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APPARATUS AND METHOD OF COATING ARTICLES

Filed Nov. 23, 1951

2 Sheets-Sheet 1

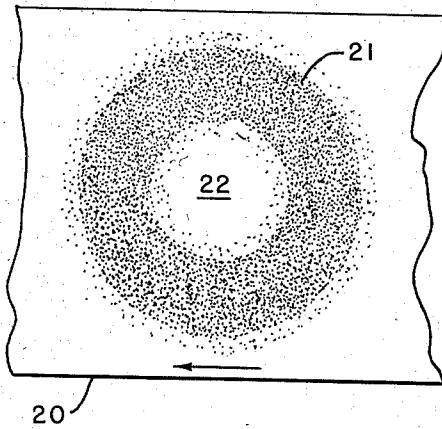


Fig. 1

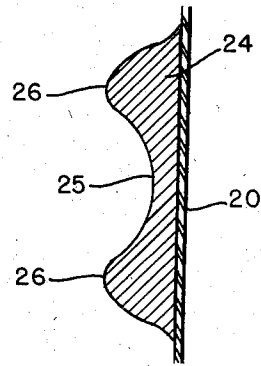


Fig. 2

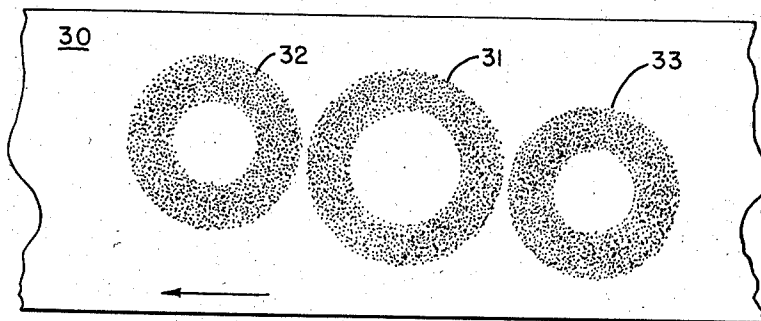


Fig. 3

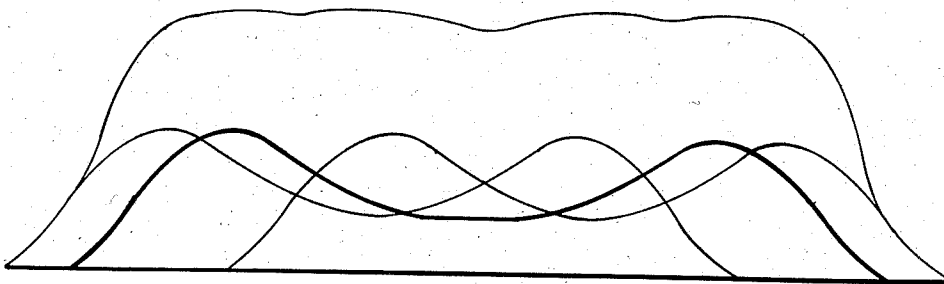


Fig. 4

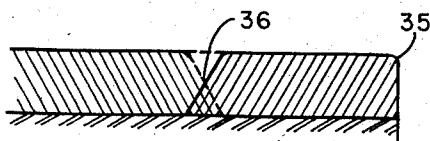


Fig. 5

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2 Sheets-Sheet 2

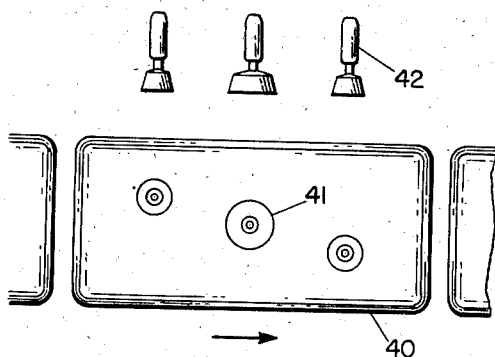


Fig. 6

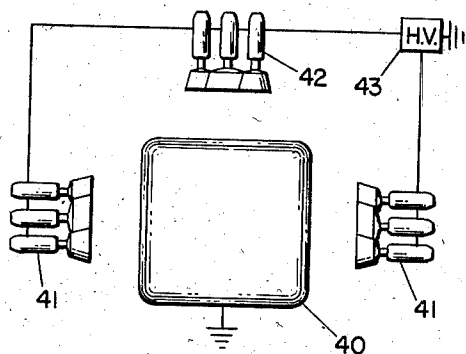


Fig. 7

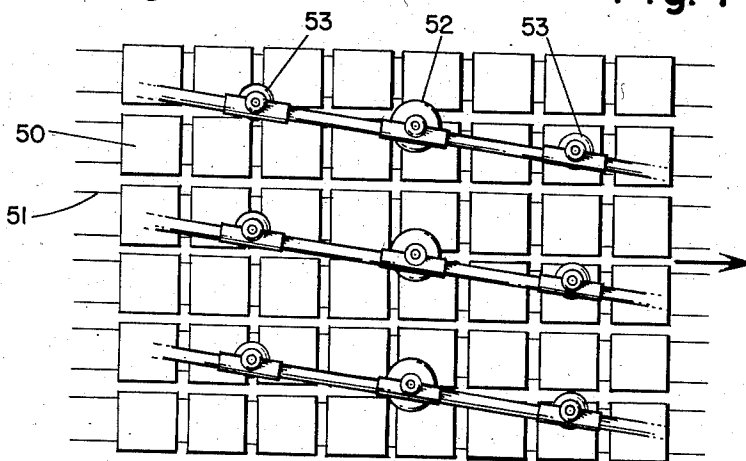


Fig. 8

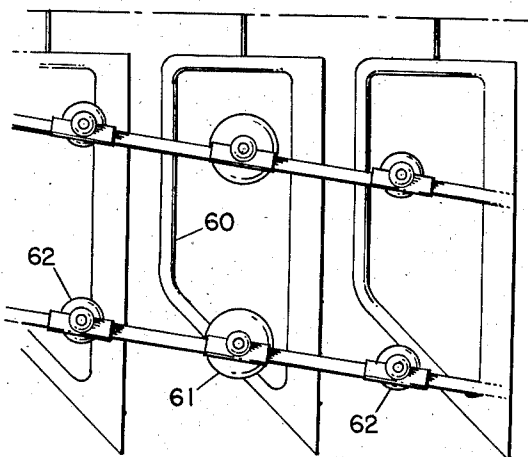


Fig. 9

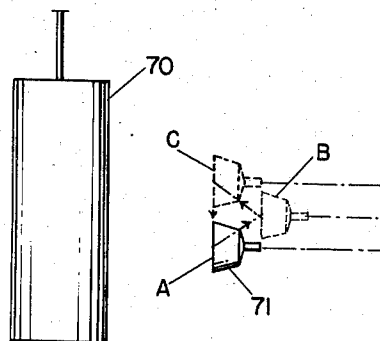


Fig. 10

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2,839,425

APPARATUS AND METHOD OF COATING
ARTICLES

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Application November 23, 1951, Serial No. 257,741

Claims priority, application Great Britain March 13, 1951

10 Claims. (Cl. 117—93)

This invention relates to an apparatus and method for applying liquid coating material to articles of manufacture and more particularly to methods and apparatus in which the coating material is projected on to the article in the form of an annular spray having a central void. Such sprays are produced by annular electrostatic atomizing heads of the type more fully set forth and described in the co-pending application of E. M. Ransburg, Serial No. 143,994, filed February 13, 1950. For convenience, the invention will be hereinafter described as embodied in an electrostatic coating apparatus employing annular atomizing heads; but in its broader aspects, the invention is independent of the manner in which the annular spray of coating material is formed.

If an annular spray of coating material is projected perpendicularly on to an extended flat surface, the pattern produced on such surface by the coating material will itself be an annulus. If the surface moves rectilinearly in its own plane, the coating material is deposited in the form of a band having a width equal to the outer diameter of the annulus. The coating is relatively thin at the longitudinal center-line of the band, increases in thickness to a maximum value outwardly from the center-line, and then decreases in thickness to the edges of the band. For ease in describing the invention, I shall hereinafter refer to the annular pattern produced on a stationary surface as the static pattern and to the band produced when such a surface is moved rectilinearly in its own plane as the dynamic pattern.

Annular sprays of liquid coating material are divergent, and the diameter of the static pattern produced on a surface transverse to the axis of the spray will therefore depend upon the distance of such surface from the spray-source. If the spray is produced by electrostatic atomization from an annular head, the diameter of the deposited static pattern will also vary with the diameter of the head. In the most common operating conditions employed in the use of annular electrostatic atomizing heads, the outer diameter of the static pattern is two or three times the diameter of the central void; and in what follows, patterns roughly approximating such proportions are assumed. As noted above, the dynamic pattern produced by an annular spray will be relatively thin at its center; and the dynamic pattern created by an annular electrostatic atomizing head may have at its center a thickness less than one-half the maximum thickness existing at a point intermediate such center and the edge.

It is an object of this invention to improve uniformity in the thickness of coating produced by annular sprays of coating material deposited on moving surfaces. A further object of this invention is to produce a dynamic pattern several of which can be deposited in contiguous relationship without the necessity for any critical control to avoid an objectionable thickness-variation where two such patterns meet. Still another object of the invention is to produce a coating method and apparatus which lends itself to the production of satisfactorily uniform coatings with

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electrostatically atomized sprays of coating material emanating from annular atomizing heads.

The invention of this application grows out of the discovery that improved uniformity of coating-thickness can be obtained by combining the spray-patterns produced by three properly arranged annular sprays of properly proportioned diameters. The apparatus employed is so arranged that the annular or static patterns produced by two of the sprays in the plane of the surface being coated will be of substantially equal diameter, while the static pattern produced by the third spray will have a diameter greater than but usually less than twice the diameter of the other pattern. The axis of the larger spray and the center-line of the surface to be coated by the group of sprays occupy a common plane, and the axes of the smaller sprays are offset from the axis of the larger spray in opposite directions, and by equal distances, transversely of the path of surface travel to such an extent that the smaller sprays jointly produce on the surface a band of coating material generally coincident with the band produced by the larger spray.

A band or dynamic pattern produced as above described is characterized by a relatively broad central portion of approximately uniform thickness and by edge portions of gradually decreasing thickness. Two or more of such bands may be deposited on the surface in contiguous relationship with the edge portions of adjacent bands overlapping to complement each other in such a way that the overlapping portions will have substantially the same thickness as the central portion of each band.

The accompanying drawings illustrate the invention: Fig. 1 is a plan view indicating the static pattern deposited on an extended horizontal surface by an annular spray; Fig. 2 is a vertical section, with the vertical thickness greatly accented, of the dynamic pattern produced by rectilinear movement of a surface receiving an annular spray; Fig. 3 is a view similar to Fig. 1 illustrating an arrangement of three annular sprays in accordance with this invention; Fig. 4 is a view similar to Fig. 2 illustrating the dynamic pattern resulting from the three-spray arrangement shown in Fig. 3; Fig. 5 is a view similar to Figs. 2 and 4 illustrating the combination of two dynamic patterns such as are shown in Fig. 4; Figs. 6 and 7 are respectively a diagrammatic side elevation and a diagrammatic end elevation of apparatus employing the principles of this application in the coating of box-like articles; Fig. 8 is a diagrammatic plan view and Fig. 9 a diagrammatic elevation illustrating further embodiments of the invention; and Fig. 10 is a diagrammatic end elevation of a modified apparatus.

In Fig. 1 I have illustrated the static pattern produced when an annular spray, such as the spray from an annular electrostatic atomizing head, is deposited upon an extended flat surface, such as the surface of a metal sheet 20. The pattern is in the form of an annular band 21 surrounding a central void 22. If the sheet is moved rectilinearly through the spray, as in the direction of the arrow shown in Fig. 1, the coating material will be deposited in the form of a band 24 having the general thickness characteristics exaggeratedly indicated in Fig. 2. At its center, indicated by the reference numeral 25, the band will be relatively thin but will increase in thickness toward the edges of the band to points of maximum thickness, or crests, indicated at 26. Outwardly beyond such crests, the thickness of the band will decrease laterally toward the extreme edges. Variations in thickness of the relative extent indicated at Fig. 2—i. e., plus or minus about 35% from a mean value—are typical and are objectionable in practice. If the band is thick enough at its center 25, the excess thickness at and adjacent the crests 26 represents a waste of coating material; and in some instances, if the band is made of

adequate thickness at its center 25, the excess quantity of coating material deposited adjacent the crests 26 may be great enough to cause sagging on vertical surfaces. On the other hand, if the band is made of the desired thickness at the crests 26, the center portion 25 of the band may be objectionably thin.

As indicated above, I have discovered that it is possible to produce a band or dynamic pattern of satisfactorily uniform thickness by employing three properly proportioned and properly positioned annular sprays. Such an arrangement is indicated in Fig. 3 where the flat surface of sheet material 30 is shown as receiving three annular sprays producing the annular patterns respectively indicated at 31, 32 and 33. These patterns are of roughly similar proportions; but the center pattern 31 has a larger diameter than the other two patterns. The sprays are offset from each other in a direction transverse to the direction in which the sheet 30 is to be moved, such offsetting however being insufficient to eliminate a very substantial overlapping of the individual dynamic patterns produced by the several sprays. The static patterns indicated in Fig. 3 are shown as also offset longitudinally of the path of sheet-movement for a purpose which will later be explained.

If the static patterns 31, 32 and 33 are properly proportioned and properly disposed relatively to each other transversely of the path of sheet travel, the three static patterns supplement each other to produce a dynamic pattern of the form shown in Fig. 4, where, as in Fig. 2, the thicknesses have been greatly exaggerated. A comparison of Fig. 4 with Fig. 2 will indicate that except at the extreme edges of the pattern the variations in thickness are comparatively much less in Fig. 4 than in Fig. 2. Even though the dynamic pattern corresponding to each of the individual static patterns shown in Fig. 3 may have a central portion which is one-half or less than one-half the crest-thickness, the aggregate dynamic pattern shown in Fig. 4 may have a minimum thickness only about 10% less than that of the maximum thickness. Such comparatively small variations in thickness are about as small as are ever obtained in commercial spray-coating operations, and are eminently satisfactory.

In order to combine the dynamic patterns produced by three annular sprays to obtain satisfactory thickness-uniformity in the aggregate dynamic pattern indicated in Fig. 4, certain relations must be maintained between the diameters and locations of the static patterns and between the respective quantities of paint deposited from the several sprays. An annular pattern such as any of those indicated at 21, 31, 32 or 33 lacks well defined inner and outer edges, for the reason that after atomized coating material has collected on the surface being coated to an extent sufficient to produce a continuous annular band there will still be isolated droplets of coating material both inside and outside that band, and the density of such isolated droplets will decrease away from the band. In contrast to the practical difficulty of defining the size of a static pattern by its diameter, it is a relatively simple matter to express pattern-size in terms of the distance between the two crests 26 (Fig. 2) of the dynamic pattern; for such crests are rather well defined. Accordingly, the distance between the crests 26 of the dynamic pattern may be regarded as the "nominal diameter" of the corresponding static pattern and will be employed hereinafter in discussing the most desirable relations between the sizes and spaces of the static patterns. It may be noted here that any annular static pattern in which the coating material has a uniform circumferential distribution will produce a crested dynamic pattern.

The sizes and relative spatial dispositions of the static patterns necessary to obtain satisfactory thickness-uniformity in the composite dynamic pattern will depend upon a number of factors, including the relative size of

the central void in each of the static patterns and the radial distribution of coating material within the annular band. In general, it may be said that for best results the nominal diameters of the smaller static patterns 32 and 33 should lie between 65% and 90% of the nominal diameter of the larger static pattern 31 and the smaller patterns should be offset from each other by a distance between 25% and 65% of their nominal diameter. The nominal diameter of the smaller patterns may be as little as 60% or as much as 95% of the nominal diameter of the larger pattern, and the offsetting of the smaller patterns relative to each other may be as little as 20% or as much as 70% of their nominal diameter, and still obtain satisfactory results. The axis of the larger spray and the center-line of the aggregate dynamic pattern will of course lie substantially in a common plane. In many instances it is desirable that the width of the dynamic pattern of the larger spray approximate that of the composite dynamic pattern produced by the two smaller sprays, as by so doing it is possible to decrease the lateral extent of the wedge-shape edge portions at the sides of the final dynamic pattern. If the lateral extent of those side portions is not deemed material, there may be considerable variation between the widths of the dynamic pattern of the large spray and that of the composite pattern produced by the two small sprays.

When the annular sprays creating the static patterns 31, 32 and 33 are electrostatically deposited, it is desirable to space the sprays apart sufficiently to prevent undesirable interaction between the electrical charges carried by the particles of adjacent sprays. When the sprays emanate from electrostatic atomizing heads, adequate separation of those heads is desirable to avoid mutual shielding and consequent reduction in the strength of the atomizing field. Such spacing can be made as great as necessary by staggering the heads or other spray-sources along the path of travel of the surface being coated while preserving the relative lateral offsetting necessary to production of the desired aggregate dynamic pattern.

When the annular sprays employed emanate from annular electrostatic atomizing heads, control of static-pattern diameter may be effected in various ways. Heads of different diameters located at equal distances from the surface being coated and maintained at equal electrical potentials will produce annular patterns of different diameters. Heads of the same diameter located at different distances from the surface being coated will likewise produce annular patterns of different diameters. The diameter of the pattern produced by any annular head can be varied by varying the strength of the electrostatic field maintained between the annular head and the surface to be coated. Of these various methods of controlling pattern-diameter, the first is preferred.

The best results with three annular atomizing heads are obtained when the rate of fluid delivery from each head is such that the maximum thickness of the coating which would be produced by each head operating independently is substantially the same for all three heads. Any head may be replaced by two or more which jointly produce a band of deposited coating material having a dynamic pattern substantially the same as those of the band produced by the head replaced.

The pattern actually created on the surface of an article by an electrostatically deposited spray will depend on the size of the article; for whatever the inherent pattern of the spray may be, the coating-material particles will be attracted toward the article. In referring above to diameters of static patterns and widths of dynamic patterns, I have contemplated patterns produced by sprays which are not influenced by the size or shape of the article. Such a spray would be one electrostatically deposited on a plane conducting surface normal to the spray-axis and extending in all directions well beyond

the limits of the deposited patterns so that the shape of that portion of the electrostatic field which effects the deposition will not be significantly modified by end effects or edge effects. A pattern so produced might be called the natural pattern.

In coating operations, it is desirable that the article being coated lie within the lateral limits of the natural pattern of the spray. If the spray is not electrostatically deposited, the article should lie within the lateral limits of the uniform-thickness portion of the natural spray in order to avoid the relatively thin coating which would result from deposition of the wedge-shaped side portions of the dynamic pattern. In electrostatic coating, however, the article may extend into those wedge-shaped side portions for some distance; for the material at the extreme edges, which would otherwise pass the article, will be attracted theretoward and will complement that nearer the bases of those side portions to maintain the desired thickness of coating to the extreme edge of the article, as indicated at 35 in Fig. 5.

The fact that the dynamic pattern does possess the wedge-shaped side portions is of advantage when the surface to be coated has an extent, laterally of its direction of travel, greater than can be coated by a single group of three sprays. As indicated at 36 in Fig. 5, when two aggregate dynamic patterns are deposited in contiguous relation, the side portions of the patterns may overlap and complement each other, thus making it possible, without critical control, to maintain a satisfactory thickness of coating at points where two aggregate dynamic patterns meet.

In one embodiment of the invention as used in practical coating employing electrostatic atomization, two atomizing heads of four inches diameter and one of six inches were mounted with their discharge edges coplanar and at a distance of eight inches from the work; the axes of the smaller heads were offset two inches from the axis of the larger head in opposite directions transversely of the path of work travel; a slightly fluctuating ($\pm 6\%$, 120 cycles per second) D. C. potential-difference having an average value of 90,000 volts was maintained between the heads and the work; the heads were rotated at about 900 R. P. M.; and a modified urea formaldehyde enamel (20 sec. viscosity on No. 2 Zahn cup at 75° F.) was supplied to each of the smaller heads at a rate of 45 cc. per minute and to the larger head at a rate of 70 cc. per minute.

Discharging on to an extended, stationary plane surface across an eight-inch gap, the larger head of the specific apparatus above described would produce an annular pattern of about 19½ inches outside diameter and about 10½ inches inside diameter, while each small head would produce a pattern having outside and inside diameters of approximately 16½ and 7½ inches, respectively. Because of the lateral offsetting of the smaller heads, the specific apparatus above described would produce on a moving, transversely extended surface a coating band about 20½ inches in width. However, the band would be relatively thin at its edges; and therefore it would usually be undesirable to employ that apparatus in the coating of articles having an extent greater than about 16 inches transversely of their path of travel. As above set forth, the material at the extreme edges of the natural aggregate pattern will be attracted electrostatically to the article. For coating surfaces of greater transverse extent the spray-patterns might be enlarged, as by increasing the size of the heads or the distance between the heads and the work, or the apparatus described might be duplicated to produce parallel coating bands the thin edges of which would overlap.

In Figs. 6 and 7 I have illustrated diagrammatically an arrangement which has been employed in the application of liquid coating material to the sides and top of box-like articles, such as refrigerator cabinets. As there

indicated, the articles 40 are moved through a coating zone while supported from below on a conveyor (not shown) moving in the direction of the arrow. At the coating zone a group of three electrostatic atomizing heads 41 is supported on each side of the path followed by the articles 40, and above such path a third group 42 of electrostatic atomizing heads is arranged. Each group of heads includes one large head and two small heads, the axis of the former coinciding with the center-line of the surface being coated and the axes of the latter being offset oppositely from the axis of the larger head.

The three groups of heads are jointly connected to one terminal of a high-voltage source 43 the other terminal of which is grounded, and the articles 40 are grounded conveniently through the conveyor on which they are supported, all as more fully set forth in the prior application above identified. As a result, an electrostatic field exists between each group of heads and the article-surface opposite it, and liquid fed to the heads will be electrostatically atomized and electrostatically precipitated on the article. Each group of heads produces an aggregate dynamic pattern of approximately uniform thickness extending completely across the surface toward which the group is pressed.

In Fig. 8 I have illustrated an arrangement employed in the coating of small rectangular plates or similar articles 50. Such plates are arranged in rows and columns on an appropriate conveyor, which may be a plurality of wires 51, and are conveyed through a coating zone through the sprays delivered from a plurality of groups of atomizing heads, three such groups being indicated, so that the sprays therefrom will span the entire width of the region occupied by the plates 50. Each group of heads comprises a large head 52 and two smaller heads 53 having the offset relationship previously described. The three groups of heads are so spaced from each other transversely of the direction of article movement that the aggregate dynamic patterns of adjacent groups are contiguous to form a coating of satisfactorily uniform thickness on all of the articles which receive it.

The invention is not limited to the application of coating material to articles having continuous or uninterrupted surfaces. Thus, I have indicated in Fig. 9 an apparatus employed in coating garnish moldings 60 of automobile windows. Such garnish moldings may be suspended from an overhead conveyor (not shown) and moved successively through a coating zone. As shown, the spraying apparatus comprises two groups each consisting of three electrostatic atomizing heads, a large head 61 and two smaller heads 62 offset as previously described. As in Fig. 8, the two groups of heads are spaced from each other by a distance such that their respective aggregate dynamic patterns will be contiguous to produce a uniform coating over the entire height of the moldings.

In Fig. 10 I have illustrated an apparatus in which, in effect, the three complementary bands of coating material are produced by a single electrostatic atomizing head. The apparatus is shown as used in coating the side surface of an article 70 suspended from an overhead conveyor. Opposite the surface to be coated, there is mounted an electrostatic atomizing head 71 arranged to be moved successively and repeatedly through the three operating positions designated A, B, and C. In position B, the axis of the head substantially coincides with the center-line of the surface being coated. In positions A and C, the head is substantially closer to the article than it is in position B and its axis is offset vertically in opposite directions from position B. Because the spray discharged from the head 71 is divergent, the pattern produced by the head in position B will be broader than that produced when the head is in either of positions A and C. If the head, while discharging coating material, is moved around its closed curved path from one position to the next, and if the rapidity of head movement is great enough with respect

to the speed of article movement, the three dynamic patterns produced respectively by the head when in the three positions A, B, and C will blend to produce on the article 70 a coating of satisfactory uniformity.

In all embodiments of the invention specifically described above, it is contemplated that the spray axes will be normal to the direction of article-travel; but it should be noted that some tipping of any spray-axis in a plane parallel to such direction will not significantly alter the lateral distribution of the coating material. If the spray-axis is so inclined, the deposited static pattern will be elliptical rather than circular, and its major axis will be parallel to the direction of article movement. The dynamic pattern produced will not differ materially, however, from the dynamic pattern produced by a spray arranged with its axis normal to the article-path and having the same transverse extent at the article surface.

I claim as my invention:

1. A method of coating the surface of an article, comprising moving the article over a predetermined path with its surface presented to receive three annular sprays of coating material capable of producing on such surface parallel bands each having two transversely spaced portions of maximum thickness, said sprays being spaced from each other laterally of the path of article movement, two of said sprays having approximately equal diameters smaller than the diameter of the third spray, with all of said sprays being so disposed transversely of the article-path that the individual bands they respectively produce partially overlap each other to produce a composite band having a width greater than but less than twice the width of any individual band, with the portions of maximum thickness of the individual bands being arranged transversely of the composite band to present in order one maximum thickness portion of the first smaller band, one maximum thickness portion of the larger band, one maximum thickness portion of the second smaller band, the other maximum thickness portion of the first smaller band, the other maximum thickness portion of the larger band and then the other maximum thickness portion of the second smaller band.

2. A method of coating the surface of an article, comprising moving the article over a predetermined path with its surface presented to receive three annular sprays of coating material capable of producing on such surface parallel bands each having laterally spaced portions of maximum thickness, said sprays being spaced from each other laterally of the path of article movement, the two outer ones of said sprays having approximately equal diameters and being offset from each other transversely of said path by a distance equal to between 25% and 65% of the distance between the points of maximum thickness of the band produced by either of said sprays, and said latter distance being between 65% and 90% of the distance between the points of maximum thickness of the band produced by the third spray, the axis of the third spray being located transversely of said path substantially midway between the axes of the other sprays.

3. A method as set forth in claim 1 with the addition that said sprays comprise electrically charged coating-material particles, the article being maintained at a potential which will cause it to attract such particles, and said sprays being spaced apart longitudinally of the path of article-movement.

4. A method as set forth in claim 3 with the addition that said sprays are formed by electrostatic atomization.

5. A method as set forth in claim 2 with the addition that said sprays comprise electrically charged coating-material particles, the article being maintained at a po-

tential which will cause it to attract such particles, and said sprays being spaced apart longitudinally of the path of article-movement.

6. A method as set forth in claim 5 with the addition that said sprays are formed by electrostatic atomization.

7. A method of coating an article, comprising moving the article over a predetermined path, directing toward said path from each of three sources located on the same side of the path an annular spray of coating material, said sources being offset from each other transversely of said path, the spray from one of said sources having at the surface of the article a diameter larger than that of the spray from either of the other two sources, the offset distance between the most widely separated of the sources being less than the diameter at the surface of the article of the spray from any of such sources.

8. In electrostatic coating apparatus, a conveyor for moving over a predetermined path an article to be coated, means disposed at one side of said path for directing theretoward three annular sprays of charged coating-material particles for attraction to and deposition on the article, said means comprising three annular atomizing heads, one of said heads being larger than the other two and being located so that the center line of the spray it projects is substantially coplanar with the longitudinal center line of the article-surface to be coated, the other two heads being offset transversely of said path in opposite directions from the first mentioned head a distance less than the diameter of the spray pattern produced on the article by either of said other heads and so oriented that the bands of coating material produced on the article by the three sprays will overlap each other.

9. The invention set forth in claim 8 with the addition that said heads are spaced from each other longitudinally of said path.

10. A method of coating the surface of an article, comprising moving the article over a predetermined path with its surface presented to receive three annular sprays of coating material capable of producing on such surface parallel bands each having two transversely spaced portions of maximum thickness, said sprays being spaced from each other laterally of the path of article movement, and being so disposed transversely of the article path that the individual bands respectively produced partially overlap each other to produce a composite band having a width greater than but less than twice the width of any individual band, to present in order transversely of the composite band one of the maximum thickness portions of each of the bands and then the other maximum thickness portions of each of the bands.

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