July 3, 1951 H. P. RANSBURG 2,559,225

ELECTROSTATIC COATING METHOD AND APPARATUS

Filed Sept. 7, 1946

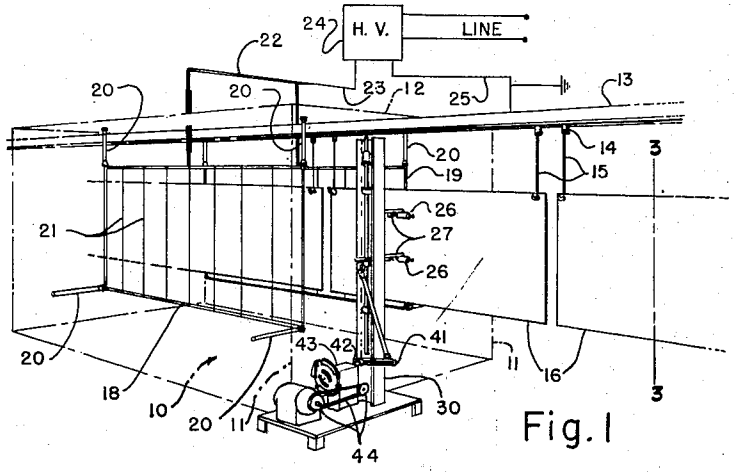


Fig. 1

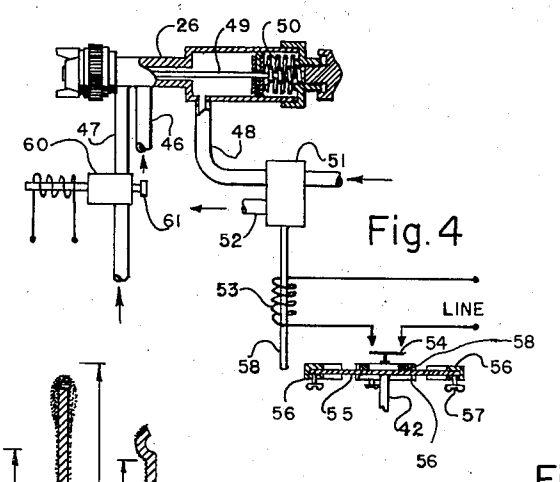


Fig. 4

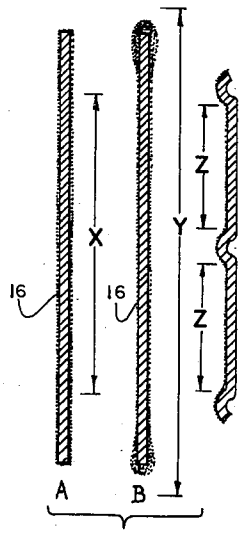


Fig. 3

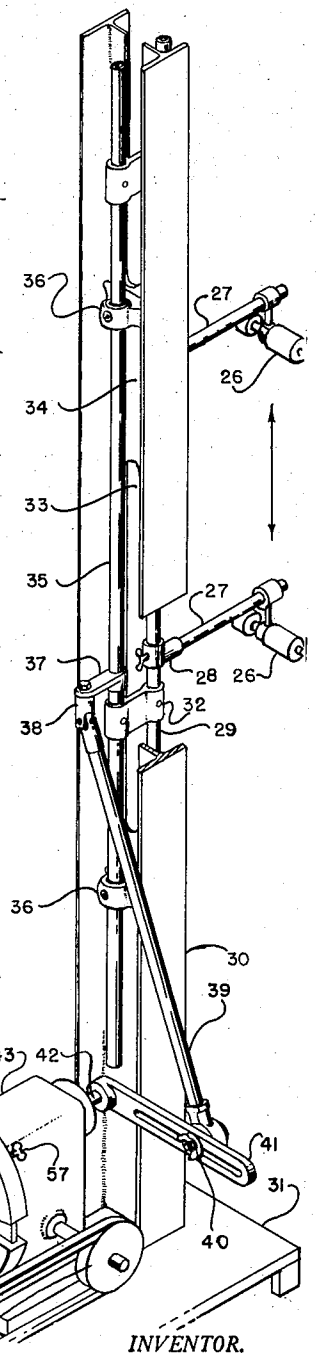


Fig. 2

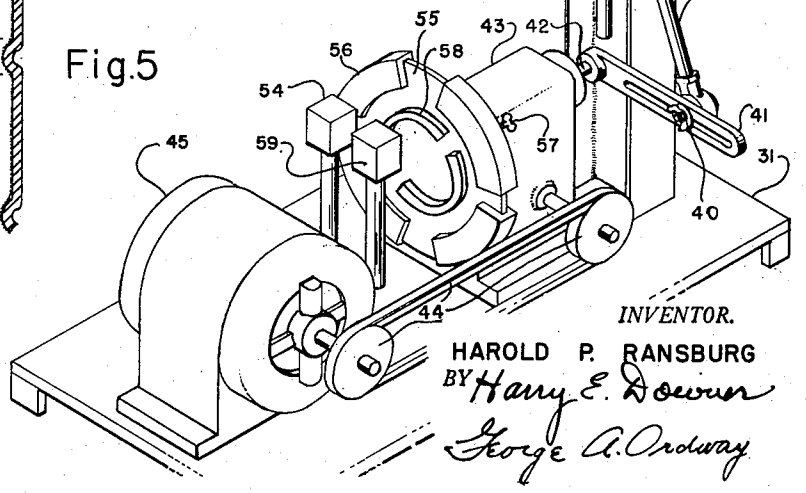


Fig. 5

INVENTOR.
HAROLD P. RANSBURG
BY Harry E. Dowson
George A. Ordway

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ELECTROSTATIC COATING METHOD AND APPARATUS

Harold P. Ransburg, Indianapolis, Ind., assignor, by direct and mesne assignments, to Ransburg Electro-Coating Corp., Indianapolis, Ind., a corporation of Indiana

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8 Claims. (Cl. 117—93)

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This invention relates to the electrical deposition of materials and more particularly to the application of coatings to surfaces by electrically depositing particled materials thereupon. The invention comprises methods and apparatus by which many types of coating material may be applied but is particularly adapted to the deposition of liquid coating materials atomistically supplied in a carrier gas stream to the depositing influence of an electrostatic field.

A principal object of the invention lies in the provision of a method and apparatus whereby a coating of superior uniformity in thickness and of overall smoothness of surface is obtained.

Another object is to provide a method and apparatus of this character which utilizes as completely and thoroughly as possible the depositing action of the electrical field throughout substantially its entire area.

A further object is to provide a method and apparatus which effects a more complete dissemination of the coating materials with respect to the area included in the electrical field and produces this dissemination in such manner that the particles entering the field are rendered more quickly and readily susceptible to its depositing influence.

A still further object is to provide a method and apparatus which readily lends itself to compensating for the characteristics inherent in electrostatic coating processes which cause certain portions of articles to receive a heavier deposition of coating material than other portions and to have the degree of compensation readily controllable by the making of a single, simple adjustment.

One typical electrical method and apparatus presently used in applying particled coating materials to a plurality of articles comprises, supporting the articles in an array, advancing the array in a path past a station where it comes under the influence of an electrical field, and issuing particles of finely divided coating material in a gaseous carrier stream into the field where, under its impelling influence, the particles are deposited upon the articles during their traverse of the field. In this, as well as in all other automatic methods and apparatus of electro-coating character that are known, it has been the practice to have the material issuing means held stationary. Under this condition, the dissemination of the particles in the field is substantially restricted to that volume delineated by the boundaries of the issuing stream or streams and coating will not be deposited by the field outside of this delineation. Moreover, it is one of the inadequacies of presently available issuing means that they do not produce an issued stream of particles which is uniform throughout and are even not consistent in producing the same distribution at two successive periods of operation. Due to material build up on their orifices and similar causes, the distribution of material within the stream will be constantly varying, erratic and uncontrollable. Hence, in instances where but a single issuing means is employed, not only will the dissemination into the electrostatic field be limited to only a part of the effective field but the dissemination will be irregular and uneven within the stream itself.

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In instances where the article presents an extended surface area it is customary to use a plurality of stationarily mounted issuing means, so spaced from each other that their issuing streams meet at certain portions of their boundaries. Here, the concentration of particles at the point or points of meeting of the streams, tends toward an uneven dissemination of the particles and a resultant unevenness in thickness of deposition. In addition, the impinging forces of the streams at the points of juncture, interact in such manner as to sustain the velocities of the particles and to create turbulence in the atmosphere of the deposition station. This is particularly true where the surface being coated is curved or cylindrical because under these circumstances to effect dissemination the issuing streams must be placed circumferentially about the surface and thus unavoidably will meet at a point where turbulence will exist and the velocity will be excessive. This effect of sustaining particle velocity and creating turbulence is indisposed to the purposes of electrical deposition and renders the particles less tractable to the forces of the field.

Moreover, in the practices above described, the continuous issuing of the particles into one volume delineated by the stream, in addition to imposing fixed limitations on the range of dissemination, creating turbulences and creating variations in particle entering velocities, establishes a slip stream through the atmosphere of the field. Particles of subsequent issue slip into this stream and in being carried forward encounter less resistance than would be encountered by a comparable particle moving through stationary atmosphere. This results in a major portion of the particles entering and moving through the field at a relatively high velocity so that their deposition by the forces of the field is materially delayed and their probability of being lost from the action of the field is correspondingly increased.

The most desirable presentation of the particles

to the electrical field is one in which each particle of the mass is inertly suspended in the atmosphere about the articles to be coated to form a calm, homogeneous mist curtain completely free of any directive or motivating force other than the electrical influencing action of the field.

The present invention is directed toward approximating as nearly as possible this end.

The invention is especially useful in applying coating material to extended surface areas but serves a useful purpose as well in applying coats of uniform thickness to surfaces which normally would be embraced within the spray pattern of a single issuing means. Any type of particled coating material may be deposited by the use of the invention but it has been found particularly useful in the deposition of liquid coating material such as, for example, paint, oils, porcelain frit suspended in a clay-water solution, and other particled liquid-borne materials.

The invention includes the use of a mechanism for reciprocating the material issuing means to aid in the dissemination of the coating materials throughout the entire field area, by breaking up, obliterating the boundaries of, and merging the successively issuing streams, one into another, whether single or multiple issuing means are employed. The reciprocation of the issuing means serves also to damp or cushion the issuing velocity of the streams as they leave the issuing means by bringing into effect upon the streams the forces of air resistance corresponding to stationary atmosphere rather than the diminished forces of resistance existing in the slip stream. This reduces the entering velocity of the particles to a minimum consistent with the force necessary to effect their delivery and makes for a more quiescent entry of the particles into the influences of the field. The streams are preferably moved continuously at a rate that is just sufficient to waft them smoothly and gently to the field area but that is insufficient to set up any substantially independent modifying air currents that would tend to divertingly move the particles in the atmosphere or render them less immediately amenable to the forces of the field. The movement of the streams is effective also, to prevent, wholly or largely, impingement of particles of an earlier issued spray stream by particles of a later issued spray stream and thus materially reduces any positive digressive diversions of the particles dilatory to their direct deposition substantially exclusively under the influences of the electrostatic field.

Preferably, the stream or streams are moved in a direction transverse to the direction of travel of the articles to be coated and, as has been the practice hitherto, are directed with their axes substantially parallel to the path of travel of the articles.

This transverse reciprocation in all cases, but especially where only a single material issuing means is employed, aids in attaining a thorough, efficient, and exhaustive use of the depositing action of the entire field area.

The advantages of this feature of the invention are more clearly recognized when it is borne in mind that certain types of material issuing means, such as the well known atomizing spray guns, easily get out of order and, in issuing certain types of materials, tend to gum or clog, require many delicate adjustments and, in general, require almost constant surveillance to insure their proper operation.

These undesirable characteristics are accentuated when such issuing means are used in electrostatic coating for the reason that the velocities of the streams must necessarily be much lower than the velocities used in the ordinary commercial automatic spray processes not incorporating as a part thereof an electrostatic field. Where the electrostatic field is employed, it is desirable to hold the velocities of the streams as low as possible to insure that the particles do not issue with a force that is generally at least superior to the electrical forces of the field. Lowered issuing velocities increase the tendencies of the issuing means toward gumming or clogging.

It is here noted that the lowering of stream velocities effected by the previously mentioned reciprocation of the issuing means occurs substantially immediately upon the streams leaving their issuing origins and after the atomized particles are out of the issuing orifice and hence, such reduction in velocity does not tend toward clogging the issuing means as does the lowering in velocity effected by reduction of air pressure in the atomizing or coating material supply sources.

All atomizing means have limits below which it is impossible to further reduce the velocity of their issuing streams and still have the means accomplish their purpose; that is to say, if this limit is exceeded the means either issues a sputtering or discontinuous stream, issues a stream without atomization or ceases altogether to issue any stream.

The volume of coating material effectively delivered by the atomizing means is therefore subjected in kind to the limit of velocity of issuance for the quantity of material must be reduced in direct proportion to the reduction of the issuing velocities and if more material is supplied to the issuing orifice than can be delivered by an atomizer when set toward its lowest limiting velocity, it functions in a sporadic and unsatisfactory manner.

Since the size of an issuing stream has a fixed, definite limitation, it follows that the number of streams necessary to effectively distribute the coating material about the surface of an article in a stationary issuing means organization will be determined by the size of surface area of that article; larger surface areas requiring proportionately larger numbers of issuing means than smaller surface areas. In either event, it is important to note that numerical increase in atomizers required is not here particularly associated with securing quantity of material issued but is primarily, if not wholly, simply to obtain an adequate and proper distribution of the material about the surface of the article. It is further noted that such numerical increase in a large majority of instances results in issuance into the field of greater quantities of coating material than necessary even though each atomizer is being operated at its condition of minimum delivery. This results in a heavier thickness of coating upon the article than may be desired and contributes toward waste of material. In some instances under such an arrangement, the heavier than desired deposition can be eliminated by increasing the speed of travel of the articles through the field by increasing the speed of the conveyor. In other instances this cannot be done for the reason that processes such as drying, baking, heating, cooling, etc., or an established rate of production volume may require that the conveyor travel at a slower rate of speed than that necessary to compensate for the overage of

material supplied by the battery of stationarily mounted atomizers.

In cases where multiple issuing means are employed, the before-mentioned reciprocating movement tends towards reducing to a minimum the number of issuing means required in accomplishing a given coating operation, permits of using the lowest possible operating issuing velocities, and effects a more even and controlled dissemination of the material which conduces toward more even and controlled deposition of the coating material both in degree of thickness and smoothness of surface. It does this not only without requiring modifications to the desired or required rate of travel of the articles on the conveyor but, in addition, if desired, the conveyor speed may be even further reduced below that at which it has heretofore been possible to operate it because of the greater dissemination effected without the corresponding increase in quantity of material issued when the issuing means are reciprocated.

Apart from the savings in costs by the reduction in number of issuing means required and material saved by the wider dissemination at reduced volume, a marked improvement is attained in the overall general efficiency of the operations since the lesser number of issuing means makes for less demands upon the operator in the number of adjustments required to keep them at an efficient operating standard and reduces the servicing requirements of the apparatus.

The invention uniquely and readily lends itself to compensating for the characteristics inherent in electrostatic coating processes which cause certain portions of articles to receive heavier coatings of material than other portions due to the higher field influenced affinities of the former with respect to the latter, for the oppositely charged coating particles. For example, edges, sharp corners, projections, sharp prominences and the like receive a higher concentration of field action than do the relatively expansive, intermediate, connecting surfaces. This higher concentration of field action inherently results in a heavier deposition of the coating materials at these points and the portions lying immediately contiguous thereto. In certain instances, as for example, a metallic counter or table top, the edges of which are subject to considerable wear and tear, it might be desirable to have the heavier coating applied to the edges for reenforcement purposes; whereas, in other instances, as for example, a metallic acoustic ceiling panel, the edges of which are subject to relatively little wear, it might be undesirable to have the coating thickness upon the edges and adjoining portions vary even slightly from that applied to the body portion of the panel as this might interfere with its proper emplacement next to another panel along a ceiling.

By the provision of means for simply and effectively varying the quantity of the particled coating material disseminated in those portions of the electrical field lying in the vicinity of the edges above referred to, a fine degree of control of coating thickness over these portions is obtained. When a larger amount of material is supplied adjacent said edge portions, the higher concentration of field action deposits a heavier coating thereupon. Conversely, when a smaller amount of material is supplied adjacent said edge portions, a correspondingly lighter coating is deposited thereupon notwithstanding the higher concentration of field action there present.

For the purpose of illustrating the invention, it will be further described with reference to the accompanying drawing in which:

Figure 1 is a view in perspective of an electrostatic coating apparatus embodying the principles of the invention,

Figure 2 is an enlarged view in perspective of the mechanism for reciprocating the material issuing means,

Figure 3 shows sectional elevations A and B taken on the line 3—3 of the article in Figure 1,

Figure 4 is a diagrammatic view of a mechanism adjustably operable to open or close automatically the material issuing means at any time throughout the length of the reciprocating stroke and

Figure 5 shows a sectional elevation of an article having irregular surface contour.

The invention is disclosed in association with an apparatus and method of the character shown in U. S. Patents Nos. 2,247,963 and 2,334,648, issued to Harold P. Ransburg and Harry J. Green, jointly, on July 1, 1941, and November 16, 1943, respectively, and is an improvement in the manner of issuing the coating material to the electrostatic field. The invention can, of course, be applied to and practiced with any other material depositing apparatus or method wherein an electrical field or the like is employed as a part thereof and is herein disclosed in connection with the Ransburg method and apparatus for illustrative purposes only.

Referring to Figure 1 of the drawing, there is shown in phantom the usual open-ended booth or enclosure indicated generally at **10** and consisting of side walls **11** and a top **12**. Secured to the underside of top **12** and extending centrally and longitudinally thereof is a guideway or track **13** along which runs an endless conveyor **14** of conventional chain or other flexible type. The conveyor carries a series of spaced depending members **15** adapted to receive and support the articles **16** which are arrayed along the conveyor in preparation for the coating operations. Vertically disposed discharge electrodes **18** and **19** are supported in spaced relation from the top and sides of the enclosure and in parallel spaced relation from the conveyor **14** by insulators **20** secured at one end to the inner surfaces of the top **12** and walls **11**, and at their opposite ends, to the electrodes.

Each electrode is comprised of a frame of heavy gauge stock upon which is strung, usually in vertical, spaced alignment, a series of fine wires **21** of copper or other suitable material. The wires are of a diameter in the order of .010 to .012 inch. The dimensions of the electrodes are governed by the length of the enclosure and by the height of the panels or other articles to be coated. Heightwise, the electrodes are generally of such dimension that their upper and lower ends overextend slightly, the upper and lower ends of the panels **16** or other articles as shown in Figure 1 on the drawing.

The electrodes are interconnected by a conductor **22** which in turn is connected by a conductor **23** to a potential of one sign of a high voltage source indicated at **24**. The potential of opposite sign of the source **24** is connected through a conductor **25** to conveyor **14** and through it and members **15** to the articles **16**. Either side of the circuit may be grounded but the side having connection with the conveyor and articles (conductor **25**, Figure 1) is a purposeful choice for

in this arrangement the operator and the articles being at the same ground potential permits of the touching of one by the other without the occurence of the harmless but unpleasant shock incident to such contact.

The voltage of source 24 is preferably in the range of 100,000 volts and is sufficiently high so that when applied an electrostatic field is created between electrodes 18—19 and the surfaces of articles 16 which ionizes the particles of coating material issued thereto and exerts on these ionic particles a force which is generally normal to the surface upon which they are to be deposited.

In the electro-coating methods and apparatus of this character hitherto employed, it has been the practice to mount one or more material issuing means, such as the atomizing spray guns 26 (Figures 1 and 2) upon an upright rod stationarily fixed to a base, the rod and base being similar to those shown herein except for the stationary connection therebetween. The guns 26 usually are arranged one above the other where mutliple guns are used, positioned approximately centrally of the space between the surfaces of the articles and the electrode and directed so that their issuing streams are projected into the field in a direction generally parallel to the path of travel of the articles 16 all as described in the before mentioned Ransburg et al. U. S. Patents Nos. 2,247,963 and 2,334,648.

As previously stated, the present invention is directed toward making full use of the field with a minimum number of guns and attaining a higher and superior degree of dissemination of the particles throughout the field at lower issuing velocities so that the particles are rendered more immediately and readily susceptible to the depositing influences of the field whereby coatings of superior uniformity of thickness and smoothness of surface are obtained. This is accomplished by the use of reciprocating mechanism of the general type now to be described.

The guns 26 (or other material issuing means) are mounted on horizontally extending arms 27 supported as at 28 upon a vertically disposed rod 29. It will be understood that any number of guns may be employed, that they may be mounted on the arms by any suitable universal means permitting of their nozzles being directed upwardly, downwardly and/or directed toward, parallel to, or away from the surfaces of the articles 16, and that the supports 28 for the arms 27 are preferably of a type that will permit of the arms being swung radially about, or moved upwardly or downwardly along, the rod 29 to aid in the adjustment of the guns conformably to the different sizes and shapes of the articles 16 to be coated. The rod 29 is mounted in one channel of an upright I beam 30 anchored at its lower end to a base 31. A member 32 fixed at one end to rod 29, extends through an elongated slot 33 formed centrally in a web 34 of the beam and is fixed at its opposite end to another vertically disposed rod 35 mounted similarly to rod 29 in the opposite channel of I beam 30. Rods 29 and 35 are each shorter in length than beam 30 and the mountings for each comprise bearings such as 36 that are secured in the channels to embrace and guide the rods for rectilinear movement. A bracket 37 is fixed to rod 35 and is connected by a universal joint 38 to one end of a pitman 39, the opposite end of which is pivotally connected by an adjustable screw and slot connection 40 to a crank 41. Crank 41 is secured to one end of a shaft 42 of a geared, speed reducer 43 that is connected by a drive belt and pulleys 44 to an electric motor 45.

Rotation of shaft 42 imparts a reciprocatory motion to rods 35 and 29 and to the guns 26. The speed of reciprocation is regulated by the reducer 43 and the stroke may be adjusted by the setting of the center of the screw and slot connection 40 nearer to the center of shaft 42 to decrease the length of stroke or further from the center of the shaft 42 to increase the length of stroke.

Where more than a single gun is employed, the guns preferably are spaced one from another at a distance sufficient to prevent any substantial overlapping of their issuing streams when the guns are not in motion. Thus sustenance or acceleration of velocity which would normally occur at the point or points of intersection of the several streams is eliminated.

In practice, it has been found that the number of traverses which the streams make per lineal foot of travel of the conveyor and the articles carried thereby should not be substantially less than three traverses per lineal foot. This is so, in order to prevent localization of dissemination and unevenness in deposition. In general, a higher number of traverses may be employed but this number should always be held to a minimum to effect a smooth, gentle reciprocatory movement which tends to waft and imbricate issuing sprays of the streams into a continuous homogeneous curtain of particles. Thus all trace or suggestion of individual spray form is obliterated completely throughout the field. The movement of the guns by continuously presenting the issuing nozzles to different regions of air also tends toward reducing or damping the issuing velocity of the particles as they leave the guns by forcing the particles to overcome the resistance of stationary air and preventing their approach directly into a slip stream path. These factors conduce toward a more placid entry of the particles into the field and toward rendering the particles more quickly and easily susceptible to the field's depositive action which results in a more even thickness of coating applied to the surfaces of the articles and a coating of superior smoothness of surface.

As has been before stated, one of the inherent characteristics of electrostatic coating processes is that certain portions of certain types of articles normally receive heavier depositions of coating material than other portions thereof due to a higher intensity of field action about said certain portions. The portions receiving the heavier coatings are sharply defined edges, corners and the immediately adjoining surfaces. The present invention readily lends itself to correctively compensating for these characteristics by controlling the quantity of material disseminated adjacent these portions which would normally receive heavier coatings. One way of doing this is by adjusting the screw and slot connection 40 so that the length of stroke is terminated short of the upper and lower edges of the articles 16 by a distance which is substantially equal to one-half of the dimension of the spray pattern heightwise. It is to be understood that the magnitude of this adjustment is determined by the requirements of the coating operation and the size of the article. This adjustment is effective to reduce the quantity of the material disseminated adjacent the upper and lower edges of the article and causes the coating thickness to be uniformly applied to the upper and lower edge regions as well as throughout the body sur-

faces as illustrated by stipple in the "A" illustration of Figure 3. The "X" dimension line in this illustration indicates, approximately, the length of stroke used in proportion to the heightwise dimension of the panel 16.

It is here noted, that the fore and aft end edges of the panels do not receive the heavier coatings even though their contours are usually as sharp as the upper and lower edges. This is so because the spacing between the end edge of one panel 16 and the end edge of the next adjacent panel is adjusted to mutually modify or lessen the higher intensity of field action along these end edges.

In certain instances it may be desirable to have the heavier coating that is normally applied to the edges; i. e., such a coating as indicated by the stipple in the "B" illustration of Figure 3. If such heavier coating is desired, it is only necessary to increase the spacing between the fore and aft edges to a proper extent and to adjust the screw and slot connection 40 so that the length of stroke is in the order of the "Y" dimension line of this figure, i. e., is such that the upper and lower halves of the spray patterns are carried to these areas during the reciprocation of the guns 26. Thus it is seen that by the making of but a single, simple adjustment, the quantity of material which may be disseminated at these upper and lower marginal edge portions may be quickly and readily varied and that thereby, the coating thickness deposited upon these portions may be quickly, easily and effectively controlled.

This control of the quantity of material disseminated in the vicinity of the marginal edge portions may be effected in a different manner as, for example, by controlling the opening and closing of the material issuing means in timed relation throughout the stroke. Where this method is used there is provided mechanism such as that shown in Figures 2 and 4.

As is well known, each gun 26 (Figure 4) is connected to an atomizing air line 46, a fluid supply line 47 and by a conduit 48 to an air supply that is used to control the opening and closing of the gun. When air is permitted to enter conduit 48, it opens the gun by forcing a plunger 49 rearwardly against the tension of a spring 50 which holds the plunger forwardly so that the nozzle of the gun is normally closed. A control valve 51 having a bleeder port 52 is interposed in the air control supply line 48 and the valve is arranged to be operated under the control of a solenoid 53. One side of the solenoid is connected directly to the line whereas the opposite side is connected to one pole of a push-button switch 54, the opposite pole of which is connected to the opposite side of the line. Switch 54 is mounted directly adjacent a disc 55, Figure 2, which is mounted on the left end of shaft 42 of speed reducer 43. Segmental cam members 56 of channeled stock are adjustably mounted on disc 55 by wing-screws 57. In this manner members 56 may be spaced one from the other and set in fixed position to open and close the guns 26 at different times during their upward and downward strokes. Closing of switch 54 by contact of a member 56 with the button of switch 54 energizes solenoid 53 which opens valve 51. Opening of valve 51 removes plunger 49 from the nozzle of the gun and permits the issuing of the coating material. Conversely, when a cam member 56 moves out of contact with the switch button and opens the switch, the plunger 49 closes the nozzle of the gun and prevents issuance of material. By arranging the cam members 56 on the disc 55 in proper position with respect to the point in the stroke where it is desired to have the guns 26 issue material, the quantity of the material issued with respect to different areas of the panels 16 may be conveniently and accurately controlled.

In the coating of articles, it may be desirable to produce variations in the dissemination at points which are not edge portions as, for example, in the case of an article of the type shown in section in Figure 5. With such an article, the desired dissemination may be effected either by having the guns issue material over the region indicated by "Z" dimension lines in Figure 5 and issue no material over the remaining portions or by having the guns disseminate material over the entire area but in different amounts to the "Z" portions than to the remaining portions.

To accomplish this varying degree of control of the amount of material disseminated into the field, additional flat inserted segments 58 are adjustably attached to the disc 55 which contact a control switch 59 which actuates a solenoid valve 60 in the fluid delivery line 47 in the same manner as the valve 51 is actuated by switch 54. This valve 60 is equipped with adjustment screw 61 by which its degree of opening and hence the fluid delivered can be controlled.

While the form of reciprocating mechanism herein shown and described is admirably adapted to the purposes of the invention because of the nature of the surface herein considered, the invention may be carried out by the use of any type of reciprocator which will effect the desired dissemination in the electrostatic field. For example, the motion could be made to conform with the general contours of any curved surface. The invention is not limited to the exact form and type of reciprocating mechanism herein disclosed.

In the present disclosure the description and drawing treat particularly with a construction adapted for use where the articles are supported in vertically disposed array along a conveyor. It will be understood, of course, that the invention is equally adaptable for use in a horizontal installation where the conveyor is of table type with the discharge electrode disposed horizontally in spaced relation therefrom. In such an arrangement the material issuing means is moved in a horizontal plane but those features of moving the issuing means to effect a desired dissemination of the particles throughout the field at reduced particle velocities are nevertheless retained and are equally advantageous.

The invention claimed is:

1. An improved method of coating articles in an electrical field, including the steps of moving an article along a path extending through said field in a direction that intersects at substantially normal the mean direction of the electrical forces acting in said field, issuing a stream of particled coating material to the field in a direction generally paralleling the path of travel of the articles, moving said stream in a direction transversely to both the direction of travel of the articles and the mean direction of said forces, and controlling the quantity of material supplied to the depositing action of said field forces in different portions of the field by shutting said stream off at predetermined intervals during its traverse of the field to thereby control the thickness of coating material applied to different portions of the article.

2. An improved method of coating articles in

an electrical field, including the steps of moving an article along a path extending through said field in a direction that intersects at substantially normal the mean direction of the electrical forces acting in said field, issuing a stream of particled coating material to the field in a direction generally paralleling the path of travel of the articles, moving said stream at a predetermined rate in a direction transversely to both the direction of travel of the articles and the mean direction of said forces, and varying the rate of material issuance in timed relation with the movement of said stream.

3. In coating articles in an electric field, the steps of issuing particled coating material to said field, moving the source of issuance at a predetermined rate transverse to the mean direction of said issuance, and varying the rate of issuance of the particled material composing said issuance in timed relation to said motion.

4. In an apparatus for electro-coating articles, a high voltage source, a discharge electrode connected to a terminal of one sign of said source, means connected to the terminal of opposite sign of said source and operable to move articles placed in contact association thereon past said electrode in spaced relation therefrom to create an electrostatic field between the articles and the electrode, means for issuing a stream of coating material in particled form to said field in a direction substantially normal to the average direction of the field-produced particle movement, means for moving said issuing means in a direction transverse to said last mentioned movement and to the direction of issuance of its stream, and means associated with said issuing means and moving means for automatically varying the rate of issuance of material issued by said issuing means at predetermined positions of its movement.

5. An apparatus for coating articles in an electrical field, means for creating said field, means for moving said articles through said field, means for issuing particled coating material to said field, means for moving said issuing means transversely to the mean direction of issuance, and means associated with said issuing means for varying the rate of issuance of material issued thereby throughout its movement and in predetermined timed relation thereto.

6. An improved method of electro-coating articles including the steps of, inducing about said articles as they arrayedly travel a path past and

spaced from a high potential electrode an electrostatic field having regions respectively of high and low intensity, issuing a stream of particled coating material to a low-intensity field-region between the articles and the electrode in a direction substantially normal to the mean direction of the depositing forces of the field, reciprocating said stream at a predetermined rate in a direction transversely to its direction of movement, and so limiting the amplitude of reciprocation of said stream that its axis is stopped short of the high intensity region of the field.

7. In coating articles in an electrical field of varying intensity, the steps of issuing particled coating material to said field, moving the source of issuance at a predetermined rate transverse to the mean direction of said issuance, decreasing the rate of issuance of the particled material composing said spray when the spray is directed toward the field regions of relatively low intensity, and increasing the rate of issuance of the particled material composing said spray when the spray is directed toward field regions of relatively high intensity.

8. The invention set forth in claim 3 with the addition that the electric field is maintained in a coating zone through which articles to be coated are moved successively along a predetermined path, said field having adjacent the surface of an article passing through the coating zone a considerable extent transversely of the article-path and, within such transverse extent, regions respectively of high and low intensity, the direction of movement of said source of issuance being transverse to the article path and the variation of the rate of material-issuance being such as to effect a relative reduction of said rate in the case of particled material issued to a field region of high intensity.

HAROLD P. RANSBURG.

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