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ELECTROSTATIC SPRAY COATING SYSTEM

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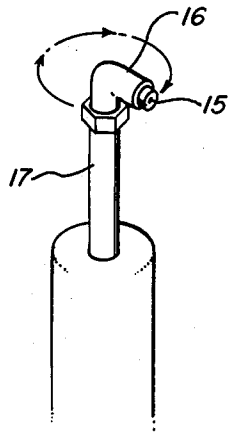

Fig. 2

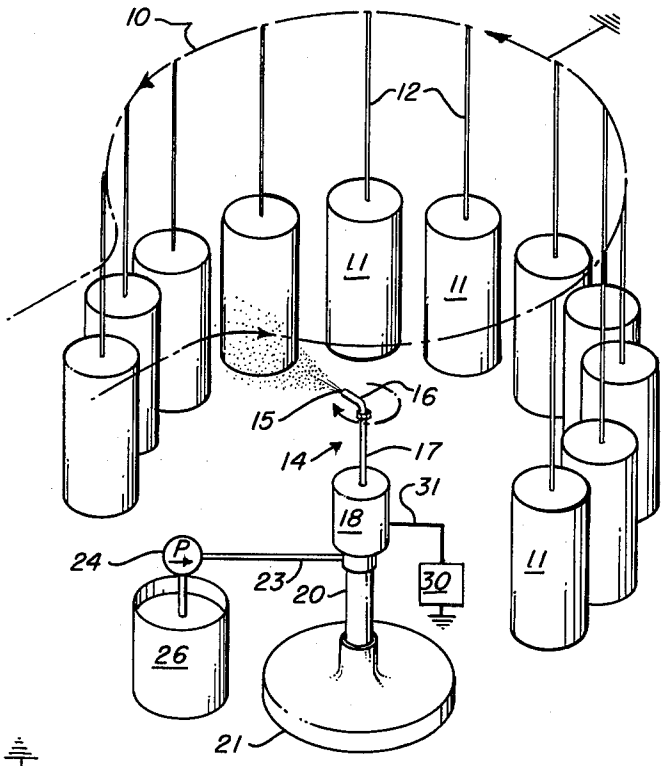

Fig. 1

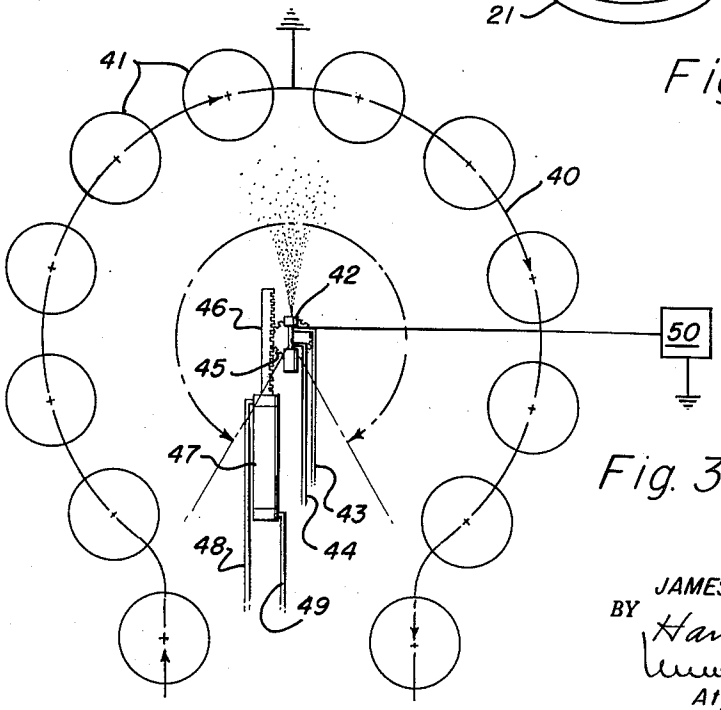

Fig. 3

INVENTOR.
JAMES W. JUVINALL
BY Harry E. Downer
Attorneys

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ELECTROSTATIC SPRAY COATING SYSTEM

James W. Juvinall, Indianapolis, Ind., assignor to Ransburg Electro-Coating Corp., Indianapolis, Ind., a corporation of Indiana

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This application relates to improvements in apparatus and methods for the electrostatic spray coating of articles by movement of atomizing devices in which the liquid coating material is atomized primarily by means other than electrostatic forces.

Electrostatic spray coating systems have been suggested employing restricted orifice atomizing nozzles or other devices in which the liquid coating material is atomized mechanically, as by high hydrostatic pressure, centrifugal force or compressed air, and in which the electrostatic depositing field is established between separate electrodes and the article to be coated or alternatively between the nozzle itself and the article. Such systems as used in the past have generally proved to be considerably less efficient and less desirable than those electrostatic coating systems wherein the liquid coating material is atomized from the edge of a disc, bell or other extended atomizing edge into an electrostatic field existing between the atomizing edge and the article.

The relatively low depositing efficiencies of mechanically atomizing devices in an electrostatic coating system can be markedly improved (all other conditions remaining unchanged) by cyclically changing the path of spray projection to significantly increase the volume of the atmosphere through which the spray is projected as it moves toward the articles. The present invention contemplates cyclically moving the atomizer to vary its angular disposition about an axis transverse to the direction of the projected spray. Changing the angular disposition of an atomizer about a closely adjacent axis has the advantage of achieving relatively large changes in the path of the spray with relatively small changes in the position of the atomizer itself. By my invention increases in deposition efficiencies in the order of 25% and more have been obtained.

The extent of increase in depositing efficiency obtained by movement of a given atomizer is apparently a complex function of such factors as the total volume of the atmosphere through which the spray is projected as it moves toward the article during each cycle of atomizer movement and also the rate and path of movement of the atomizer. Generally, increasing the total volume of the atmosphere increases depositing efficiency, but increasing the rate of atomizer movement beyond a certain speed will often result in less efficiency. Preferably the path of movement of the atomizer is without discontinuities (without sudden changes in the path and/or velocity of the atomizer) and along a closed continuous path, but oscillation of a nozzle about a fixed axis is within the scope of my invention provided its rate of movement is sufficient and the volume of the atmosphere through which the spray is projected is markedly greater than the volume of the atmosphere encountered when the nozzle is stationary. In such case, the atomizer movement should provide a spray path through the atmosphere the volume of which is in the order of ten times that provided by a stationary atomizer and the atomizer should traverse such path at a rate of at least several times per minute.

I have discovered an improvement in the method of electrostatically spray coating articles in which the articles are moved along a predetermined path and in which liquid coating material is fed to an atomizing source and mechanically atomized from said source and projected as a substantially unidirectional spray of finely divided particles. A substantial electrostatic potential difference is maintained between the atomized liquid coating material

particles and the article to be coated and the angular disposition of the spray about an axis transverse to the direction of spray projection is continuously and repeatedly changed during the coating operation to increase by many times the volume of the atmosphere through which the spray is moved in order to reduce the velocity of the liquid spray particles and render them more susceptible to the action of the electrostatic forces.

My invention will be fully understood from the following detailed description and the attached drawings, in which:

FIG. 1 illustrates an electrostatic coating system utilizing one embodiment of my invention;

FIG. 2 is a detailed view of the atomizer shown in FIG. 1; and

FIG. 3 illustrates an alternative embodiment of the invention.

There are some advantages in using nozzles fed by high hydrostatic pressures and which atomize airlessly (without compressed air); however, compressed air spray guns and other types of mechanical atomizers may also be used with my invention. As illustrative there are shown in the drawings and will now be described embodiments employing two types of restricted orifice nozzles. The scope of the invention, however, is not to be limited by the following description.

Referring first to FIG. 1 there is illustrated an electrostatic coating system utilizing a circular loop conveyor 10 for moving a succession of articles to be coated, shown as canisters 11 suspended from hangers 12, into coating relation with an atomizing device shown as 14. The atomizing device comprises a restricted orifice nozzle, means for rotating the nozzle, liquid supply means therefor, and high voltage means for charging the atomized liquid spray.

The nozzle 15 whose details are hereinafter described is mounted in the end of a hollow pipe 16 bent at right angles and mounted for rotation on the upper end of a hollow shaft 17. Shaft 17 constitutes the central rotatable shaft of an electric motor 18 which is mounted on the upper end of a vertical column 20 of insulating material. The lower end of column 20 is mounted on a base 21.

Liquid coating material is supplied under high pressure, preferably 300 p.s.i. or more, to nozzle 15 through the liquid passageway in pipe 16 and shaft 17. Liquid is fed to the lower end of rotating shaft 17 through a sealing device (not shown) within the lower end of motor 18 from a supply pipe 23, high pressure pump 24 and reservoir 26.

In order to charge the liquid spray and provide an electrostatic field over the articles to be coated, nozzle 15 is maintained at high potential in relation to the articles which are grounded through their hangers 12 and conveyor 10 as shown. This may be accomplished by a high voltage source 30 having its high voltage terminal 31 connected to motor 18 and hence through shaft 17 and pipe 16 to nozzle 15. The nozzle is maintained at more than 40 kilovolts and preferably at more than 100 kilovolts.

Mechanically atomizing devices in an electrostatic spray coating system have an advantage over electrostatic atomizers in being able to atomize some liquid coating materials not readily atomizable solely by electrostatic forces, such as certain water based paints and metallic pigmented enamels. To minimize wear caused especially by pigmented coating materials, which may be highly abrasive, passing through the restricted orifice of atomizing nozzle 15, the nozzle is preferably constructed of wear-resistant material such as stainless steel, tungsten carbide or sapphire. The nozzle is preferably threaded and securely fitted into the end of pipe 16 with the forward tip of the nozzle projecting somewhat beyond the end of the pipe. The outlet orifice of the nozzle is preferably elongated in

cross-section, with the elongation positioned vertically. The narrowest dimension may be only a few thousandths of an inch with the elongation two or three times this dimension. Such a restricted orifice nozzle discharges the liquid coating material as a flat fan-like film with atomization occurring from the forward edge of the fan somewhat beyond the nozzle tip.

The nozzle may be rotated at about 30 r.p.m. with the nozzle tip approximately 2 inches from the axis of rotation. Operation of the pump 24 forces liquid coating material from reservoir 26 to be fed through pipe 23, shaft 17 and pipe 16 to nozzle 15 under hydrostatic pressures in the order of 300 pounds per square inch which are capable of atomizing the liquid coating material projected through nozzle 15 into a spray of electrically charged, finely divided liquid particles.

Rotation of restricted orifice nozzle 15 causes the fan-like spray to sweep around the axis of the atomizing device in a 360° arc to create a continuous spray moving outwardly from the atomizing device toward the surrounding array of articles to be coated. Due to the electrical charge impressed on the spray particles and the electrostatic field existing between the charged atomizing device and the grounded articles, the spray particles are attracted toward and deposited on the articles to form a liquid coating thereon. With articles such as canisters 11 it may be desirable to rotate the moving articles about their supports 12 as is well-known to provide a more uniform coating over all surfaces of the articles.

When restricted orifice nozzle 15 is maintained in a stationary position and supplied by a pump with liquid under pressure in the order of 300 p.s.i. and articles moved past nozzle 15 substantially as above described, and with the same electrostatic field existing between the nozzle and the articles, relatively low deposition efficiencies are obtained during coating of the articles. Specifically, the deposition efficiencies of the liquid coating material (obtained by tests measuring the actual percentage of the atomized coating material actually deposited on the articles) have been found in the order of 25% higher in coating small, spaced articles when the atomizing device is rotated rather than maintained stationary. Similar increases in depositing efficiency by the use of my invention have been obtained when the pressure nozzle of the apparatus shown in FIG. 1 is replaced with a conventional compressed air spray gun.

While rotations of a few dozen revolutions per minute of the nozzle 15 are all that is necessary, it is possible by materially increasing the rate of rotation of atomizing nozzle 15 to eliminate both the sealing means for the high pressure liquid line and the separate high pressure pump. For example, rotation of nozzle 15 at 3500 r.p.m. with the nozzle tip approximately 6 inches from the axis of rotation causes liquid coating material from a reservoir to be drawn upwardly through hollow shaft 17 to the nozzle under hydrostatic pressures created by centrifugal force in the order of 300 p.s.i. Such pressures are capable of atomizing the liquid film projected through the nozzle into a spray of electrically charged, finely divided liquid particles. Thus the need for high pressure seals and a separate pump to feed the liquid to the nozzle and to generate high hydrostatic pressures is eliminated with attendant advantages in simplification of equipment and reduction in cost. In some instances higher rates of rotation result in somewhat lower depositing efficiencies, but the efficiencies are still greater than those achieved with a stationary atomizer.

FIG. 3 illustrates an electrostatic coating system differing from that of FIGS. 1 and 2 in that the atomizer is a conventional compressed air spray gun and in that the atomizer oscillates instead of rotating continuously in one direction. A circular loop conveyor 40 moves a succession of articles to be coated, shown as canisters 41, into coating relation with an atomizing device 42. The atomizing device may be a Binks automatic compressed air spray gun, model 21V with a 63 PC air cap, connected by a flexible line 43 to a supply of compressed air and by a line 44 to a source of liquid coating material. Preferably line 43 delivers 20 pounds per square inch of atomizing air and line 44 delivers coating material at about 150 cc. per minute. Spray gun 42 is mounted on the upper end of a vertical column of insulating material, the lower end of which is pivotally mounted on a base not shown.

A toothed circular gear 45 is concentrically affixed about the column of insulating material on which spray gun 42 is mounted. The teeth of gear 45 are engaged by the teeth of a ratchet 36 which is attached to the reciprocable piston (not shown) of an air operated reciprocator 47. Lines 48 and 49 provide air to reciprocator 47 for moving ratchet 46 forth and back and thereby oscillating spray gun 42 about the axis of its vertical column through an arc of approximately 300° as shown. It will be noted that the arc of oscillation of spray gun 42 corresponds substantially to the curved or looped path portion of conveyor 40. By such movement, the discharge of coating material into the "throat" of the loop conveyor is avoided. If desired, conventional means may be employed for triggering spray gun 42 to an "off" position at the opposite ends of its path of oscillation.

In order to charge the liquid spray and provide an electrostatic field over the articles to be coated, spray gun 42 is maintained at high potential in relation to the articles 41 which are grounded through their hangers and conveyor 40 as shown. This may be accomplished by a high voltage source 50 having its high voltage terminal connected to spray gun 42. The nozzle of the spray gun is maintained at more than 40 kilovolts and preferably at more than 100 kilovolts.

When oscillatory movement of the atomizer is employed, a plurality of flexible fluid lines such as lines 43 and 44 can be attached in fixed relation to the atomizer thereby eliminating the need for the rotating seals required when rotation is used. The oscillatory motion may encompass substantially a full 360° or may be adjusted to the requirements of the article path.

In electrostatic spray coating systems using charged mechanical atomizers up to the present time, it has been desirable to position the atomizer away from the article path a distance considerably greater than that required for electrostatic atomizing devices. While electrostatic atomizers are normally spaced about ten inches from the articles being coated, mechanical atomizers due to the high velocities of the spray particles issuing therefrom are generally spaced in the order of 24 inches from the articles. To achieve proper charging of the spray particles and the desired potential gradient between the mechanical atomizer and the articles it has been necessary to utilize voltage sources delivering potentials considerably higher than those required for electrostatic atomizers, for example, voltages greater than 150 kilovolts. My invention causes the mechanically atomized spray particles to be slowed down considerably sooner than heretofore, and hence it is feasible to place the atomizer much closer to the article path than before. This permits material reductions in the voltage to which the atomizer is charged with attendant savings in voltage source and power costs.

Preferably the atomizer itself is charged as shown in FIGS. 1 and 3, so that an electrostatic field is maintained between the atomizer and the articles. However, this is not necessarily the case and the charging and depositing may be accomplished by means of an electrically charged wire or series of points or other form of electrode in lieu of or in addition to the charged atomizer.

I claim:

1. Apparatus for electrostatically spray coating a plurality of articles comprising a restricted orifice atomizing nozzle, means for supplying liquid coating material under

high hydrostatic pressure to mechanically project the liquid from said nozzle generally along the axis of the nozzle-orifice as a spray of finely divided liquid particles, means for rotating said nozzle at a rate of at least several revolutions per minute about an axis substantially normal to the direction of spray projection, conveyor means for moving the articles to be coated along a looped path concentric with such axis and in the path swept by the spray as said nozzle rotates, and means including a high voltage source having a terminal connected to said nozzle for establishing between the terminus of the liquid projected from said nozzle and the articles on said looped path an electrostatic field capable of electrostatically depositing atomized spray particles on the articles to form a liquid coating thereon.

2. Apparatus for electrostatically spray coating articles comprising: an atomizing device having a restricted discharge orifice for mechanically atomizing and projecting liquid coating material as a generally conical spray of finely divided liquid coating material particles, means for supplying liquid coating material at a controlled rate to said atomizing device for atomization, means for rotating said atomizing device along a closed circular path about an axis transverse to the direction of spray projection, conveyor means for distributing a plurality of articles to be coated along a generally circular path concentric with such axis and in the path swept by the spray as said nozzle rotates, and means including a high voltage source having a terminal connected to said atomizing device for establishing between the liquid coating material projected from said atomizing device and the articles being coated an electrostatic field having a potential of at least 40,000 volts.

3. Apparatus for electrostatically spray coating articles in which a conveyor distributes a plurality of articles along a predetermined path and an atomizing nozzle spaced from such path and having a restricted orifice for mechanically atomizing liquid coating material is supplied with liquid coating material for atomizing and projecting a spray of finely divided particles from the nozzle generally along the axis thereof toward the articles, comprising means including a high voltage source having a terminal connected to said atomizing nozzle for establishing between said atomizing nozzle and said articles an electrostatic field having a substantial electrostatic potential, and means for cyclically changing the angular disposition of said atomizing nozzle about an adjacent axis which lies transverse to the article path to vary the path of the projected spray and increase by many times the volume of atmosphere through which the spray moves during the coating operation thereby to markedly reduce the velocity of the spray particles and render them more susceptible to the action of the electrostatic field.

4. In apparatus for electrostatically coating articles including a conveyor for distributing a plurality of articles along a substantial arc of a circle, an atomizing nozzle supported for movement at a fixed distance from such path and having a restricted orifice for mechanically atomizing liquid coating material, and means for supplying liquid coating material to said nozzle for atomization and projection as a generally conical spray of finely divided particles from the nozzle toward the articles, the combination of a high-voltage source having a terminal connected to said atomizing nozzle for establishing between said atomizing nozzle and said articles an electrostatic field having a potential of at least forty thousand volts, and means for cyclically moving said atomizing nozzle substantially concentric with the arcuate distribution of the articles and repeatedly to vary the path of the projected spray and increase by many times the volume of atmosphere through which the spray moves during the coating operation thereby to markedly reduce the velocity of the spray particles and render them more susceptible to the depositing action of the electrostatic field.

5. Apparatus as set forth in claim 4 in which the means for moving the nozzle includes means for rotating said nozzle in a circular path at a uniform rate of at least several revolutions per minute.

6. Apparatus as set forth in claim 4 in which the means for cyclically moving the nozzle includes means for oscillating said nozzle.

7. A method of electrostatically spray coating articles comprising moving a plurality of articles to be coated along a predetermined path, feeding liquid coating material to an atomizing source to project said liquid coating material from said atomizing source, mechanically atomizing said projected liquid coating material into a substantially unidirectional spray of finely divided liquid particles, establishing a substantial electrostatic potential difference between the atomized liquid coating material particles and the articles to be coated electrostatically to deposit spray particles on the articles as a liquid coating, and continuously and repeatedly changing the angular disposition of said spray about an axis transverse to the direction of spray projection to increase by many times the volume of the atmosphere through which the spray is moved during the coating operation thereby to markedly reduce the velocity of the liquid spray particles and render them more susceptible to the action of the electrostatic forces.

8. A method as set forth in claim 7 wherein said predetermined path is a looped path within which said atomizing source is located, the mechanical atomizing and projecting of the liquid material is effected by feeding such material under high hydrostatic pressure to the restricted orifice of said atomizing source, the establishing of said substantial electrostatic potential difference between the atomized particles and the articles to be coated is effected by maintaining an electrostatic field of at least 40,000 volts between said articles and the liquid coating material projected from said restricted orifice, and said changing of the angular disposition of said spray is effected by rotating the atomizing source to cause the spray to sweep along said looped path.

9. A method of electrostatically coating articles distributed along a predetermined path in which liquid coating material is fed at a controlled rate to an atomizing source and atomized by mechanical force from such source in a generally unidirectional spray of finely divided particles projected generally along an axis substantially normal to the article path, comprising the steps of establishing a substantial electrostatic potential difference between the atomizing liquid coating material and the articles to be coated electrostatically to deposit spray particles on the articles, and cyclically changing the angular disposition of the atomizing source while maintaining it at a substantially constant distance from the article path to increase by many times the volume of atmosphere through which the spray is moved during the coating operation thereby to markedly reduce the velocity of the spray particles and render them more susceptible to the action of the electrostatic forces.

10. In a method of electrostatically coating articles distributed along a curved path, in which liquid coating material is fed at a controlled rate to an atomizing source and atomized by mechanical force from such source as a substantially unidirectional spray of finely divided particles projected generally along an axis substantially normal to the article path, the steps of establishing a substantial electrostatic field between said atomizing source and the articles to be coated electrostatically to deposit spray particles on the articles, and cyclically moving the atomizing source generally parallel to the article path to increase by many times the volume of atmosphere through which the spray is moved during the coating operation thereby to markedly reduce the velocity of the spray particles as they move between the atomizing source and the articles and render them more susceptible to the depositing action of the electrostatic field.

11. In a method of electrostatically coating articles distributed along a predetermined path, in which method

liquid coating material is fed at a controlled rate to an atomizing source and atomized by mechanical force from such source as a substantially unidirectional spray of finely divided particles projected generally along an axis substantially normal to the article path, the steps of establishing a substantial electrostatic potential difference between the atomized liquid coating material particles and the articles to be coated electrostatically to deposit spray particles on the articles, and rotating the atomizing source about an axis displaced from said first named axis and generally perpendicular to the article path to increase by many times the volume of atmosphere through which the spray is moved during the coating operation thereby to markedly reduce the velocity of the spray particles as they move between the atomizing source and the articles and render them more susceptible to the depositing action of the electrostatic forces.

12. The method set forth in claim 11 characterized in that the liquid coating material is atomized by high hydrostatic pressure exerted on the liquid.

13. The method set forth in claim 11 characterized in that the liquid coating material is atomized by compressed air.

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