July 10, 1956 J. W. JUVINALL 2,754,226

ATOMIZING AND COATING SYSTEM AND METHOD

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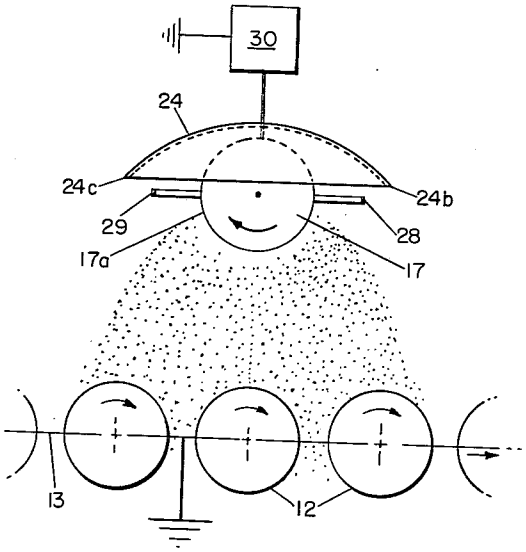

Fig. 1

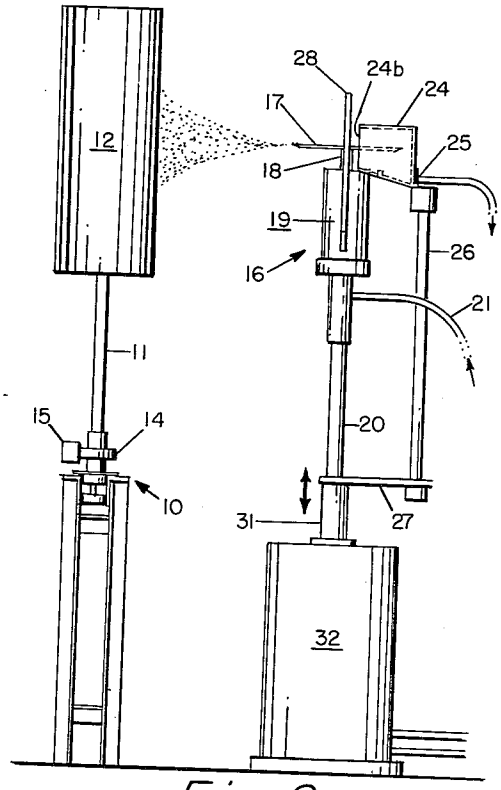

Fig. 2

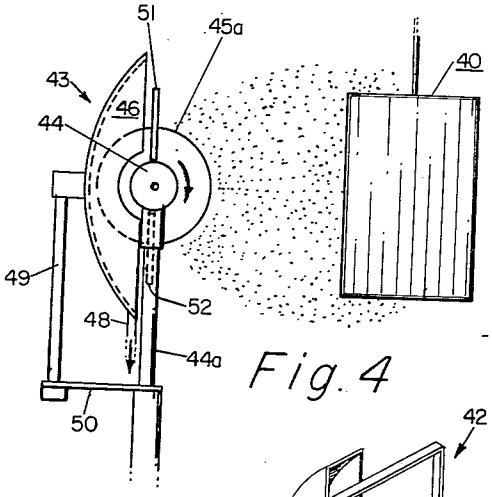

Fig. 4

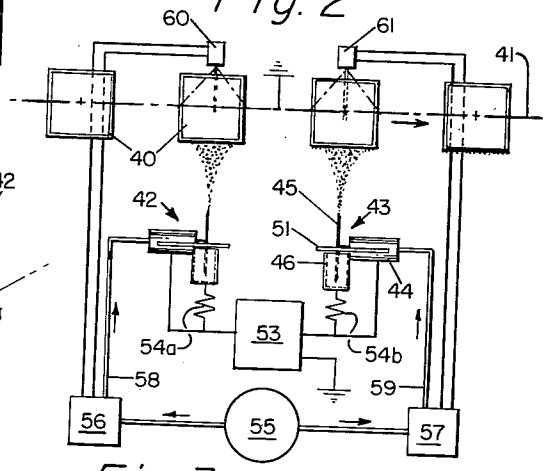

Fig. 3

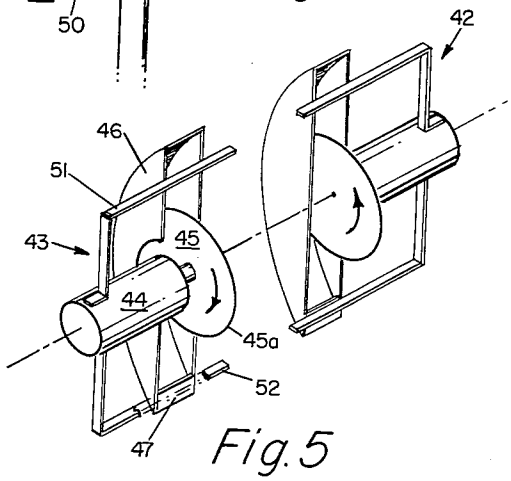

Fig. 5

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ATOMIZING AND COATING SYSTEM AND METHOD

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13 Claims. (Cl. 117—93)

The invention relates to atomization and deposition of a spray of liquid coating material particles in an electrostatic field and more particularly the invention relates to methods and apparatus for electrostatically controlling the deposition of charged, atomized liquid spray particles.

Electrostatic deposition of a charged spray of enamel, paint, lacquer, and the like on articles in a coating zone having a quiescent atmosphere has marked advantages in paint savings, coating uniformity, and ready adaptation to conveyorized production methods. Coating in a quiescent atmosphere and the elimination of the turbulent air blasts of conventional compressed air atomizing guns result in the deposition of the coating material being effected mainly if not entirely by electrostatic forces exerted on the charged spray particles projected into the electrostatic field. The term "quiescent atmosphere" as used herein does not mean an absolute stillness for freedom from all air movement since such factors as rotation of a member of the atomizing device or the electric wind may cause air movement in the coating zone. However, the coating zone is free of the turbulent air blasts of the order of those used with conventional compressed air spray guns which would prevent the deposition of a substantial portion of the spray particles onto the articles being coated.

To eliminate the objectionable compressed air atomizing guns and effect the desired quiescent atmosphere in the coating zone certain atomizing devices have been suggested which produce expanding annular or ring-like sprays of finely divided liquid coating material particles. Annular-edged atomizing devices which produce annular sprays, that is, expanding circular sprays having a central area substantially devoid of spray particles, are described in the previously filed application of W. W. Crouse, Serial No. 13,174, filed March 5, 1948.

My invention includes an electrostatic spray coating apparatus which comprises an atomizing device of a type capable of forming and projecting into a quiescent atmosphere a charged spray of finely divided liquid coating material particles having a substantially annular pattern. Such apparatus includes a shielding member for intercepting a substantial segment of said spray and apparatus associated therewith for collecting and recovering the liquid material so intercepted. The apparatus further includes a conveyor for moving articles along a path on the generally opposite side of the atomizing device from the shielding member and a source of high electrical potential which is used to create an electrical potential difference between the spray particles or atomizing device and the articles to be coated so as to electrostatically move and deposit charged spray particles. The shielding member is preferably maintained at the same electrical potential as the articles or at an electrical potential intermediate between that of the atomizing device and the articles being coated.

The invention further encompasses deflecting electrodes for dividing an annular spray into two segments, one segment being deposited on articles of manufacture and

the other being collected in a shroud. These deflectors, normally maintained at or near the potential of the charged atomizer, provide the further feature of repelling spray particles from the edges of the shroud to keep the edges free from liquid which might interfere with the satisfactory operation of the system.

I have discovered an efficient process for the coating of articles of manufacture by which an annular spray of charged liquid coating material particles is projected from an annular atomizing zone into an electrostatic field. The particles from a substantial arc of said spray are intercepted by a shielding member, the liquid material so intercepted is reclaimed, and the balance of said spray is electrostatically deposited on the articles.

A feature of the present invention is directed to the more efficient use of a rotating annular-edged atomizing device or other atomizer capable of producing an annular spray in an electrostatic coating system. A further feature is that of improved coating uniformity, that is, more uniform thickness of the deposited material. Other features and objects of this invention will now be described in detail in connection with the accompanying drawings, in which:

Fig. 1 is a plan view, somewhat diagrammatic, showing an atomizing device utilizing the invention in an electrostatic system for coating cylindrical articles;

Fig. 2 is an elevational view of the system shown in Fig. 1;

Fig. 3 is a top plan view, somewhat diagrammatic, showng the invention used in another coating system;

Fig. 4 is an elevational view of a portion of the system shown in Fig. 3; and

Fig. 5 is an isometric view showing details of the pair of oppositely rotating discs used in the system illustrated in Figs. 3 and 4.

The invention may be utilized in numerous forms. There are shown in the drawings and will be fully described two specific embodiments which it is understood are merely illustrative of the principles of the invention without limiting the invention to the embodiments shown and described. The full scope of the invention is set forth in the appended claims.

Referring to Figs. 1 and 2, a spindle conveyor **10** uses a plurality of spaced supports **11** to move a series of articles, shown as cylindrical ammunition containers **12**, in succession along a predetermined rectilinear path whose center line is indicated in Fig. 1 by broken line **13**. The articles may be rotated about their centers by friction contact between rotators **14** rigidly mounted on each support **11** and a rotator bar **15**.

Spaced from the article path **13** to form therebetween a coating zone is an atomizing device **16**. The atomizer includes an annular-edged flat horizontal disc **17** fixed for rotation on a hollow shaft **18** of a motor. The motor **19** is mounted on a column **20** of insulating material. Liquid coating material is fed from a source of supply (not shown) through a conduit **21** to the interior of the hollow motor shaft, then through a hole in the center of disc **17** to the upper surface of the disc. A trough-like shielding member or shroud **24** surrounds one side of disc **17**. Shroud **24** may be made of either conducting or insulating material but in the embodiment shown it is of a conductor, sheet steel. The shroud shown encloses an arc of about 150° of the edge **17***a* of the disc and its open face lies generally parallel to article path **13**. The closed, curved rear side of shroud **24** has a radius of curvature substantially greater than that of disc **17** so that its terminal edges **24***b* and **24***c* lie further from disc edge **17***a* than does the rest of the shroud. The bottom of the shroud is sloped toward a drain opening **25** for collecting and recovering liquid material. The shroud is supported in fixed relation to atomizer **16**

by a supporting column 26 of insulating material and a bracket 27 preferably with the shroud substantially closer to disc edge 17*a* than are articles 12. Thus spray particles intercepted by the shroud, as hereinafter described, will retain a substantial portion of their volatile solvents thereby making recovery and reuse of the liquid material easier and more economical. Two substantially identical deflecting electrodes 28 and 29 of suitable conducting material may be mounted on opposite sides of motor 19 extending outwardly somewhat beyond disc edge 17*a* and terminating in vertical portions passing through the plane of the disc.

Disc 17 and electrodes 28 and 29 may be maintained at substantially the same high electrical potential by electrical connection of atomizer 16 to the high voltage side of a voltage source 30. A particle-depositing electrostatic field is thereby established throughout the coating zone between disc edge 17*a* and adjacent articles 12 which are grounded through conveyor 10. The particle-depositing field may alternatively be established by maintaining the articles at high voltage and grounding the atomizer and deflectors. It is noted that the shroud 24 is electrically isolated from both disc 17 and articles 12 and preferably the shroud is maintained at such voltage that the potential gradient along the entire circumference of disc edge 17*a* is approximately uniform. Subjecting a rotating disc edge portion alternately to widely varying potential gradients as it revolves through the field may adversely affect the spray particle size and the volume of atomization from such edge portion. A reasonably uniform potential gradient extending around disc edge 17*a* is therefore desirable to insure relatively uniform conditions for the atomization of the liquid material. This may be accomplished by allowing the shroud to "float" and thus seek a potential determined by its position in the electrostatic system or by connecting the shroud to a source of voltage intermediate that of the disc and articles of such value that the field around the disc edge is generally uniform even though the shroud may be somewhat closer to the disc edge 17*a* than are articles 12.

In the operation of the system, power supplied to the motor of atomizer 16 causes rotation of shaft 18 and disc 17 while the desired liquid coating material is fed at a controlled rate through conduit 21 and hollow shaft 18 to the upper surface of the rotating disc. Liquid coating material thus fed to the surface of the rotating disc will flow as a thin film over the surface to disc edge 17*a*. At or adjacent the disc edge the liquid material will be atomized into the electrostatic field existing about the edge as a spray of finely divided particles in a substantially annular pattern.

The deflectors 28 and 29, due to the potential at which they are maintained as above set forth, tend to form zones of particle-repelling electrostatic force which serve to split or divide the annular spray into two semi-annular portions, one portion being directed into shroud 24 and the other being directed into the coating zone for deposition on articles 12. The deflectors are preferably located intermediate terminal edges 24*b* and 24*c* of the shroud and disc edge 17*a* and serve to keep spray particles from depositing on shroud edges 24*b* and 24*c* where an accumulation of liquid material may be most undesirable because of dripping and electrostatic atomization from such edges. Since the presence of electrostatic repelling zones closely adjacent disc edge 17*a* may unduly deteriorate the atomization of the coating material from the disc edge, deflectors 28 and 29 should be spaced a sufficient distance from edge 17*a*. Other types of deflectors may, of course, be used to create the desired particle-repelling zones and to divide the annular spray.

Where the system is to be used to coat articles whose dimensions parallel to the disc axis are materially greater than the width of the spray, the disc may be somewhat tilted from horizontal (or otherwise maintained at an angle in relation to the article path) in order to increase the effective width of the spray band, or the atomizer 16 may be reciprocated along the axis of rotation of the disc. Fig. 2 shows apparatus for reciprocating the atomizer 16 integrally with shroud 24. Insulating columns 20 and 26 and bracket 27 are mounted for vertical reciprocation on shaft 31 of a reciprocator 32. By suitable means the reciprocation of shaft 31 may be varied in order to provide a stroke substantially equal to the vertical dimension of the articles being coated or, if it is desired to coat the tops and bottoms of the articles, a stroke which somewhat "overshoots" the upper and lower edges of the articles may be used.

While the invention is, of course, not limited thereto, an electrostatic coating system of the type shown in Figs. 1 and 2 has been successfully operated wherein the following dimensions and conditions prevailed:

Minimum distance from disc edge 17*a* to articles 12.	12 inches.
Diameter of disc 17	10 inches.
Speed of rotation of disc 17	900 rev. per minute.
Voltage of atomizer 16 and electrodes 28 and 29.	90,000 volts (negative).
Voltage of articles 12	Grounded.
Minimum distance from disc edge 17*a* to electrodes 28 and 29	4½ inches.
Minimum distance from disc edge 17*a* to shroud 24.	1 inch.
Voltage of shroud 24	73,000 volts (negative).
Type of coating material	Red synthetic enamel, modified urea formaldehyde, 20 sec. on Zahn #2 Cup at 68° F.
Rate of feed of coating material.	100 cc. per minute.

Referring now to Figs. 3, 4, and 5, there is illustrated a further embodiment of the invention for electrostatically coating sides of generally cubical boxes 40. This system with the narrow elongated band form of its deposited spray pattern is especially adapted to the triggering or automatic turning on and off of the spray of coating material from the atomizing devices in response to the presence or absence of an article in the coating zone. Articles 40 to be coated are moved on an overhead conveyor system (not shown) along a generally rectilinear path indicated by broken line 41. The articles moving along path 41 are successively presented in coating relation to first one and then the other of two substantially coaxial atomizing devices shown generally as 42 and 43. Atomizer 43 only is shown in detail in Fig. 4 but atomizer 42 is generally of similar construction.

Atomizer 43 comprises a motor 44 mounted on an insulated support 44*a* adapted to cause the rotation of a disc 45 lying in a substantially vertical plane. Open-faced shielding member 46 encloses one side of disc 45 and the member's open face lies generally parallel to article path 41. A vertical dam 47 (shown only in Fig. 5) closes off the bottom portion of the open face of shielding member 46 in order to collect liquid material intercepted by the shielding member and a conduit 48 is provided in the bottom of the shielding member to drain off accumulated liquid material. Member 46 is supported in fixed relation to disc 45 and motor housing 44 and in electrical isolation therefrom by an insulating column 49 and a bracket 50. A pair of deflecting electrodes 51 and 52 are mounted on motor 44 and extend generally horizontally respectively above and below the vertical edge 45*a* of disc 45.

Disc 45 and electrodes 51 and 52 are maintained at a high electrical potential in relation to the grounded articles 40 by their connection through motor 44 to a source of high voltage 53 in order to establish a particle-depositing electrostatic field between edge 45*a* of disc 45 and an ad-

jacent article 40. Shielding member 46, electrically isolated from disc 45 and articles 40, is also connected to source 53 but is maintained at a potential intermediate between the discs and the particles by means of suitable resistors 54*a* and 54*b* between the members and the voltage source so as to permit disc edge 45*a* to have a substantially uniform potential gradient along its entire extent.

Liquid coating material stored in reservoir 55 is fed through a pair of pumps 56 and 57 adjusted to deliver substantially equal amounts of the liquid coating material through feed lines 58 and 59 to atomizers 42 and 43 respectively. Each of pumps 56 and 57 is independently operated by a triggering mechanism comprising micro-switches 60 and 61 respectively which are activated by the passing of an article 40 into contact with an arm of the micro-switch. Micro-switches 60 and 61 are so located in relation to atomizing devices 42 and 43 respectively that liquid coating material will be pumped to the associated atomizing device only when an article is moved into coating relation, i. e., directly opposite from, the atomizing device as is shown in Fig. 3. It may be noted that the relatively narrow or thin spray band projected radially from an atomizer such as device 42 lends itself especially well to incorporation in an arrangement where the spray is triggered. With both the atomizer axis and the least dimension of the spray pattern extending parallel to the path of article movement, it is a comparatively simple matter to trigger the supply of coating material in a way which, while avoiding excessive loss of coating material, will still provide an adequate coating at the leading and trailing edges of the articles.

The detailed construction of atomizer 42 is not described since it is generally similar with the foregoing description of atomizer 43. One important difference, however, exists. While the atomizers are coaxial and revolve around their substantially common axis, their directions of revolution are opposed as is shown in Fig. 5. The reason for the opposed revolution of the discs of atomizing devices 42 and 43 lies in the fact that the rotation of a single disc results in a somewhat heavier deposition of coating material at one end of the elongated spray pattern. For example, considering one of atomizers 42 or 43 alone, the device deposits spray particles on an article to form a narrow vertically extended or elongated band which, apparently due to the rotation of disc 45, tends to have one end of the band with a somewhat heavier or thicker deposit of material than the opposite end of the spray band. In order to "balance out" this non-uniformity where articles are being passed generally parallel to the axis of the atomizing device, two discs rotating in opposite directions are used.

Except for the feature of opposite rotation of their discs, atomizing devices 42 and 43 each operate substantially as atomizing device 16 previously described insofar as feed, atomization, separating the spray into two portions, electrostatic deposition of spray particles and intercepting and collecting that portion of the spray not deposited on articles. Each of atomizers 42 and 43, however, is triggered individually through pumps 56 and 57 and micro-switches 60 and 61 to deliver a substantial amount of spray into the coating zones only when articles 40 are passing through these zones.

A further feature of the invention lies in the ease with which undeposited liquid spray is collected and made ready for reuse. In most older systems requiring collection and reclamation of a portion of the spray of liquid coating material elaborate baffles and/or other expensive collecting apparatus are employed. Moreover, since the coating material was recovered at a relatively great distance from the spray guns and almost invariably at a distance greater than that between the spray guns and the articles being coated, most of the solvents and other volatile ingredients of the coating material would have vaporized, leaving only a disagreeable gummy residue

of pigments and slow drying oils to be collected. Such residue was not only difficult and expensive to recapture, but required a complete reformulation in order to obtain a product suitable for reuse.

By providing an intercepting shield and collecting device relatively close to the atomizer as described above the spray is collected in a liquid state with most of its solvents intact. Deposition of coating material on the shield is favored by the electrostatic field between the disc edge and the shield. Thus, the collected material is both easily recovered and requires only the addition of a small amount of solvent, rather than factory reformulation, to obtain a reusable coating material.

I claim:

1. An electrostatic coating apparatus comprising a rotatable disc, means for rotating said disc about its axis, means for flowing liquid coating material onto the surface of said disc for movement to and atomization from the outer edge thereof, a conveyor for moving articles to be coated along a substantially rectilinear path spaced from said disc, a shroud surrounding that portion of said disc most remote from said article path, a pair of deflecting electrodes each spaced from said disc and article path and located adjacent the generally opposite edge portions of said disc emerging from said shroud, and means including a high voltage source for establishing between said disc and the conveyed articles an electrostatic field of sufficient force to cause atomized liquid coating material particles to move toward and be deposited on the articles, said last mentioned means also maintaining said deflecting electrodes at substantially the same potential as said disc edge to electrostatically repel spray particles from the regions adjacent said electrodes.

2. Apparatus as set forth in claim 1 with the addition of means for reciprocating said disc and shroud together along the axis of said disc.

3. An electrostatic apparatus for coating articles comprising a conveyor for moving the articles along a predetermined path, an atomizing device with a rotating annular-edged atomizing member spaced from the article path with one portion of said annular edge lying substantially more remote from said predetermined path than the other portion thereof, means for supplying liquid coating material to said member for atomization from the annular edge thereof, a shroud partially surrounding said atomizing member and disposed in opposed spaced relation to that portion of said annular edge which lies more remote from such article path, the distance between the annular edge of the atomizing member and the shield being less than the distance between such edge and the article-path, a high voltage source having a terminal connected to said annular-edged member to establish a particle-depositing electrostatic field between the articles to be coated and that portion of said annular edge not surrounded by said shroud, and means for maintaining said shroud at an electrical potential intermediate between said member and the articles whereby it will attract atomized particles discharged from said member.

4. Apparatus as set forth in claim 3 with the addition of means for reciprocating said atomizing member along its axis of rotation.

5. An electrostatic spray coating system comprising an annular-edged atomizer capable of forming an outwardly moving annular spray of coating material particles; a curved shield spaced from said atomizer for receiving a substantial segment of said spray; a deflector lying at least in part in the plane of the edge of said atomizer and adjacent to an edge of said shield; means for reciprocating said atomizer, shield and deflector as an integral unit along the axis of rotation of said atomizer; a grounded conveyor for moving an article to be coated in a path passing through a second segment of said spray; a source of high electrical potential; means for connecting said source to the rotating atomizer to create a high electrical

potential difference between said atomized particles and the article electrostatically to move particles toward and deposit them on the article; means connecting the deflector to said source of high potential; and means for electrically isolating said shield from said atomizer, deflector, and article.

6. An electrostatic spray coating system comprising an atomizer for creating and projecting into a quiescent atmosphere a charged spray of liquid coating material particles radiating from the atomizer outwardly across and throughout substantially the entire circumference of an annular region surrounding the atomizer, a spray-collecting shielding member spaced from said atomizer and occupying a first substantial segment but less than all of the circumference of said region and located in the paths of the spray particles within such segment to intercept spray particles within such segment, means for supporting an article to be coated within a second segment of said region, means including a source of high voltage for maintaining an electrical potential difference between said atomizer and the article to electrostatically deposit charged spray particles on the article, and means for maintaining said shielding member at a potential such that it attracts said spray particles in said first segment.

7. An electrostatic spray coating system comprising an atomizer including an annular-edged member mounted for rotation about an axis, means for feeding liquid coating material to the surface of the member, means for rotating said member to flow coating material on said surface to the edge thereof for atomization therefrom as a spray in a generally annular pattern, a shield spaced about a portion of the edge of said member for receiving a limited segment of said spray, means operatively associated with said shield for collecting the liquid coating material received by said shield from said spray segment, deflecting electrodes positioned in the plane of the annular edge of said member, circumferentially beyond the respective ends of the shield, and radially intermediate the shield-ends and the annular edge of said member, said member and a grounded conveyor for moving a plurality of articles into and through a coating zone adjacent to a second portion of the edge of said member, a source of high electrical potential, means for connecting said source to the atomizer to create an electrical potential difference between the atomized particles and articles in said coating zone to move a substantial portion of the particles toward and deposit them on the articles in said coating zone, and means for maintaining said deflecting electrodes at a particle-repelling potential.

8. An electrostatic coating apparatus comprising a pair of similar coaxial discs, means for rotating said discs in opposite directions, pump means for feeding liquid coating material at an equal rate to each of said discs for atomization therefrom as an annular spray, a pair of curved shielding members each spaced from a disc and positioned to receive a substantial segment of the spray from said disc, means operatively associated with each of said shielding members for collecting the liquid coating material received by said shielding members, a conveyor for moving a series of articles successively past said discs along a path generally on the opposite side of said discs from said shielding members and parallel to the axis of said discs, four similar deflecting electrodes each spaced from a disc and lying adjacent to an edge portion of said disc emerging from a shielding member, means including a source of high voltage for creating a spray particle depositing electrostatic field between the unshielded portion of each disc and the articles, and means for creating a spray particle repelling zone about each of said deflecting electrodes and the adjacent edges of said shielding members.

9. An electrostatic coating apparatus comprising a pair of similar coaxial discs, means for rotating said discs about their axis in opposite directions, pump means for feeding liquid coating material at an equal rate to each of said discs for atomization therefrom as an annular spray of finely divided particles, a pair of shielding members each spaced from a disc and positioned to receive a substantial segment of the spray from said disc, means for collecting and recovering the liquid coating material received by said shielding members, a conveyor for moving a series of articles successively past said discs along a path generally on the opposite side of said discs from said shielding members and parallel to the axis of said discs, means including a source of high voltage for creating a particle depositing electrostatic field between the unshielded portion of each disc and the articles, and means for creating a particle-attracting electrostatic field between the shielded portion of each disc and its adjacent shielding member.

10. An electrostatic spray coating system comprising an atomizer including an annular-edged member mounted for rotation about an axis, means for feeding liquid coating material to the surface of the member, means for rotating said member to flow coating material on said surface to the edge thereof for atomization therefrom as a spray in a generally annular pattern, a shield spaced about a portion of the edge of said member for receiving a limited segment of said spray, means operatively associated with said shield for collecting the liquid coating material received by said shield from said spray segment, deflecting electrodes positioned in the plane of the annular edge of said member, circumferentially beyond one end of the shield, and radially intermediate such shield-end and the annular edge of said member, a grounded conveyor for moving a plurality of articles into and through a second segment of said spray, a source of high electrical potential, means for connecting said source to the atomizer to create an electrical potential difference between the atomized particles and articles within said second spray-segment to urge the particles of such segment toward deposition on such articles, and means for maintaining said deflecting electrode at a particle-repelling potential.

11. An electrostatic spray coating system comprising an atomizer including an annular-edged member mounted for rotation about an axis, means for feeding liquid coating material to the surface of said member, means for rotating said member to cause such coating material to flow to the annular edge of the member for atomization therefrom as a spray of substantially annular pattern, a shield for intercepting a substantial segment but less than all of the projected spray, said shield having a first wall extending in and transversely to the plane of the annular edge of said member in opposed radially spaced relation to such edge and at least one side wall joining said first wall and located in axially spaced, overlapping relation to said member, a peripheral portion of said member projecting radially outward beyond said side wall, means associated with said shield for collecting and recovering the liquid material intercepted by said shield from said substantial segment, a support to position an article in a coating zone in opposed spaced relation to said projecting peripheral portion of said member, a source of high electrical potential, and means for connecting said source to the shield and atomizer to create an electrical potential difference between the spray particles and the article in the coating zone to electrostatically move charged spray particles toward and deposit them on the article in said coating zone and to maintain the shield at a potential such that it attracts said spray particles.

12. In a method of electrostatically coating articles wherein electrically charged particles of liquid coating material are atomized from an annular atomizing zone and projected therefrom generally in the plane thereof with a substantial radial velocity component, the steps of maintaining in the plane of the atomizing zone two electrically charged zones of particle-repelling potential spaced from said atomizing zone and from each other

within the limits of said spray to divide the spray into two segmental spray portions, intercepting one of said spray portions, collecting and reclaiming the liquid material so intercepted, and electrostatically depositing the second portion of said spray on the articles to be coated.

13. An electrostatic spray coating system comprising a rotating atomizer for creating and projecting into a quiescent atmosphere a spray of liquid coating material particles radiating from the atomizer outwardly across and throughout substantially the entire circumference of an annular region surrounding the atomizer, a spray-collecting shielding member spaced from said atomizer and occupying a first substantial segment but less than all of the circumference of said region and located in the paths of the spray particles within such segment to intercept spray particles within such segment, means for supporting an article to be coated within a second segment of said region, and means for electrically charging the spray particles and for electrostatically urging charged particles in said second segment toward deposition on said supported article, said last named means including an electrode spaced from said article and shielding member and a high-voltage source connected to said electrode and article for maintaining the electrode at a particle-repelling potential and the article and the shielding member at particle-attracting potentials.

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