METHOD OF ELECTROSTATICALLY COATING AN ARTICLE

Filed May 13, 1952 2 Sheets-Sheet 1

Fig. 1

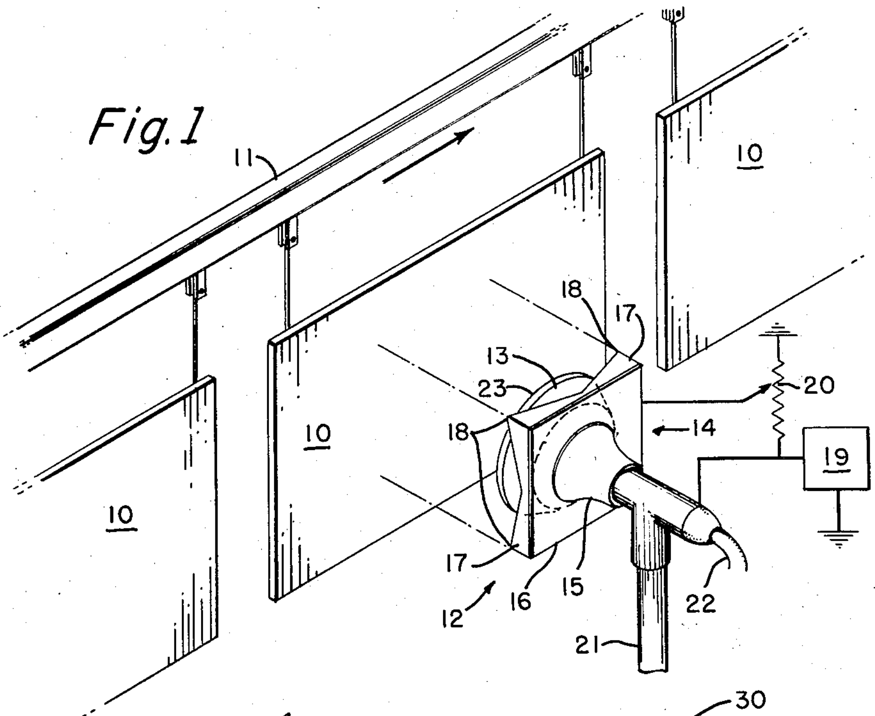


Fig. 2

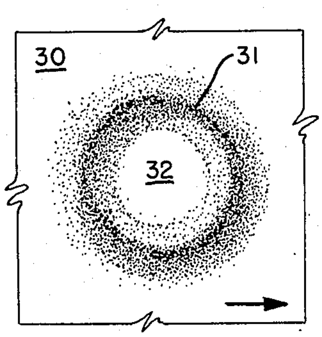


Fig. 3

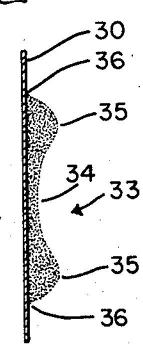


Fig. 4

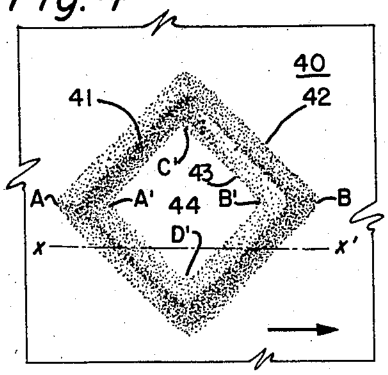
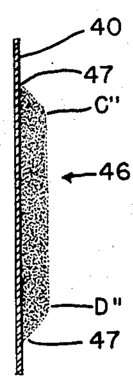


Fig. 5

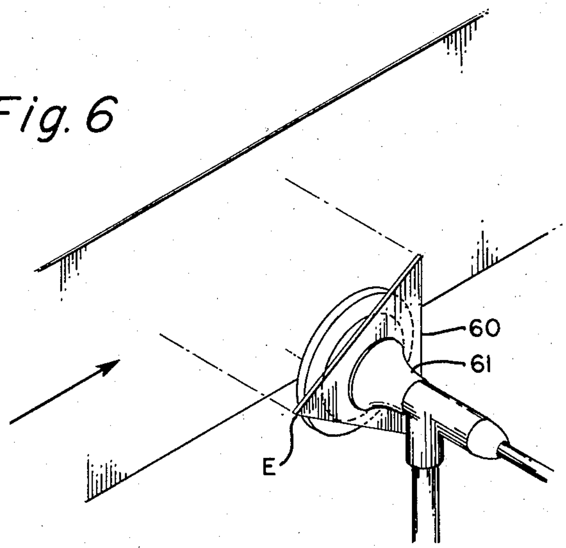


INVENTORS
ROBERT C. JUVINALL
ARTHUR W. VON FANGE
BY Schroeder, Merriam, Hofgren & Brady
Attorneys

METHOD OF ELECTROSTATICALLY COATING AN ARTICLE

Filed May 13, 1952 2 Sheets-Sheet 2

Fig. 6



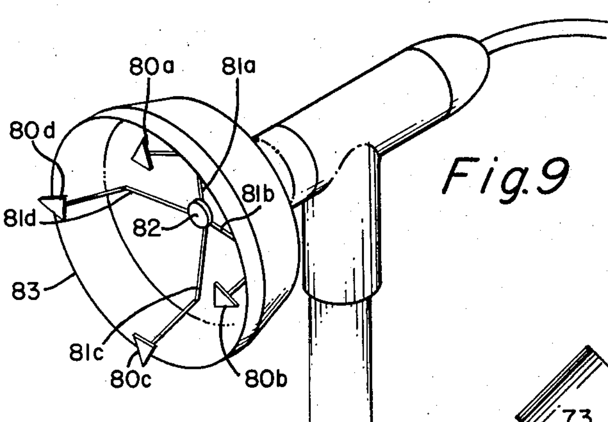


Fig. 9

Fig. 7

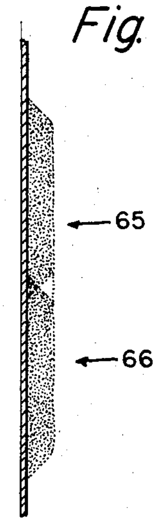
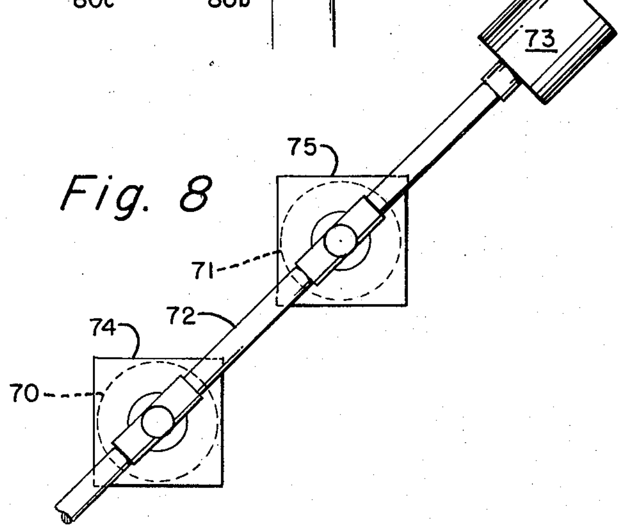


Fig. 8



INVENTORS
ROBERT C. JUVINALL
ARTHUR W. VON FANGE
BY Schroeder, Merriam, Hofgren & Brady
Attorneys

United States Patent Office

2,877,137

Patented Mar. 10, 1959

2,877,137

METHOD OF ELECTROSTATICALLY COATING AN ARTICLE

Robert C. Juvinall and Arthur W. Von Fange, Indianapolis, Ind., assignors to Ransburg Electro-Coating Corp., a corporation of Indiana

Application May 13, 1952, Serial No. 287,468

4 Claims. (Cl. 117—93)

This invention relates to novel methods of and apparatus for controlling particles of matter being carried in a fluid. In particular, the invention is directed to shaping a dispersion of finely divided particles during their travel in a fluid medium to produce a predetermined and usable pattern or arrangement of the particles.

Numerous commercial processes and apparatus employ or produce a dispersion of particles emitted from a source into a fluid medium. Generally the spacial limits or boundaries of this dispersion or spray of particles consists of various types of curved surfaces such as cones, frusto-cones, and the like. These curving boundaries are generally inherent in the spray or dispersion producing system employed. In various commercial processes it is often desired to shape or confine the particles comprising the spray within predetermined spacial limits or boundaries having relatively sharp angles, straight-line edges, and flat non-curved sides. Where the spray particles are to be deposited on an article to produce a coating thereon, it has been desired to so shape the pattern of the spray as to produce the desired thickness of coating over all areas of the surface being coated. It is, of course, desired that this shaping of the aggregate of the spray particles be accomplished without the use of physical boundaries such as walls or sheets.

One commercially successful spray coating method is shown and described in the copending application of E. M. Ransburg, filed February 13, 1950, as Serial No. 143,955, and employs an annular or ring-shaped spray source which emits a spray of liquid particles into the atmosphere. The pattern of the spray as it is deposited on a stationary flat surface of relatively large area maintained perpendicular to the axis of the spray, herein termed the static pattern, is an annulus having a center portion substantially devoid of spray particles. For convenience of description, such a pattern as just described will be referred to herein as an annular pattern. In such a coating process in order to produce a desired distribution of coating over an article it is often desirable to produce a spray pattern having a shape other than annular.

It is an object of our invention to provide methods and apparatus for producing more usable patterns of particles being carried in a fluid medium. It is also an object of our invention to provide means for producing a spray having a predetermined shape such as when moved relative to the surface of the article being coated, will produce thereon a desired distribution of coating material. Yet another object is to produce a spray having flat sides and linear edges. It is a further object of our present invention to provide a new method and apparatus for eliminating the inherent non-uniformity of the normal or conventional spray deposition pattern from an annular atomizing edge as deposited on an article surface moving normal to the spray axis. Another object of the invention is to produce methods and apparatus for controlling the pattern of a spray deposited on an article moved relative thereto so as to expose equal areas thereof lying on a line normal to the direction of relative movement to desired quantities of the spray particles for desired periods of time, which quantities and times may be equal or unequal for various areas, to produce on such areas desired thickness of coating material. It is still a further object of this invention to produce a uniform deposition of coating material on a moving article or, in the terminology of this disclosure, to produce a dynamic spray pattern which is uniform across a major portion of its width, that is, a pattern which will produce a coating of uniform thickness on the article. Still another object of this invention is to provide a new and improved method and apparatus for spray coating by a relatively simple and inexpensive modification of existing commercial practices.

While our invention relates to dispersions generally, it is of particular use in obtaining a uniform dynamic pattern in electrostatic coating processes. A description of our process as employed, as an exemplary embodiment, in electrostatic spray coating processes employing an annular spray will now be set forth, but the adaption of our invention to other spray processes will be readily apparent to those skilled in the art.

One widely practiced form of electrostatic spray coating involves a series of articles to be coated moving on a conveyor line through a coating zone. Liquid coating material is supplied to the inner surface of a rotating bell-shaped head, such as the type described in the previously mentioned application of E. M. Ransburg, which is maintained in fixed position in the coating zone adjacent to the articles on the moving conveyor with its axis normal to the surface of the article to be coated. The rotation of the head causes the coating material to form a thin liquid film which moves outwardly to the annular outer edge of the head. A high electrical potential difference is maintained between the outer edge of the head (connected to a source of high electrical potential) and the articles on the conveyor. The liquid coating material leaves the outer edge of the bell in a finely divided or atomized state and these liquid droplets of coating material each carry a high electrical charge due to the contact of the liquid film and with the charged bell. As the droplets leave the outer edge their sameness of electrical charge causes them to disperse one from another and at the same time each particle is attracted in the direction of the article to be coated by reason of the electrical potential difference between the particles and the article. As the mutual attraction between the charged droplets and the grounded article is the predominating force, the droplets will generally follow the lines of force between the head and the article and the spray particles will be deposited in an annular pattern on a flat stationary article having a relatively large surface area. Such pattern is hereinafter sometimes referred to as the "static pattern." The inner and outer boundaries of this static pattern are somewhat indefinite, and the thickness of the deposited film of liquid coating material is considerably greater along a circle half way between the inner and outer peripheries of the annulus than is the film thickness immediately adjacent to its inner and outer peripheries.

In the coating of a flat surfaced article whose width is at least coextensive with the outer diameter of the annular spray pattern, such as a continuous web of material or a series of flat panels, it will be apparent that as the article being coated is moved through the coating zone normal to the axis of the spray of coating material a non-uniform band of coating material will be deposited on the article surface. The band deposited on a flat, relatively large surface moving at a constant rate normal to the spray axis is referred to as the dynamic pattern.

As sprays of coating material from an annular edge are somewhat divergent, the diameter of the static pattern will depend partially upon the distance of the article surface from the atomizing head. In one commercially used process of electrostatic coating, the outer diameter of the static pattern is approximately two times the diameter of the inner periphery of the annular pattern, at normally used distances between the head and the article, and in the following description of our invention such proportions are assumed. In such a process the cross-section of the dynamic pattern produced by an annular spray will be relatively thin through its center line where the film thickness of the coating material may often be approximately one-half the maximum thickness which exists along the two lines intermediate between the center line and each outer edge of the dynamic pattern.

We have discovered that by properly regulating the voltage of a correctly spaced and designed spray-shaping electrode which may be separate from a spray source but adjacent thereto, the spray can be shaped or controlled into a pattern other than the normal static pattern. For example, by the use of such a spray-shaping electrode the normal annular static pattern produced by a rotating bell-type head previously described can be controlled and converted into a static pattern which is oval in shape, or into a pattern which is bounded by two substantially similar polygon-like figures, lying symmetrically one within the other, whose adjacent sides are approximately parallel. By similar polygons we mean similar in the Euclidean geometric sense, to wit: having respective angles equal and corresponding sides proportionate. By spray-shaping electrode we mean a structure arranged adjacent to the spray source and designed so that the electrostatic lines of force from the spray-shaping electrode assist in guiding and directing the spray particles into the desired pattern. Various widely different designs of spray-shaping electrodes have been used, but one of the simplest consists of a flat, straight-sided metal plate lying slightly rearward of the spray source. If desired, the plate may be provided with probes or fins extending from each corner of the plate forwardly toward the article. The number of sides of the two similar polygons which bound the static pattern will depend on the shape of this electrode and particularly on the number of terminal portions thereof. Generally, if the spray-shaping electrode has N corners or terminal portions the similar polygons will each have N sides. Inasmuch as the static pattern can be shaped and modified, the dynamic pattern resulting from relative movement between the article and the atomizing source can be modified to produce equal or predetermined desired unequal exposures of various areas of the surface to the spray. Thus to expose equal areas of the article to equal quantity-time ratios of coating material particles to produce equal thickness of coating on all such areas, the polygon-bounded static pattern of N sides as described is oriented upon the surface of the article being spray coated so that N minus two of the angles of each of the two similar bounding polygons are bisected by lines parallel to the path of relative movement between the article being coated and the spray source. When such conditions are obtained the cross-section of the resulting dynamic pattern will be a trapezoid wherein the thickness of deposited coating material is uniform between the parallel sides of the trapezoid.

By way of analogy, where a field shaping electrode in the form of a square whose corners are spaced equidistant about the annular outer edge of the atomizing head is used, the net result of the action of the resultant force on the aggregate of the spray particles will be like four fingers pressing inwardly at four equidistant points around the outer edge of a rubber ring so as to shape or bend the ring into a hollow square.

The detailed manner of accomplishing the foregoing will be fully understood from the following description, with reference to the accompanying drawings wherein:

Fig. 1 is a perspective view, somewhat diagrammatic, showing a form of apparatus used in the practice of our invention;

Fig. 2 is a plan view illustrating the static pattern deposited on an extended flat surface by an annular spray;

Fig. 3 is a cross section, with the dimensions of the film thickness greatly accented, of the dynamic pattern produced by uniform transverse movement of a surface receiving an annular spray;

Fig. 4 is a view similar to Fig. 2 showing the static pattern deposited on an extended flat surface by a spray produced by apparatus arranged as in Fig. 1;

Fig. 5 is a view similar to Fig. 3 illustrating the dynamic pattern resulting from the use of the apparatus shown in Fig. 1;

Fig. 6 is a perspective, somewhat diagrammatic, view of apparatus for producing a triangular static deposition pattern;

Fig. 7 is a cross sectional view showing the blending or interconnection of the dynamic pattern of two separate annular atomizing devices employing our invention;

Fig. 8 is a diagrammatic view of apparatus for producing the dynamic pattern shown in Fig. 7, and

Fig. 9 is a view like Fig. 1 showing a further form of the apparatus.

Fig. 1 illustrates a convenient apparatus for the practice of our invention. A series of flat metal panels **10** to be coated suspended on a suitable conveyor **11** are moved in the direction of the arrow through a coating zone. An atomizing device **12** is maintained at a fixed distance from panels **10** with the axis of its bell-shaped head **13** normal to the path of movement of the panels. A spray-shaping electrode **14** is affixed by means of insulating connecting ring **15** to the atomizing device to the rear of bell-shaped head **13**. The spray-shaping electrode **14** consists of a square metal plate **16** whose outer dimensions are slightly larger than the diameter of head **13** to the outer edges of which are attached four metal fins **17** each having its ends somewhat wider than its center so that four points **18** project outwardly toward the surface of the article to be coated. That portion of the electrode **14** which projects radially beyond the outer edge of the head (the four corners of plate **16** and the metal fins **17**) are referred to herein as the terminal portions of the electrode.

A source of high electrical potential **19** is connected to the bell-shaped head **13** to maintain the head at high electrical potential in relation to the panels **10** to be coated which are grounded through their conveyor. At the same time the spray-shaping electrode, which is suitably insulated from the remainder of the atomizing apparatus by insulated connecting ring **15**, is maintained at a suitable electrical potential which is regulated by a voltage divider **20** connected to high voltage source **19**. In the exemplary embodiment under description, the spray-shaping electrode is preferably maintained at a potential near that of the head **13**.

Atomizing head **13** is rotated by a motor through suitable shafts and gears not shown within support **21**. Liquid coating material from a source not shown is fed at a controlled rate through a hose **22** of insulating material and suitable couplings and tubes within device **12** to the inner surface of atomizing head **13**. Rotation of the head causes the liquid to form an outwardly moving thin film which is brought to a high electrical potential by contact with the charged head. Finely divided discrete liquid droplets of coating material are atomized from outer edge **23** of the rotating head with the aid of electrostatic forces. The movement of these droplets or spray particles is governed principally by the forces described and as a result of these forces the spray particles will be deposited on a stationary surface in the form of a hollow square as shown in Fig. 4.

Fig. 2 shows the static pattern produced by an annular spray, such as the spray from an annular electrostatic atomizing head, deposited on an extended flat sheet **30**. The pattern forms annulus **31** which surrounds a central area **32** devoid of coating material. When sheet **30** is moved normal to the spray axis in the direction of the arrow shown at Fig. 2, the dynamic pattern of the deposited coating material will be in the form of an extended band, the cross section of which is shown at Fig. 3.

In Fig. 3 the film thickness of band **33** is exaggerated for convenience of illustration. The center portion **34** of the cross section of the band or dynamic pattern is relatively thin and the film thickness increases to two maximum crests **35** located something more than half way between center **34** and outer edges **36** of the band, as shown. On the outer sides of each crest **35** the band decreases to zero thickness at outer edges **36**. Variations in thickness as illustrated in Fig. 3 are typical and the minimum thickness is often 50% to 60% of the maximum thickness of the dynamic pattern. Such variation and non-uniformity are often objectionable in commercial coating processes particularly when coating large flat areas. If the band is at the desired thickness at crests **35**, the center portion **34** will be objectionably thin. Conversely, if the article being coated is moved so slowly that film thickness at center portion **34** is permitted to build up to a commercially acceptable minimum, coating material will be deposited at crests **35** to an uneconomical thickness which may sag or run.

Our invention presents a simple and economical means for eliminating the objectionable features just described. The apparatus shown in Fig. 1 is used to reorient and shape the static pattern of the deposited coating material into a hollow square **41** as shown in Fig. 4. While one feature of our invention with a properly designed and arranged spray-shaping electrode maintained at suitable voltages generally speaking produces a static pattern of spray deposition having an area bounded by two similar polygons whose number of sides is determined by the number of terminal portions of the spray-shaping electrode, it has been found that the one of the most useful and commercially adaptable static patterns is the hollow square as shown in Fig. 4 and produced by the apparatus shown in Fig. 1 and heretofore described.

Fig. 4 shows a static pattern **41** bounded by outer and inner rather well defined and straight-sided squares **42** and **43** respectively. The pattern surrounds a central square area **44** which is substantially devoid of coating material. The adjacent sides of outer and inner bounding squares **42** and **43** are approximately parallel. When sheet **40** is moved transverse to the spray axis in the direction of the arrow shown at Fig. 4, it will be seen that angles A and B of square **42** and angles A′ and B′ of square **43** will be bisected by a line parallel to the path of movement of sheet **40**. As N minus two angles of each bounding four sided polygon (A and B of square **43** and A′ and B′ of square **44**) are thus bisected, the static pattern is so oriented that its dynamic pattern will be a trapezoid. It will be further apparent that the total exposure to coating of any given increment of area moved along a line parallel to the line of movement of sheet **40**, such as line *x—x′*, will be the same as the exposure of any other increment similarly moved. It is this phenomenon which causes a uniform deposition of coating material at all points between angles C′ and D′ when sheet **40** is moved through the coating zone.

Fig. 5 shows a cross section of the band or dynamic pattern resulting from the movement of sheet **40** through a coating zone having the static pattern shown at Fig. 4. In Fig. 5 the film thickness of band **46** is exaggerated for convenience of illustration. It will be seen that a cross-section of the band is in the form of a trapezoid and that the film thickness between edges C″ and D″ which correspond to angles C′ and D′ of the static pattern in Fig. 4, is uniform. From edges C″ and D″ to the outer edges **47** of the band the film thickness decreases to zero at a constant rate. It will be apparent that if a static pattern is any area bounded by two similar polygons, lying symmetrically one within the other, wherein adjacent sides of the inner and outer polygons are parallel, and if all but two of the angles of each polygon are bisected by a line or lines parallel to the path of articles movement, then the cross section of the dynamic pattern will be a trapezoid with a uniform film thickness deposited between the parallel sides of the trapezoid.

In order to compensate for the circumferential velocity of the spray particles caused by rotation of head **13**, it is desirable to position plate **16** so that its top and bottom edges are at a slight angle to the path of movement of the conveyor, say a few degrees. Such positioning would permit the formation of a static pattern having its angles A, A′, B and B′ more nearly bisected by a line parallel to the path of article movement. As can be seen from an inspection of Fig. 1, the terminal portions **18** on the left-hand side of the electrode **17** are substantially vertically spaced from each other except for the compensation just mentioned above. As used in the claims, however, the term "vertically spaced," or terms otherwise correlating the direction of a line connecting such terminal portions with the line of article movement, are intended to be interpreted without giving effect to any tilting of the electrode to compensate for rotational twist of the spray. Thus, for the purposes of the specifications and claims, the two left-hand portions **18** of the electrode **17** are vertically spaced from each other.

By use of the apparatus shown in Fig. 1 a static and dynamic spray deposition pattern as shown in Figs. 4 and 5 respectively was obtained wherein the following conditions were maintained:

Potential of atomizing head 13	90,000 volts (negative).
Potential of spray shaping electrode 14	90,000 volts (negative).
Potential of panels 10	Ground potential.
Spacing between outer edge 23 of atomizing head and panels 10	12 inches.
Speed of rotation of head 13	900 revolutions per min.
Spacing between points 18 and panels 10	14⅛ inches.
Diameter of atomizing edge 23	10 inches.
Distance from axis of head 13 to points 18	7¾ inches.
Outside dimensions of plate 16	10¾ inches by 10¾ inches.
Dimensions of panels 10	36 inch width by 48 inch length.
Rate of delivery of liquid coating material	100 cc. per minute.
Type of liquid coating material	Red synthetic enamel, modified urea formaldehyde, 20 sec. on Zahn #2 Cup at 68° F.
Speed of panels 10 on conveyor 11	10 feet per minute.

Fig. 6 illustrates a modified form of coating apparatus designed to produce a hollow triangular-shaped static spray pattern. The spray-shaping electrode consists of a flat triangular metal plate **60** which is connected to the central housing of an atomizing device similar to device **12** shown in Fig. 1 by a connecting ring **61** of insulating material. Plate **60** is in the shape of an equilateral triangle the angles of which are spaced rearward of and somewhat outwardly beyond the plane of the annular edge of the bell-shaped atomizing head. Plate **60** is positioned so that the angle E is a few degrees from being bisected by a line parallel to the path of movement of the article to be coated; its exact position being dependent upon the speed and direction of rotation of the atomizing head.

The remaining parts of the apparatus are arranged substantially as is the apparatus shown and described in Fig. 1. The operation of such an apparatus produces a static deposition pattern of spray particles in the form of a hollow equilateral triangle with an angle which is bisected by a line parallel to the path of movement of the articles to be coated, and the dynamic pattern is a trapezoid. Thus the film thickness of the liquid coating material deposited on the article will be substantially uniform over a major portion of its width.

Fig. 7 shows the blending or complementing of two trapezoidal dynamic patterns **65** and **66** to produce a uniform film of coating material over a wide expanse of article surface. This result is obtained by utilizing two atomizing heads of the general type disclosed in Fig. 1 and Fig. 6. The heads should be spaced transversely of the path of article movement at a sufficient distance so that the edges of their trapezoidal spray dynamic patterns complement or "fill in" each other to achieve a uniform coating thickness. At the same time the atomizing heads should be spaced somewhat apart to prevent interference between the electrostatic fields of each head which would warp or distort the trapezoidal dynamic pattern of each separate atomizing head.

This spacing can be obtained by offsetting the heads along the path of article movement. One method of spacing the atomizing heads embodying the foregoing principles is shown in Fig. 8. The two atomizing heads **70** and **71** are both supported by and connected to a tubular housing **72** which housing also supports motor **73**. Suitable spray-shaping electrodes **74** and **75** are positioned around atomizing heads **70** and **71** respectively. Motor **73** rotates atomizing heads **70** and **71** through suitable shafts and gearing not shown. The heads are spaced transverse to the path of article movement by tipping tubular housing **72** at a sufficient angle so that the spray deposition pattern from heads **70** and **71** complement each other to form a continuous band of uniform thickness except at its two outer edges. Heads **70** and **71** are spaced along housing **72** at a sufficient distance to prevent mutual electrical shielding or interference between their separate electrostatic fields. It is obvious that more than two atomizing heads can be arranged, either integrally or separately supported, so as to obtain an almost unlimited width of the band of coating material having a uniform film thickness.

In the embodiments of the invention heretofore described the spray-shaping electrode was provided with corners or terminal portions positioned outwardly of the atomizing edge. Similar advantageous results can be achieved by locating the spray-shaping electrode within the atomizing edge, that is where the atomizing edge is circular in form as illustrated, the spray-shaping electrode or electrodes may be located within the annulus. Apparatus of this character is illustrated in Fig. 9. The spray-shaping electrode in this embodiment consists of four small, equilateral, triangular, metal plates **80*a***, **80*b***, **80*c*** and **80*d*** each mounted on relatively heavy wires **81*a***, **81*b***, **81*c*** and **81*d*** which in turn are connected to a disc **82** mounted on the end of a rod (not shown) which runs axially through the tube by which liquid coating material is supplied to the inner face of the rotating bell type atomizing head **83**. The plates **80*a*–80*d*** are equally spaced around the inner edge of the head **83** and are so arranged that each of the plates lies in a plane parallel to and slightly forward axially of the atomizing edge of the bell. The spray-shaping electrode which includes the four triangular metal plates is maintained at or near the same high electrical potential as that of the atomizing means **83**.

The operation of the apparatus illustrated in Fig. 9 produces a static deposition pattern of spray particles substantially in the form of a hollow square. With the spray-shaping electrodes positioned within the annular edge, however, the hollow polygonal static pattern produced thereby is somewhat larger in diameter than the normal annular pattern produced by an atomizing means similarly constructed but without the spray-shaping electrodes. Also with the spray-shaping electrodes being located within the edge of the outer boundaries of the polygonal pattern produced are somewhat rounded but the general static pattern produced by the apparatus shown in Fig. 9 approximates a hollow square sufficiently closely as to produce a dynamic pattern substantially uniform in thickness when relative motion between the atomizing means and the article to be coated are produced.

In the various embodiments of our invention as above shown and described, the axis of the spray of atomized coating material is normal of the path of article movement. However, it is apparent that some variation of the angle of the axis of the spray to the path of article movement will not significantly affect the distribution of the coating material on the article. The dynamic pattern from a spray having a slightly tipped axis will not be substantially different from the dynamic pattern produced from a spray having its axis normal to the path of article movement and such modification may, of course, be made without varying from the scope of our invention.

In the specific embodiments on the invention described in detail, the static pattern was so oriented on the article as to produce a dynamic pattern on a moving article capable of depositing coating material equally on equal areas of the article. It will be readily apparent to those skilled in the art that the principles of the invention can be utilized to direct unequal amounts of coating toward areas lying along a line transverse to the direction of article movement where, for example, the shape of the article is such as to require heavier concentrations of spray particles in certain areas. Thus, when coating an article shaped as an I-beam, the pattern of Fig. 4 may be oriented so as to have two sides parallel to the upper and lower flanges of the beam and two sides perpendicular thereto. While the concentration or quantity of particles is substantially the same in all areas of the static pattern, movement of such article through a pattern so oriened exposes the flanges to coating deposition for a longer time than the intervening rib connecting the flanges and, when properly controlled, results in a uniform deposition of coating over the entire surface of the article exposed to coating deposition. The triangular spray-shaping electrode may also be used to expose areas of an article to unequal times of coating deposition in the event such unequal exposure is desired. For example, if the article being coated has generally the shape of a T-beam, the pattern may be so oriented on the article that one side of the triangle is parallel to the flange of the beam while the two other sides cover the web or leg portion of the beam and thus as the article is moved relative to the spray, the flange portion is exposed to coating for a greater period of time and thus may receive coating equal in amount to that applied to the balance of the beam. Equal thicknesses of coating may also be applied to objects or articles of other shapes by properly forming the spray-shaping electrode so as to vary either the time or the quantity of coating material deposition on various areas of the article.

It also may be desired to apply unequal thickness of coating to different areas of an article and the invention hereof is readily adaptable for such use. By proper shaping of the static pattern and by proper orientation of the pattern on the surface to be coated, a dynamic pattern can be produced by relative movement between the article and the spray having any desired cross-sectional configuration.

While this invention is susceptible of embodiments in many different forms, there has been shown in the drawings and described in detail three specific embodiments, with the understanding that the detailed description is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiments illustrated. The scope of the invention is pointed out in the appended claims.

We claim:

1. The method of depositing a coating of uniform thickness on an article comprising the steps of forming a spray of coating material into a hollow static pattern bounded by two similar polygons lying symmetrically one within the other, and moving the article to be coated through the spray generally normal to the axis of the spray and in such direction that all but two of the angles of each bounding polygon are bisected by a line parallel to the path of article movement to produce on the article a substantially uniform dynamic pattern.

2. The method of electrostatically coating an article which comprises supplying liquid coating material to an annular atomizing zone lying in a substantially vertical plane, moving the articles to be coated along a horizontal path and through a coating zone spaced from said atomizing zone axially thereof, electrostatically charging the atomizing zone to form a depositing electrostatic field having lines of force extending between the atomizing zone and an article in said coating zone, said field being of sufficient strength as to be capable of electrostatically atomizing coating material at said atomizing zone and electrostatically depositing the atomized particles on the article in said coating zone, said field being so shaped as to cause such deposition of atomized particles normally in an annular static spray pattern, maintaining closely adjacent said atomizing zone a plurality of electrode terminal portions charged to the same sign as said atomizing zone with at least two of said portions being maintained vertically spaced from each other and on opposite sides of a horizontal plane through the spray axis, and the said path of article movement in the coating zone being along a line extending substantially normal to a line joining said two electrode terminal portions, said electrode terminal portions being arranged to reshape said annular static pattern into a non-annular pattern more uniformly to deposit coating material on the articles.

3. The method of electrostatically coating an article which comprises supplying liquid coating material to an annular atomizing zone, moving the articles to be coated along a predetermined path through a coating zone spaced from said atomizing zone, electrostatically charging the atomizing zone to form a depositing electrostatic field having lines of force extending between the atomizing zone and an article in said coating zone, said field being of sufficient strength to be capable of electrostatically atomizing coating material at said atomizing zone and electrostatically depositing the atomized particles on the articles in said coating zone, said field being so shaped as to cause such deposition of atomized particles normally in an annular static spray pattern, maintaining closely adjacent said atomizing zone a plurality of electrode terminal portions charged to the same sign as said atomizing zone with at least two of said portions being maintained spaced from each other equidistantly from and on opposite sides of a plane through the spray axis and having said predetermined path lying therein, said predetermined path of article movement in the coating zone being along a line extending substantially normal to a line joining said two electrode terminal portions, said electrode terminal portions being arranged to reshape said annular static pattern into a non-annular pattern more uniformly to deposit coating material on the articles.

4. The method of electrostatically coating an article which comprises supplying liquid coating material to an annular atomizing zone, moving the articles to be coated along a predetermined path through a coating zone spaced from said atomizing zone, electrostatically charging the atomizing zone to form a depositing electrostatic field having lines of force extending between the atomizing zone and an article in said coating zone, said field being of sufficient strength to be capable of electrostatically atomizing coating material at said atomizing zone and electrostatically depositing the atomized particles on the article in said coating zone, said field being so shaped as to cause such deposition of atomized particles normally in an annular static spray pattern, maintaining closely adjacent said atomizing zone a plurality of electrode terminal portions charged to the same sign as said atomizing zone with at least two portions being maintained spaced from each other and on either side of the spray axis, said predetermined path of article movement in the coating zone being along a line extending substantially normal to a line joining said two electrode terminal portions and substantially normal to the spray axis, said electrode terminal portions being arranged to reshape said annular static pattern into a non-annular pattern more uniformly to deposit coating material on the articles.

References Cited in the file of this patent

UNITED STATES PATENTS

1,832,096	Chaffie	Nov. 17, 1931
1,861,475	Hopkins	June 7, 1932
2,097,233	Meston	Oct. 26, 1937
2,221,338	Wintermute	Nov. 12, 1940
2,421,787	Helmuth	June 10, 1947
2,456,853	Arbron	Dec. 21, 1948
2,466,906	Miller	Apr. 12, 1949
2,525,347	Gilman	Oct. 10, 1950
2,562,358	Huebner	July 31, 1951
2,568,611	Crouse	Sept. 18, 1951
2,581,957	Jones	Jan. 8, 1952