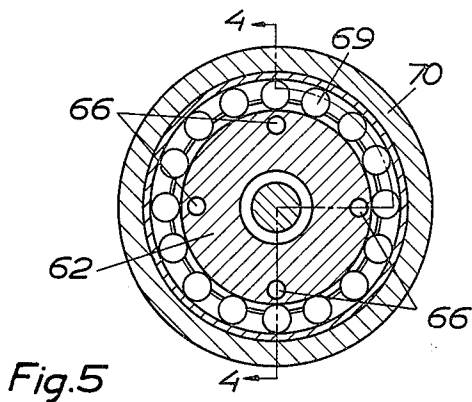
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ELECTROSTATIC SPRAY COATING APPARATUS

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2 Sheets-Sheet 2



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ELECTROSTATIC SPRAY COATING APPARATUS

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This invention relates to spray coating apparatus and more particularly to an electrostatic spray coating apparatus for atomizing and charging particles of coating material for use in electrostatic liquid coating deposition systems incorporating an electrostatic field created between the article to be coated and the issuing source of the coating material. As a such issuing source the invention features a gaseous pressure fluid driven spray gun.

One object of the invention is to provide an electrostatic spray coating apparatus which works on the principle of atomization of the coating material with the help of a gaseous pressure fluid and simultaneous electrical charging of the material, the gun being provided with improved means for performing said charging in connection with the atomization. Another object of the invention is to provide an electrostatic spray coating apparatus of the above character with projection of a jet of liquid particles into the atmosphere via a mixing chamber for the jet placed under high electrostatic tension in order to retard and efficiently charge said particles. A further object of the invention is to provide an electrostatic spray coating apparatus of the above character in which the particles of the jet receive an additional retardation and charging by means of a secondary electrode in the path of said jet. A still further object of the invention is to provide, in an electrostatic spray coating apparatus of the above character, a rotatable mixing chamber or a rotatable spray nozzle under high tension for rotating the jet and thereby retarding the projected particles of said jet.

The above and other objects of the invention will become obvious from the following description and from the accompanying drawings, in which three embodiments of the invention are illustrated by way of examples. It should be understood that these embodiments are only illustrative of the invention and that various modifications may be made within the scope of the claims without departing from the scope of the invention.

In the drawings, wherein like parts are designated by like reference characters throughout the several views,

FIG. 1 is a sectional side view of an electrostatic spray coating gun according to the invention,

FIG. 2 is a nozzle end view of the spray gun in FIG. 1,

FIG. 3 is a sectional side view of the nozzle end of a modified spray gun according to the invention,

FIG. 4 is a sectional diagrammatic side view of the nozzle end of another modification of the spray gun, viewed substantially on line 4-4 in FIG. 5 but omitting some of the needle bearings, and

FIG. 5 is a section on line 5-5 in FIG. 4.

The spray coating apparatus in FIG. 1 incorporates a body portion or barrel portion 10 of electrically insulating material carried by a conventional body 11 of a spray gun provided with a hand grip 12 and an inlet 13 for gaseous pressure fluid such as air. The apparatus is also provided with a liquid inlet 14 for fluent or liquid coating material and a trigger 15 for controlling by means of a valve 16 the delivery of air from the inlet 13 to the body portion 10. The trigger 15 is also arranged to control the discharge of liquid coating material by displacing a spindle 17 of insulating material in rearward

direction against the action of a return spring 18 interposed between a sleeve 20 and the spindle 17. The rate of retraction of the spindle 17 may be set by an adjusting nut 19 cooperating with a threaded portion of the sleeve 20, which is slidably but unrotatably arranged in the body 11 and forms an axial abutment for the spindle 17. The forward end of the body 11 receives a bushing 21 of insulating material, preferably of nylon, to the interior of which the liquid inlet 14, which may incorporate a nylon nipple, is connected. The spindle 17 extends through a plug 22, which is threadedly received in the bushing 21 and compresses a tubular sealing member 23 tightly between the bushing 21 and the spindle 17. To the forward end of the body 11 is also threaded a coupling ring 24 for securing the gun body portion 10 to the body 11.

The body portion 10 consists of an inner tube 25, hollow end pieces 26, 27 threadedly secured to the ends of the inner tube 25, and an outer tube 28 extending between and tightly connected to the end pieces 26, 27 and surrounding the inner tube 25 with some play. All these parts 25-28 forming the body portion 10 are of electrically insulating material, preferably of nylon. The rear end piece 27 has a circumferential flange 29 and is tightly centered by means of rear conical surfaces 30 in a centering collar 31 nested in the forward end of the body 11 and tightly surrounding the bushing 21. The end piece 27 is also threadedly received in the bushing 21 and the clamping ring 24 coacts with the circumferential flange 29 for keeping the rear end piece 27 and the centering collar 31 firmly attached to the body 11, thereby keeping the entire body 10 secured to said body 11. The spindle 17 extends forwardly through the bushing 21 and the body portion 10. Around the spindle 17 there is formed an annular central passage 32 for conveying the liquid coating material to the nozzle end of the body portion 10. The air inlet 13 is connected over a passage containing the control valve 16, to an annular chamber 33 formed in the body 11 around the bushing 21 and tightly closed by the centering collar 31. From the chamber 33 the air passes through axial passages 34, 35 in the collar 31 and the rear end piece 27, respectively, through the space 37 between the tubes 25 and 28 of the body portion 10, and thence to the forward end of the front end piece 26 through axial passages 38 therein.

At the front end of the end piece 26 a hollow nozzle body 39 of electrically conductive material is screwed into the piece 26. A central liquid discharge nozzle 40 is formed in the body 39 and is controlled by a needle valve 41 forming the tip of the axially displaceable spindle 17. In the nozzle body 39 there are arranged gaseous pressure fluid or air passages 42 oriented to direct forwardly converging air jets. A metallic cuplike sleeve or spray nozzle 43 fits coaxially over and surrounds the discharge end of the nozzle 40 and of the passages 42 and is tightly pressed over and against the nozzle body 39 by a clamping ring 44 threadedly secured to the mantle of the front end piece 26. Inside of the clamping ring 44 there is defined an annular air chamber 45 receiving air through the passages 38 in the front end piece 26 and communicating with the passages 42 of the nozzle body 39. The spray nozzle has a bore or recess, which freely surrounds the outlet tip of the liquid discharging nozzle 40, and forms a gaseous pressure fluid or air discharging nozzle 46 around said tip. Downstream of the nozzles 40 and 46 the spray nozzle 43 forms a mixing chamber 47 for the jet of liquid particles formed and projected into the atmosphere by the air discharging nozzle 46. This mixing chamber 47 is provided with a discharge passage in the form of a transverse spray slot 48 for finally forming or shaping the cross section of the jet.

Oriented in a plane through the spray slot 48 and through the central axis of the body portion 10 and fixed to the spray nozzle 43 are opposed insulated conductors 49 carrying between their forwardly directed ends a secondary electrode 50 in the form of a fine wire disposed transversely of and in the path of the jet in front of the spray slot 48, i.e. in the plane of the conductors 49. An electrically insulated oval ring 51, for example consisting of an insulated wire ring, may extend between the conductors 49 in order to prevent accidental contact between the secondary electrode 50 and the object to be coated. Adjacent the inner surfaces of the ring 51 there may be provided supplemental or secondary electrode wires 52 in conductive contact with the conductors 49 in order to prevent accumulation of coating material from the jet on the ring 51.

The body 11 may be grounded by a wire 54 connected to the hand grip 12. An efficiently insulated high tension conductor 53 is connected to one of the conductors 49, for example to the spray nozzle 43, for applying a high voltage to the conductive nozzles 40, 46 and 43 and the electrode wires 50 and 52.

In operation, the conductor 53 will be connected to a high potential source in the form of a suitable conventional electrostatic generator, while the liquid inlet 14 will be connected to a pressurized liquid coating supply and the air inlet 13 to a compressed air source. The electrostatic generator keeps the spray gun nozzles 40, 46, 43 as well as the electrode wires 50, 52 at a high negative or positive potential with respect to the environment, for example at 90,000 volts or more, while the object to be coated is kept at a low potential, for example grounded, with respect to the nozzle end of the spray gun. After bringing the spray gun to a suitable close distance from the object to be coated, the operator actuates the trigger 15, thereby retracting the spindle 17 and its tip 41 to a pre-adjusted extent, whereupon liquid coating material is fed through the passage 32 and discharged through the liquid discharging nozzle 40. Simultaneously compressed air is admitted to the annular chamber 33 via the valve 16, and passes therefrom through the passages 34, 35, 37 and 38 to the annular chamber 45, and thence through the air passages 42 to the air discharging nozzle 46 and on to the mixing chamber 47 and the atmosphere. The liquid coating material is efficiently atomized in the mixing chamber 47 by the air jet and the liquid particles are then projected through the spray slot 48, which retards the particles of the jet and defines the final cross section of the jet. Obviously, use of internal mixing chamber 47 makes possible efficient atomization at substantially less than the air pressure necessary for conventional external pneumatic atomization (perhaps as much as half), and, therefore, there is a marked primary slowing down or retardation of the particles carried in the jet stream. Such retardation is highly desirable because it gives the electrostatic field more dominance over the air pressure in transferring the coating particles. Simultaneously with pneumatic atomizing there takes place in and adjacent the nozzles 40, 46, 43 and the mixing chamber 47 an electrostatic charging and atomizing due to the high potential of the nozzles and the corona discharge caused thereby. Subsequently the spray is acted upon electrostatically by the fields around the secondary wire electrodes 50 and 52. The electrode 50 by electrostatic repulsion produces an additional retardation of the jet and charging of the dispersed liquid particles, whereupon they are deposited on the object to be coated by the combined action of the comparatively slow air stream and the electrostatic forces. Obviously such combined action is apt to overcome efficiently irregularities of the electrostatic field at corners and the like of irregularly formed objects, thereby producing an evenly distributed coating while the sufficient retardation of the air stream results in small coating material losses to the environment. The clogging tendencies of hitherto known spraying devices equipped with internal mixing

chambers are overcome thanks to the high potential of the spray nozzle, by which coating particles tending to accumulate thereon are repelled so that the nozzles are kept clean.

In the modified nozzle portion according to FIG. 3, to be used with a hand grip and body arrangement according to FIG. 1, the secondary electrode together with its forwardly protruding carrying conductors are omitted. The conductor 53 is directly connected to the spray nozzle 43. The front piece 26 may be fixedly connected to the outer tube 28 by a stop screw 56 and a sealing ring 57 may be inserted to secure tightness between the piece 26 and the tube 28. The modification with respect to FIGS. 1, 2 consists mainly in the provision of multiple forwardly directed transverse spray slots 58 from the mixing chamber 47, which may be arranged in parallel, angular, cross-wise or other relation with respect to each other. Use of multiple narrow slots instead of a single wide slot brings about more efficient atomization at a still lower mixing chamber pressure and the slots 58 serve to finally shape the cross section of the projected jet in a manner to retard the coating particles of the jet sufficiently, so that no further retarding and charging of the particles by means of secondary electrodes will be necessary.

In the modified nozzle portion according to FIG. 4 the body portion 10 consists of an integral nylon tube 60 with a central passage 61 therein for the liquid coating material and the spindle 17. Threadedly secured to the outer end of the tube 60 is a metallic nozzle body 62 which is centered on the tube 60 by a conical surface 63. Adjacent to the surface 63 there is formed an annular chamber 64 in the body portion 10. An air passage 65 supplies the chamber 64 with air. Axial passages 66 extend from the chamber 64 through the nozzle body 62 to the forward end thereof adjacent to the mantle of a reduced cylindrical portion 67 thereon. On the portion 67 there is formed a liquid discharging nozzle 68 having a forwardly directed tip. Rotatably arranged and journaled by means of a needle bearing 69 on a cylindrical portion of the nozzle body 62 is a metallic spray nozzle 70 fitting over the portion 67 and the liquid discharging nozzle 68 with some axial play and forming a converging conical air discharging nozzle 71 around the tip of the liquid discharging nozzle 68. The spray nozzle 70 also incorporates a mixing chamber 72 downstream of the liquid discharging nozzle 68 for the jet produced by the air discharging nozzle 71.

A flange 73 is provided on the rear of the spray nozzle 70. The flange 73 is surrounded by a clamping ring 74 threadedly secured to the body 10 and forming a support for the flange 73. Inside of the flange 73 the spray nozzle 70 is provided with turbine blading 75 and in front thereof with an annular exhaust chamber 76 communicating with the atmosphere through radial ports 77. The turbine blading 75 forms a motor for rotating the spray nozzle 70 on the nozzle body 62. An axial passage 78 is provided in the body 10 through which air may be blown against the turbine blading 75 to rotate the spray nozzle 70. The air to the passage 78 may be branched off at a suitable location, for example in the body of the spray coating apparatus adjacent to a hand grip according to FIG. 1, and may be led through the diagrammatically indicated passages 79 and 80 to the passages 73 and 65, respectively. At a suitable location there may also be provided a valve 81 for regulating the air stream through the passage 65 to the air discharging nozzle 71 independently of the air stream to the turbine blading 75. A radially extending protective ring 82 is provided on the spray nozzle 70 for preventing the turbulent air exhausting from the ports 77 to influence the spray pattern of the jet issuing from the spray nozzles 71 and 70. The jet of liquid particles projected into the atmosphere from the air discharging nozzle 71 receives its final form by a spray slot 83 extending from the mixing chamber 72 for example in a plane through the rotational axis of the

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spray nozzle 70 and being directed angularly with respect to the rotational axis of the spray nozzle 70.

The conductor 53 may be suitably anchored to the body portion 10 as at 84 and has a terminal 85 arranged to slide for charging purposes on the rear mantle surface of the spray nozzle 70.

In operation, the nozzle arrangement according to FIG. 4 receives air through the passages 79 and 78 so that the spray nozzle 70 will be rotated by the turbine blading 75. Thereupon liquid material fed through the passage 61 will be discharged through the liquid discharging nozzle 68 and atomized in the mixing chamber 72 by the air jet discharged from the air nozzle 71, to which the air is led through the passage 80, the valve 81, the chamber 64 and the passages 66. After having been atomized in the mixing chamber 72 and charged by the high voltage applied to the conductive nozzles 70, 71, 68 by means of the high tension conductor 53, the jet of dispersed liquid particles is finally formed by and discharged in a retarded state through the rotating constricted spray slot 83 into the atmosphere. As a result of the radial deflection the particles of the jet receive an additional retardation prior to deposition on the object to be coated, which is located in front of the nozzle end of the spray gun. Obviously the arrangement may also be used for coating the inner surface of tubular articles.

The embodiments of the invention above described and illustrated in the drawings should only be considered as examples and the invention may be modified in several different ways within the scope of the following claims.

What we claim is:

1. In an electrostatic spray coating apparatus of the character described for imparting a coating of charged particles of a material to an object and having a body of insulated material, a liquid material inlet in said body and a gaseous pressure fluid inlet in said body, the combination which comprises a liquid discharging nozzle on said body at the end thereof opposite said liquid inlet, a gaseous pressure fluid discharging nozzle adjacent said liquid discharging nozzle for atomizing the liquid discharging therefrom, passages in said body in flow communication with said liquid inlet and said liquid nozzle and with said gaseous inlet and said gaseous nozzle, a substantially cup-shaped electrically conductive spray nozzle formed over the ends of said liquid and gaseous discharging nozzles defining a mixing chamber for said atomized liquid particles and for imparting an electrostatic charge thereto before entering the atmosphere, at least one restricted electrically conductive jet orifice in said spray nozzle leading to the atmosphere for projecting the charged particles to the object to be coated and for forming the cross-section of said projection, and high tension conductor means for applying said electrostatic charge to said spray nozzle and said jet orifice.

2. In an electrostatic spray coating apparatus of the character described for imparting a coating of charged particles of a material to an object and having a body of insulated material, a liquid material inlet in said body, and a gaseous pressure fluid inlet in said body, the combination which comprises an electrically conductive liquid discharging nozzle on said body at the end thereof opposite said liquid inlet, an electrically conductive gaseous pressure fluid discharge nozzle adjacent said liquid discharging nozzle for atomizing the liquid discharging therefrom, passages in said body in flow communication with said liquid inlet and said liquid nozzle and with said gaseous inlet in said gaseous nozzle, a substantially cup-shaped electrically conductive spray nozzle formed over the ends of said liquid and gaseous discharging nozzles defining a mixing chamber for said atomized liquid particles and for imparting an electrostatic charge thereto before entering the atmosphere, at least one restricted electrically conductive jet orifice in said spray nozzle leading to the atmosphere for projecting the charged particles to the article to be coated and for forming the cross-section of said

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projection, and high tension conductor means for applying said electrostatic charge to said liquid discharging nozzle, said gaseous pressure fluid discharging nozzle, said spray nozzle, and said jet orifice.

3. Apparatus as recited in claim 2 in which said jet orifice is formed as a slot transverse to said body of insulated material for forming the cross-section of said projection.

4. In an electrostatic spray coating apparatus of the character described for imparting a coating of charged particles of a material to an object and having a body of insulated material, a liquid material inlet in said body and a gaseous pressure inlet in said body, the combination which comprises a liquid discharging nozzle on said body at the end thereof opposite said liquid inlet, a gaseous pressure fluid discharging nozzle adjacent said liquid discharging nozzle for atomizing liquid discharging therefrom, passages in said body in flow communication with said liquid inlet and said liquid nozzle and with said gaseous inlet and said gaseous nozzle, a substantially cup-shaped electrically conductive spray nozzle formed over the ends of said liquid and said gaseous discharging nozzles defining a mixing chamber for said atomized liquid particles and for imparting an electrostatic charge thereto before entering the atmosphere, a slot-shaped electrically conductive jet orifice in said spray nozzle and transverse thereto leading to the atmosphere for projecting the charged particles to the object to be coated and for forming the cross-section of said projection, said spray nozzle and said jet orifice forming a primary electrode, a secondary electrode disposed transversely to the path of said projection and downstream of said jet orifice for retarding said projection by repulsing said charged particles therein, and high tension conductor means for applying said electrostatic charge to said primary and secondary electrodes.

5. In an electrostatic spray coating apparatus of the character described for imparting a coating of charged particles of a material to an object and having a body of insulated material, a liquid material inlet in said body and a gaseous pressure fluid inlet in said body, the combination which comprises a liquid discharging nozzle on said body at the end thereof opposite said liquid inlet, a gaseous pressure fluid discharge nozzle adjacent said liquid discharging nozzle for atomizing the liquid discharging therefrom, passages in said body in flow communication with said liquid inlet and said liquid nozzle and with said gaseous inlet and said gaseous nozzle, a substantially cup-shaped electrically conductive spray nozzle formed over the ends of said liquid and said gaseous discharging nozzles defining a mixing chamber and a primary electrode for said atomized liquid particles and for imparting an electrostatic charge to said atomized liquid issuing from said discharge nozzles, a slot-shaped jet orifice in said spray nozzle transverse to said body leading to the atmosphere for projecting the charged particles to the article to be coated and for forming the cross-section of said projection, a secondary wire-shaped electrode disposed transversely to the path of and in said projection in front of and spaced apart from said transverse jet orifice for retarding said projection by repulsing said charged particles therein, and high tension conductor means for applying said electrostatic charge to said primary and secondary electrodes.

6. In an electrostatic spray coating apparatus of the character described for imparting a coating of liquid to an object and having a body of insulated material, a hand grip portion on said body, trigger means on said body adjacent said hand grip portion, a liquid material inlet in said body and a gaseous pressure fluid inlet in said body, the combination which comprises an electrically conductive liquid discharging nozzle on said body at the end thereof opposite said hand grip portion, valve means in said liquid discharging nozzle, a spindle of insulating material extending through said body and connected to said valve means for controlling the discharge from said liquid

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discharging nozzle, said spindle being connected to said trigger means for the actuation thereof, an electrically conductive gaseous pressure fluid discharging nozzle adjacent said liquid discharging nozzle for atomizing the liquid discharging therefrom, passages in said body in flow communication with said liquid inlet and said liquid nozzle and with said gaseous inlet and said gaseous nozzle, second valve means in said gaseous fluid discharging nozzle and connected to said trigger means for controlling the discharge from said gaseous pressure fluid discharging nozzle, a substantially cup-shaped electrically conductive spray nozzle formed over the ends of said liquid and gaseous discharging nozzles defining a mixing chamber for said atomized liquid particles and for imparting an electrostatic charge thereto before entering the atmosphere, at least one restricted jet orifice in said spray nozzle leading to the atmosphere for projecting the charged particles to the object to be coated and for forming the cross-section of said projection, and high tension conductor means for applying said electrostatic charge to said liquid discharging nozzle, said gaseous pressure fluid discharging nozzle, and said spray nozzle.

7. Apparatus as described in claim 1 in which the portion of said spray nozzle carrying said jet orifice for forming the said cross section of the said projection of charged particles is rotatable, and which also includes means for the rotation of said jet orifice with respect to said body for rotating said projection with respect to the ambient atmosphere.

8. Apparatus as described in claim 1 in which the axis

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of said jet orifice is at an angle to the axis of said spray nozzle, and in which said spray nozzle includes means for the rotation thereof and said jet orifice therein with respect to said body for rotating said projection of charged particles with respect to the ambient atmosphere.

9. Apparatus as described in claim 8 in which said rotating means includes a gaseous pressure fluid operated motor connected to said spray nozzle and to said gaseous pressure fluid passages in said body providing flow communication between said gaseous pressure fluid inlet and said motor.

10. Apparatus as described in claim 6 in which said spray nozzle includes gaseous pressure fluid operated means for the rotation thereof and which is in flow communication with said gaseous pressure fluid passages in said body and connected to said trigger means for rotating said projection of charged particles with respect to the ambient atmosphere.

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