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2,636,471

ELECTROSTATIC COATING APPARATUS

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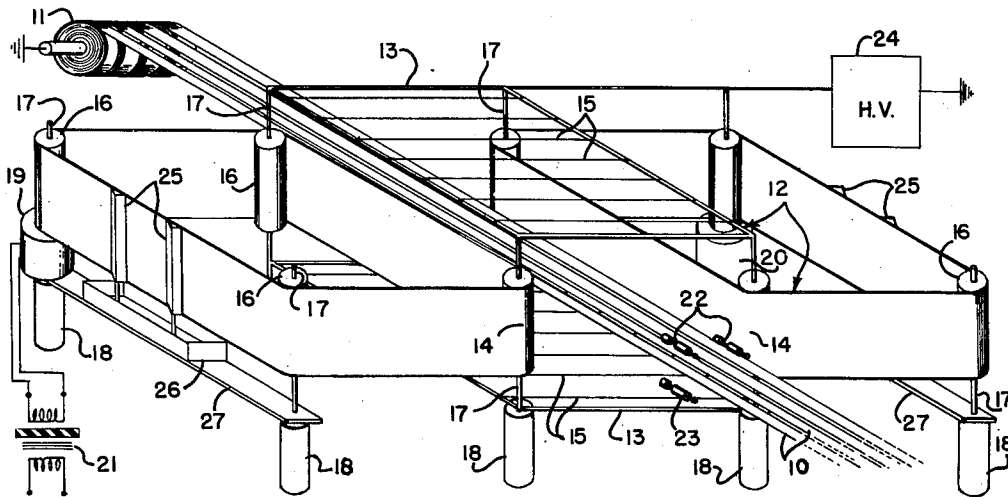


Fig. 1

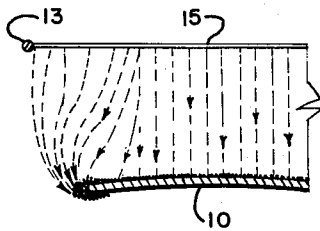


Fig. 2

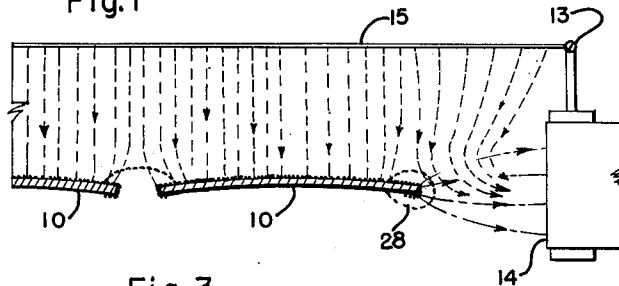


Fig. 3

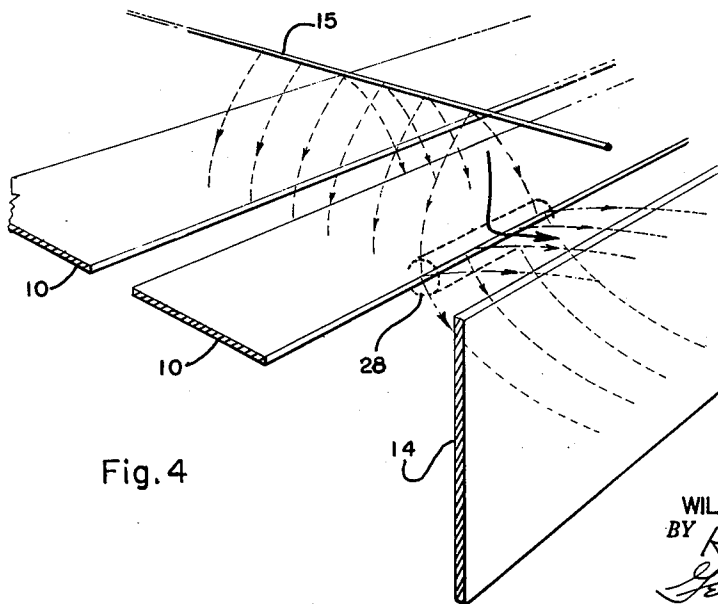
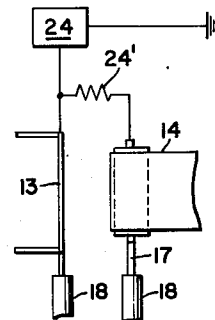


Fig. 4

Fig. 5



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ELECTROSTATIC COATING APPARATUS

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11 Claims. (Cl. 118—51)

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This invention relates to apparatus for applying coating to an article brought into an association productive of an electrostatic field. It has to do in particular with an apparatus of this character which is especially useful in coating articles the various surface portions of which have varying degrees of field-influenced affinity for the coating material. The general apparatus of applying coating electrostatically is well known, as exemplified, respectively, in U. S. Patents No. 2,247,963 and No. 2,334,648 issued to Harold P. Ransburg and Harry J. Green, jointly, on July 1, 1941 and November 16, 1943, respectively.

In such electrostatic coating apparatus, the article to be coated is supported in spaced relation to a discharge electrode between which and the article a substantial potential difference is maintained to create an electrostatic field. The particled coating material is issued in a gaseous carrier stream directed into the field where the particles acquire an electrical charge from the discharge electrode. The charged particles are thus attracted to and precipitated upon the oppositely charged article.

There is, in such apparatus, when used in connection with certain types of articles, an inherent tendency of the electrostatic field to precipitate the particles of coating material most heavily on surface portions over which the field strength is greatest. Since field strength is always relatively higher over and about sharply defined edge portions, isolated prominences and the like than over and about the relatively broad, expansive, intermediate connecting surface portions of an article, the influence of the field accordingly tends to deposit heavier coatings upon such edge portions than upon the body portions due to this lack of balance in distribution. Moreover, where such edge portions lie immediately and directly exposed to the discharge electrode in the electrical sense without any other surface or surfaces intervening, the great volume of coating existing in the relatively expansive area between the electrode and the thin edge feeds the concentration of field strength existing over and about such edge in such volume that the edge receives a much heavier coating than that received on the body portion of the article.

Hitherto the distribution of coating particles has been improved by promoting a more uniform field strength over all surface portions of the article, as through use of especially shaped electrodes in the manner taught by the copending application of Harold P. Ransburg, Serial No.

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519,332, filed January 22, 1944, now U. S. Patent No. 2,428,991; through the use of auxiliary electrodes as disclosed in my copending application, Serial No. 519,333, filed January 22, 1944, now U. S. Patent No. 2,425,652; or through the use of spacing the articles in a particular manner as disclosed in my copending application, Serial No. 619,371, filed September 29, 1945. These applications depend in the main upon modification of the field action, with respect to the variations in the field-influenced affinity of the various surface portions of the articles, being effected by decreasing the field strength about the normally higher affinity portions of the articles.

The present invention accomplishes a more uniform application of the coating about all surfaces of the article but approaches the problem in an entirely different manner. It provides a field-intensifying electrode the purpose of which is to increase rather than reduce the field strength about the normally higher field-influenced affinity surface portions of the article and thereby create over and about such portions a localized zone of reionization within the field. This reionizing zone tends to establish an equilibrium in the depositive action by causing a percentage of the particles attracted toward the normally higher affinity portions to be reionized. That is, a percentage of the particles upon entering such zone have their original charge converted into one identical to that possessed by the article and hence are repelled. In other words, briefly, the invention tends toward establishing a balance in the deposition upon the various surface portions by increasing the field intensity over and about a normally high electrical affinity surface to a point where the attendant repulsion electrically shields such surface against excessive deposition and thus brings the affinities of the different surface portions more nearly into an approximation of one to the other. The invention is particularly useful in controlling deposition on edge portions immediately and directly exposed to the discharge electrode.

It is an object of the present invention to produce apparatus by the use of which articles whose various surface portions having varying degrees of field-influenced affinity may be electrostatically coated with a marked degree of uniformity.

A further object of the invention is to produce apparatus which will be adaptable for use in mass production methods, which will not require the use of especially shaped discharge electrodes nor a particular arrangement or spacing of

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the articles for presentation to the electrostatic field and which is easily and conveniently maintained at a high operating efficiency.

To facilitate description the higher field-influenced affinity and lower field-influenced affinity portions of the article surfaces shall hereinafter be designated as "high affinity portions" and "low affinity portions."

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

Figure 1 is an isometric view of the apparatus;

Figure 2 is a schematic view showing the relative positions of the discharge electrode and the article and shows schematically the heavy concentration of the lines of force that normally exist about the high affinity portions when no field-intensifying electrode is employed;

Figure 3 is a view similar to Figure 2 but showing schematically the effect produced by the application of the field-intensifying electrode;

Figure 4 is a perspective view of the parts illustrated in Figure 3 but showing schematically somewhat more clearly the establishment of the zone of reionization; and

Figure 5 is a diagrammatic view illustrating a modified arrangement of electrical connections.

In the apparatus illustrated in Figure 1, the articles 10 (for illustrative purposes herein shown as continuous strips or bands of sheet material such as are used in making Venetian blind slats) are supported at one end upon a supply roll 11, the strips being supported at their opposite ends upon a take-up roll (not shown) but similar to the supply roll 11. The strips are preferably stretched taut between the rolls and are thus conveyed through an area enclosed by an electrode generally indicated at 12. The enclosing electrode 12 is comprised of top and bottom horizontally disposed discharge sections 13 and oppositely and vertically disposed field-intensifying side sections 14, preferably all of the sections being electrically interconnected with each other. The discharge sections 13 are formed of rectangular frames upon which extend transversely a plurality of spaced ionizing wires 15, the latter being on the order of .010 to .012 inch diameter.

The field-intensifying sections may comprise single separate sheets of electrically conductive flat stock that are stationarily supported on the opposite sides of the discharge sections 13 or may, as shown, take the form of endless conducting belts mounted for movement around rollers 16 rotatively supported on upstanding rods 17. The lower ends of the rods 17 are supported on insulators 18 so as to completely insulate the entire structure from ground. In passing around the rollers the exterior surfaces of the belts have portions extending parallel to and in spaced relation from the outer edges of the two outermost articles or strips 10. The belt-electrode sections 14 may be continuously driven in rotation around the rolls 16 by electric motors 19 and 20 each of which has a driving connection with one of the rods 17 of each group lying on opposite sides of the enclosure. The motors 19 and 20 are, of course, insulated from ground and are connected to the line through an insulated type of transformer such as designated at 21.

Approximately centrally of the forward end of the electrode assembly 12, there are supported one or more spray guns 22 above the strips or articles 10 and, similarly, one or more spray

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guns such as 23 below the articles. Preferably, the guns 22 and 23, respectively, are spaced approximately midway between the upper and lower surfaces of the articles 10 and the discharge sections 13. The upper guns 22 are preferably directed slightly downwardly toward the upper surfaces of the articles, and the lower guns 23 are preferably directed slightly upwardly toward the under surfaces of the articles. A high voltage source 24, one terminal of which is connected to the electrode 12 and the other terminal of which is grounded, is used to maintain the high voltage field between the electrode and the articles 10 which are grounded through their contact with the supply and take-up rolls 11 supporting them. It is to be understood that, if desired, the discharge sections 13 and intensifying sections 14 may be arranged so that they are not electrically interconnected as above described but so that each has its own independent high voltage source which sources may have different voltage outputs. On the other hand, the different sections may be arranged so that a resistance 24' (Fig. 5) placed in series with either one of separate, independent conductors connecting them with a common high voltage source causes a different voltage output to be delivered to one than is delivered to the other. In any event, with respect to the articles, the polarity of each electrode is opposite to that of the article and when their potentials vary, they must, of course, be spaced sufficiently far apart to prevent sparkover.

Referring now to Figure 2, it has been found that in running the strips through the apparatus above described but without the field-intensifying section 14 mounted thereon, the outer edges of the outermost strips 10 receive a heavier deposition of the coating material than do the inner edges of the strips which lie edge to edge in spaced parallel relation with adjoining strips. These narrow edge portions have a higher affinity for the coating material than the broad top and bottom portions of the strips for the reason before stated that the field strength is most concentrated at these points. This concentration of strength is indicated in Figure 2 schematically by dotted line suggestions of lines of force which, it will be observed, have a fairly uniform distribution over the broad flat surface and concentrate to an extremely marked degree over and about the edge portions. When the edge of a strip 10 is placed alongside in spaced parallel relation to the edge of an adjoining strip as shown in the left-hand portion of Figure 3, the concentration of the lines of force about the edges, i. e., the field strength, is approximately evenly divided between the two so that the field strength over and about such adjoining edge portions is rendered more nearly consistent with the field strength existing over and about the relatively broad flat body surfaces. Such method of modification of field strength is taught in my before-mentioned copending application, Serial No. 619,371. From the foregoing it is noted that the problem of controlling the distribution of field strength may be very satisfactorily met where it is possible to use adjoining edges of strips placed in proper spaced relation.

The problem remains, however, of controlling distribution to the outer edges of the outermost strips 10. As before mentioned, this may be done by following the method taught in my application, Serial No. 519,333, now U. S. Patent No. 2,425,652, through the use of an auxiliary elec-

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trode supported in spaced relation from the edge of the strip and having a connection to the same side of the high voltage source as that of the strip and thus modifying the field action.

Another method of controlling the distribution of coating material to outer edges, however, is to provide the field-intensifying sections 14 above described and running the outer edges of the outermost strips alongside, parallel to and in spaced relation from said sections.

Referring to Figures 3 and 4, it will be evident that the effect of the field-intensifying sections 14 will be to increase the concentration of the lines of force immediately adjacent the outer edges of the outermost strips 10. It might appear that the increased concentration of lines of force at and about the outer edges of the outermost strips 10 might increase the deposition of coating material upon such edges. However, the local potential gradient in an electrostatic field varies in the same sense as does the concentration of the lines of force adjacent such point; and as the potential gradient determines the capability of the field to effect ionization, the increase in the concentration of lines of force resulting from the presence of the intensifying electrode is accompanied by an increase in the tendency of the particles to become reionized as they approach the outer edges of the outermost strips. By appropriately locating the field-intensifying electrode, the intensity of the field at such strip edges may be increased to such an extent that a substantial proportion of the coating material particles initially accelerated toward the strip edges will become reionized—i. e., undergo a reversal of charge—and will be repelled from the strip toward the field-intensifying electrode. In other words, the field-intensifying electrode section 14, if properly located with respect to the adjacent edge of the outermost strip 10 will create at such edge a zone of reionization 23 which acts to convert the charge originally impressed upon some particles to a charge of the same sign as that of the strip 10, thereby causing those particles whose charges have been reversed to be repelled from the strip before they come into actual contact therewith. The repellent effect of the zone, however, is not sufficiently strong to prevent the infiltration of a certain quantity of particled coating material therethrough and onto the article and hence has an equalizing effect promoting uniformity of distribution.

It is not essential that the reionizing zone 23 extend continuously throughout the longitudinal extent of the coating zone. Where, as is preferred, the wires 15 of the discharge electrode extend in spaced relation transversely of the articles 10, the potential gradient at the edge of the article will be greatest at points opposite such wires and thus the effect of reionization in preventing excessive deposition may be more or less concentrated at one or more points in the coating zone.

In carrying out the process, the reionized particles, having acquired a charge identical with that possessed by the article, are repelled by the effect of that portion of the field which has its highest potential gradient near the high affinity edge portion of the article toward the oppositely charged electrode system. Some of the particles will be repelled toward the moving intensifying sections 14 and be deposited thereon while others will move toward the discharge sections, be re-

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ionized again to their original charge and be driven again toward the articles. The precise path followed by any one particle depends upon its residual momentum and force of gravity as well as the accelerating action of the forces of the field. In order that the sections 14 may be kept at their highest operating efficiency and to prevent repetitive accumulations of coating material thereon which would ultimately tend to defeat the purposes of the invention, means are provided to clean the belts as an incident to their rotative movement over the rolls 16. This means could be provided by passing the belts through a solvent bath at points in their travel when their surfaces are out of effective field-intensifying position or, as shown, may be provided in the form of upstanding scrapers 25 having frictional contact with the surfaces of the belts and arranged to squeegee the coating from the surface of the belts as they pass over the scrapers, the latter being supported in receptacles such as 26 mounted on supports 27 insulated from ground.

Where stationary single separate sheets are substituted for the moving belt form of field-intensifying sections, this cleaning could be effected as by moving mechanical wipers or by the provision of detearing electrodes positioned beneath the plates and connected to ground.

I claim:

1. Apparatus for depositing coating in an electrostatic field upon an article whose surfaces have varying degrees of field-influenced affinity for the coating, including an electrode having a stationary ionizing section and a movable field-intensifying section, means for moving the article in spaced relation from and past said discharge and intensifying sections with its low affinity surface disposed toward the former and its high affinity surface disposed toward the latter, means for maintaining a high potential difference between the electrode and the article to establish an electrostatic field therebetween, means for introducing particled coating material into said field, and means for moving said movable section.

2. Apparatus for depositing coating in an electrostatic field upon an article whose surfaces have varying degrees of field-influenced affinity for the coating, including an electrode having a stationary ionizing section and a movable field-intensifying section, means for moving the article in spaced relation from and past said discharge and intensifying sections with its low affinity surface disposed toward the former and its high affinity surface disposed toward the latter, means for maintaining a high potential difference between the electrode and the article to establish an electrostatic field therebetween, means for introducing particled coating material into said field, means for moving said movable section, and means for cleaning said movable section.

3. In apparatus for electrostatically depositing on a strip or sheet of conducting material finely divided electrically charged coating material dispersed in the atmosphere of a coating zone; means for moving the sheet or strip over a predetermined path through the coating zone, a precipitating electrode located at said coating zone and lying in a plane in opposed spaced relation to the face of the sheet or strip to urge the charged particles toward the sheet or strip, said precipitating electrode presenting a relatively small surface area to said face, an intensifying electrode of relatively large area extending in a second plane parallel to the path of movement

of the sheet or strip, a voltage supply connected to said electrodes and such sheet or strip, and means supporting said electrodes with their planes forming a dihedral angle of approximately 90 degrees containing said predetermined path.

4. In apparatus for electrostatically depositing on a strip or sheet of conducting material finely divided electrically charged coating material dispersed in the atmosphere of a coating zone, means for moving the sheet or strip over a predetermined path through the coating zone, a precipitating electrode located at said coating zone and extending in a plane in opposed spaced relation to a face of the sheet or strip to urge the charged particles toward the sheet or strip, said precipitating electrode presenting a relatively small surface area to said face, an intensifying electrode of relatively large surface area extending in a second plane parallel to the path of movement of the sheet or strip, means supporting said electrodes with their planes forming a dihedral angle of approximately 90 degrees containing said predetermined path, and means including a high voltage source for maintaining each electrode at a different electrical potential both from the other electrode and from the sheet or strip.

5. In apparatus for electrostatically depositing on a strip or sheet of conducting material finely divided electrically charged coating material dispersed in the atmosphere of a coating zone, means for moving the sheet or strip over a predetermined path through the coating zone with an edge of the strip or sheet parallel to such path, a precipitating electrode located at said coating zone in opposed spaced relation to a face of the sheet or strip to urge the charged particles toward the sheet or strip, an intensifying electrode in opposed spaced relation to an edge of the sheet or strip and extending for substantial distances in two directions which are respectively parallel to and normal to the direction in which the edge of the sheet or strip extends, a voltage supply connected to the electrodes and such sheet or strip, a cleaner for said intensifying electrode, and means for producing relative movement of the cleaner and intensifying electrode to remove from the latter coating material collected thereon.

6. The invention set forth in claim 5 with the addition that such cleaner is stationary, said last named means operating to move the intensifying electrode in contact with the cleaner.

7. The invention set forth in claim 6 with the addition that said intensifying electrode is an endless flexible member.

8. In apparatus for electrostatically depositing on a strip or sheet of conducting material finely divided electrically charged coating material dispersed in the atmosphere of a coating zone, means for moving the sheet or strip over a predetermined path through the coating zone with an edge of the sheet parallel to such path, a precipitating electrode located at said coating zone in a plane in opposed spaced relation to

a face of the sheet or strip to urge the charged particles toward the sheet or strip, said precipitating electrode presenting a relatively small surface area to said face, an intensifying electrode of relatively large surface area lying in a second plane and extending in that plane in two directions, one of which is generally parallel to the path of sheet movement and the other of which is generally normal to the extent of the sheet edge, and means including a high voltage source for maintaining a potential difference between said electrodes and the sheet or strip.

9. In an apparatus for electrostatically coating an article, a spray gun for directing a spray of finely divided coating particles over a predetermined path, at least a portion of which extends in a coating zone, a conveyor for moving the article through the coating zone adjacent the spray of coating material, two electrodes disposed in different planes adjacent the spray of coating material, said electrodes being so arranged that an electrostatic field established between them electrically charges the spray to a potential opposite from that of the article whereby the spray is attracted to the article, one of said electrodes being of relatively small surface area and the other electrode being of relatively large surface area, and means including a high voltage source for establishing a substantial potential difference between said electrodes and also between each of said electrodes and the article.

10. In electrostatic coating apparatus for depositing on an article finely divided electrically charged particles of coating material dispersed in the atmosphere adjacent the article, first and second electrodes, means for supporting said first and second electrodes in spaced, insulated relation from the article and from each other, and means including a high voltage source for creating a predetermined potential difference between said electrodes and between each electrode and the article for influencing the precipitation of the charged particles of coating material on the article.

11. The invention set forth in claim 10 with the addition of means for moving the article along a predetermined path past said first and second electrodes, said electrodes having portions coextensive with each other parallel to the path of article movement.

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