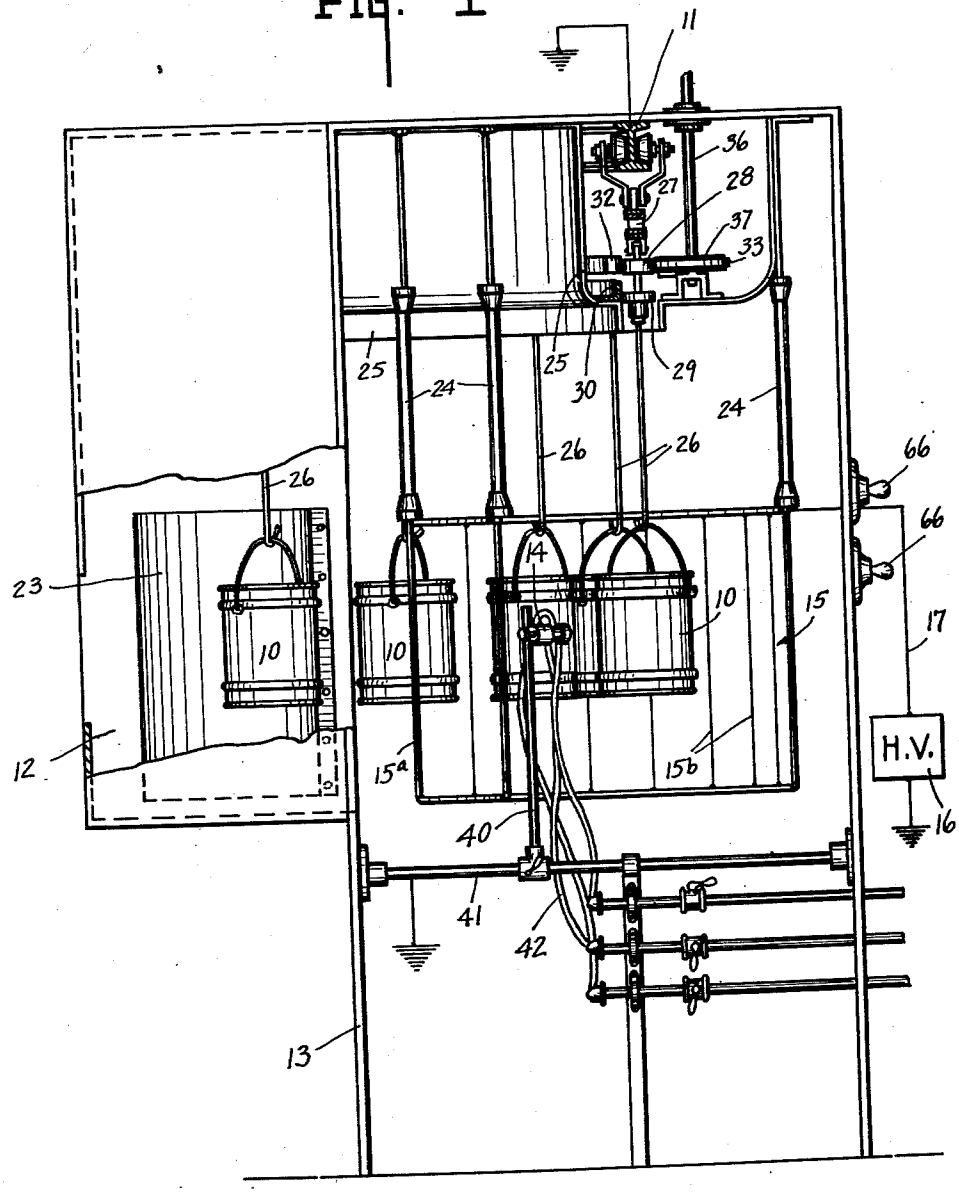
March 1, 1949. H. P. RANSBURG ET AL 2,463,422

METHOD AND APPARATUS FOR COATING ARTICLES BY ELECTROSTATIC DEPOSITION

Filed Feb. 3, 1945

4 Sheets-Sheet 1

FIG. 1



INVENTORS.
HAROLD P. RANSBURG.
RICHARD E. HELMUTH.
BY
Lockwood, Goldsmith & Galt.
ATTORNEYS.

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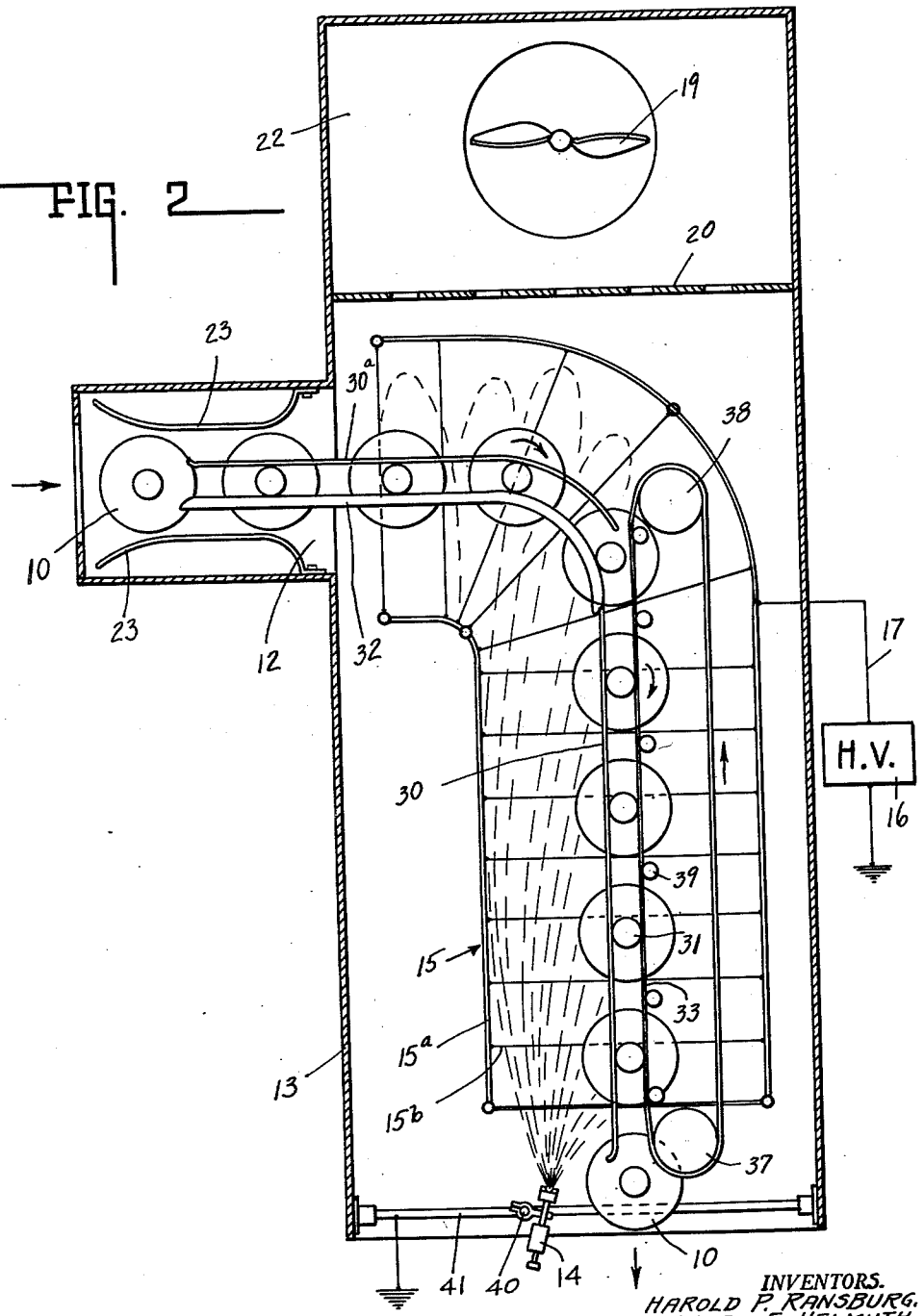
METHOD AND APPARATUS FOR COATING ARTICLES BY ELECTROSTATIC DEPOSITION

Filed Feb. 3, 1945 4 Sheets-Sheet 2

FIG. 2



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RICHARD E. HELMUTH.

BY Lockwood, Goldsmith & Galt,
ATTORNEYS.

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Filed Feb. 3, 1945 4 Sheets-Sheet 3

FIG. 3

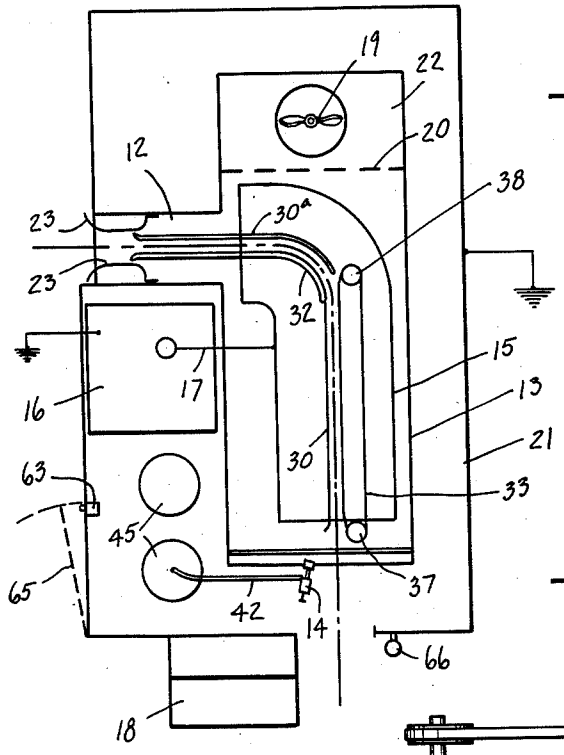


FIG. 4

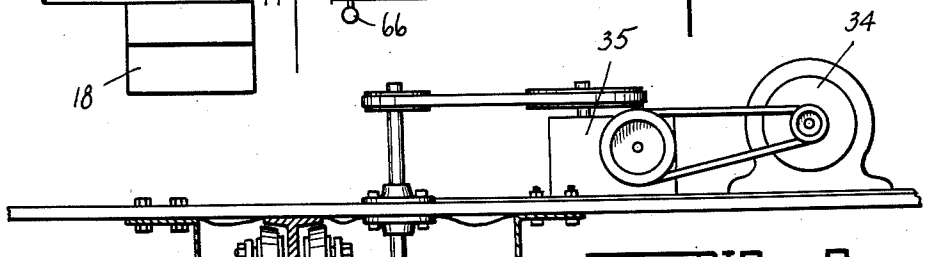


FIG. 5

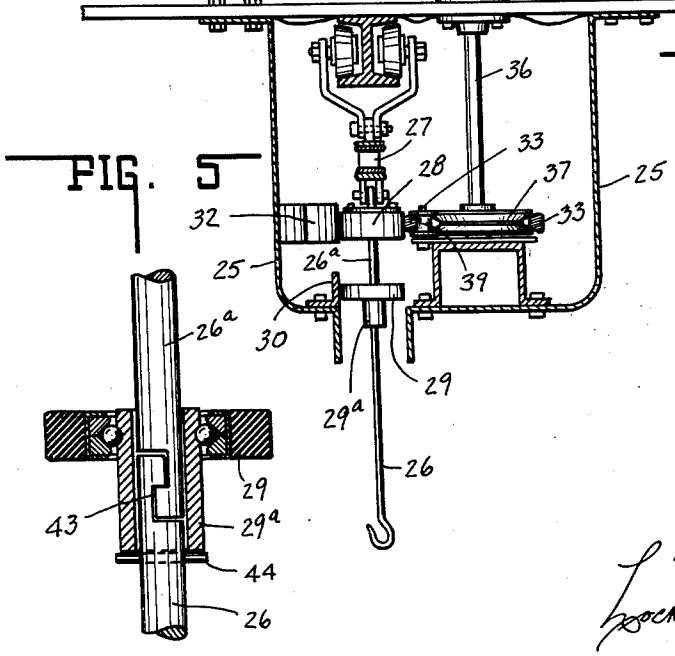
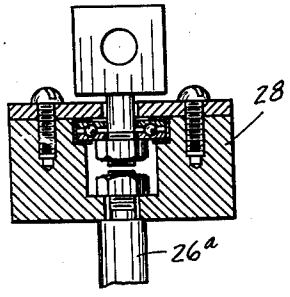


FIG. 6



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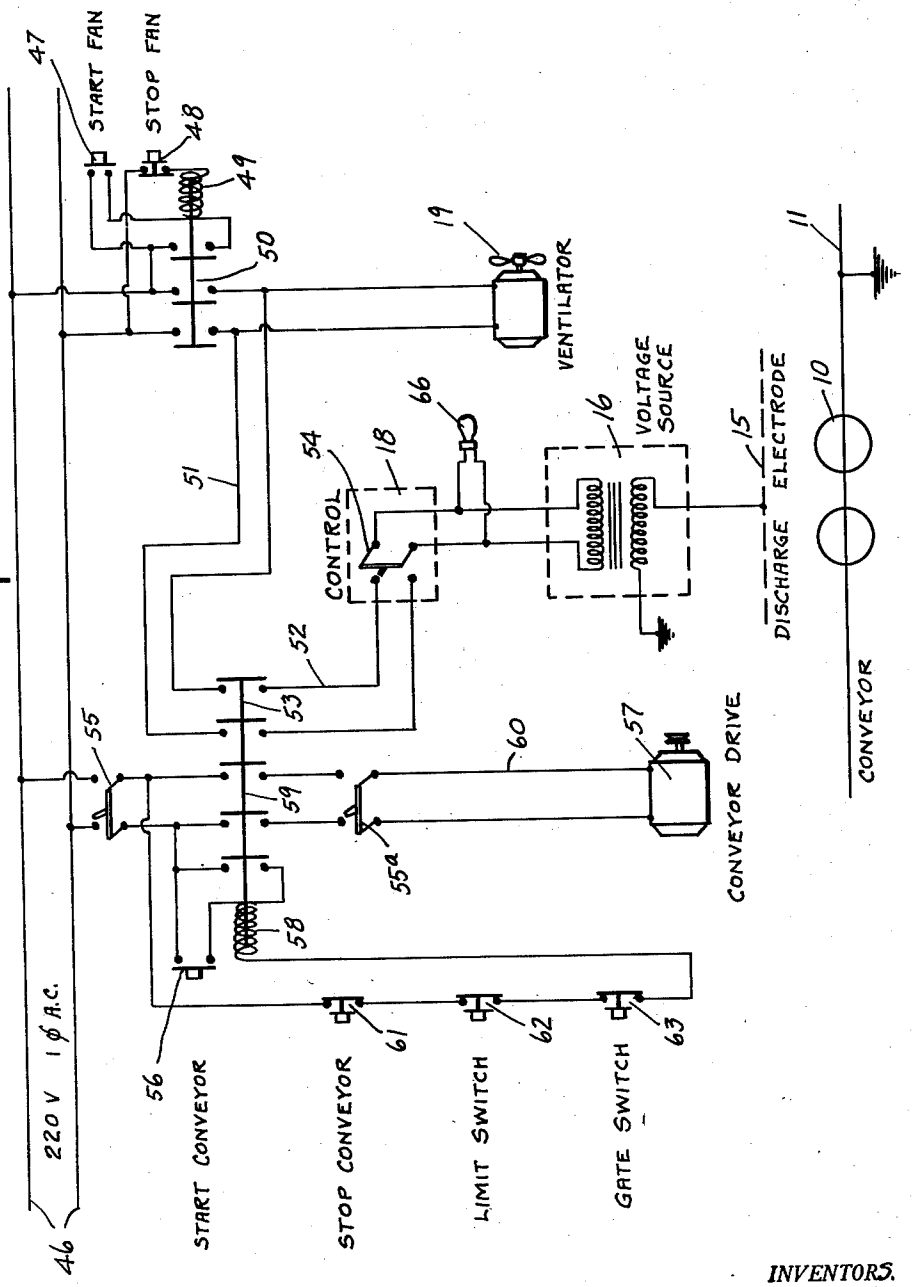
METHOD AND APPARATUS FOR COATING ARTICLES BY ELECTROSTATIC DEPOSITION

Filed Feb. 3, 1945 4 Sheets-Sheet 4

FIG. 7



INVENTORS.
HAROLD P. RANSBURG.
RICHARD E. HELMUTH.

BY Lockwood, Goldsmith & Galt.
ATTORNEYS.

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UNITED STATES PATENT OFFICE

2,463,422

METHOD AND APPARATUS FOR COATING ARTICLES BY ELECTROSTATIC DEPOSITION

Harold P. Ransburg and Richard E. Helmuth, Indianapolis, Ind., assignors, by mesne assignments, to Ransburg Electro-Coating Corp., Indianapolis, Ind., a corporation of Indiana

Application February 3, 1945, Serial No. 575,956

31 Claims. (Cl. 117—93)

1

This invention relates to electrostatic coating and is especially directed to improved methods and apparatus for handling articles to be coated, to the positioning and construction of discharge electrodes, and to the provision of various safety factors.

Objects of the invention are to provide methods and apparatus which achieve greater uniformity of coating, greater economy in utilization of coating material, speedier and more efficient coating production and greater safety to personnel and property.

A preferred embodiment of my invention comprises a number of novel features of method and apparatus, but many of the advantages of the invention can be attained through the use of less than all of such novel features. In the preferred embodiment, which is described in detail hereinafter, the articles to be coated are conveyed in spaced relation successively through a precoat zone and a finish-coat zone over a path which includes portions lying respectively within such two zones and disposed at an angle to each other. Coating material in finely divided condition is discharged into the finish zone toward the precoat zone and with sufficient velocity to cause at least some of the particles of coating material to be carried into the precoat zone. A discharge electrode possessing several novel features and disposed in spaced relation to the article path is employed in creating an electrostatic field promoting the deposition of coating material on the articles. The discharge electrode may include a section disposed to redirect toward the article-path coating-material particles which are carried across the article-path through the spaces between adjacent articles. Where the apparatus includes means for rotating the articles as they pass through the coating zones, such means is desirably arranged to rotate the articles at a relatively high speed in that portion of the coating zones where the concentration of coating material is relatively great and at a lower speed in those regions when the concentration of coating material is relatively low.

Where the articles are moved by an overhead conveyor, each article may be supported therefrom through the medium of an improved two-part hook, and guide means may be provided to reduce such swaying of the articles as would vary their distance from the discharge electrode.

Ventilating means employed to withdraw air from the booth in which the coating operation is customarily performed is so arranged as to maintain the air at a relatively low velocity

2

within the coating zones and at a higher velocity after it has left such zones, whereby any adverse effect of the moving air on the deposition of coating material within the coating zones will be reduced, while volatilized solvents and any coating material which does escape deposition on the articles will be rapidly carried away.

Safety features of the invention include the use of an isolating fence, a gate therein, and a gate-operated switch controlling energization of the field-creating means and the use of interlocking electrical circuits which prevent energization of the field-creating means except while the ventilating means is in operation.

Other features of the invention will be described hereinafter and pointed out in the appended claims.

The full nature of the invention will be understood from the accompanying drawings and the following description and claims:

Fig. 1 is a front elevation of the spray booth with a portion broken away and parts removed.

Fig. 2 is a schematic illustration showing a plan view of the spray booth.

Fig. 3 is a schematic illustration showing a plan view of the spray booth on a reduced scale with the isolating fence and associated apparatus.

Fig. 4 is a cross section through a portion of the conveyor mechanism.

Fig. 5 is an enlarged elevational view of a portion of the article supporting hook with its associated idler wheel in section.

Fig. 6 is a sectional detail of the spinner hook.

Fig. 7 is a wiring diagram of the electrical control circuits.

In the drawings, illustrative of one arrangement and application of the invention, there are shown articles 10 to be coated which are hung in spaced relationship from a conveyor support 11 which carries them through an entrance opening 12 in the side of a spray booth 13 constructed of insulating material. Once inside the booth the path of travel of the articles changes by 90° (as shown in Fig. 2) and they are carried toward the open exit end of the booth and out of it, having been coated with finishing material in the process.

While inside the booth, the articles are surrounded with a fog of coating material finely atomized by suitable atomizing means such as the air guns indicated at 14 into an electrostatic field established between the articles and a fine wire discharge electrode 15. This field, which charges and electrically precipitates the

material onto the article, is maintained by a suitable voltage source 16 connected to the discharge electrode by a lead-in conductor 17. While in this field the articles are rotated by a mechanism, to be hereinafter described, as they move along the conveyor support.

The nature of the atomized spray is controlled by suitable regulators contained in a control cabinet generally indicated at 18. A general convection through the booth past the items is maintained by a fan 19 and is further distributed by the baffles indicated at 20 in Fig. 2. The entire assembly of booth and voltage supply is electrostatically isolated from its surroundings by an isolating shield 21.

In the modification shown the spray booth 13 is constructed of electrically non-conducting material. It is approximately rectangular in shape with its exit end open, and is fitted with an air outlet chamber 22 that is fronted with a series of non-conducting baffles 20 to control the flow of air through the booth. This results in a lower air velocity within the electrostatic field, a still lower air velocity at the air entrance end and a higher air velocity where the air leaves the electrostatic field. The slow air movement within the field aids electrostatic deposition, and the air that has left the field carrying residual particles is sped-up to minimize settling of the residual particles. The fan 19 providing this ventilation is of non-conducting material so that the tendency of charged material to collect on it will be reduced to a minimum. The entrance opening 12 of the booth is silhouetted generally to the shape of the articles 10, and is located on one side adjacent the air outlet chamber 22. This opening is extended outward from the booth wall so that the amount of air entering therethrough will be reduced to a minimum. The booth has a ceiling and floor to complete the enclosure.

Situated in the entrance opening 12, and attached thereto is a series of removably mounted spring guide plates 23 between which the articles pass to arrest and control any lateral swinging movement of the articles transverse to their path of travel. Such motion must be restricted during the articles' travel through the booth so that the distance between the surface of the article and the discharge electrode will remain fixed. If this distance does not remain constant a hazardous spark may result. Said guide plates also serve to block and reduce any air current through the opening 12.

The discharge electrodes 15 are located in the booth adjacent to and conforming with the path of travel of the articles. They are composed of a plurality of frames 15a suspended from the booth ceiling by electrical strain insulators 24. These frames supply the supports across which a series of .010" diameter wires 15b are stretched for producing the necessary ionizing and precipitating fields. These wires are equally spaced from each other on centers which are about two thirds of the distance of the electrode plane from the surface of the article. A number of such frames 15a form each complete discharge electrode 15 and are arranged adjacent to the articles on both sides and about the bottom as they pass through the booth. The electrode is thus, in effect, U-shaped or trough-like, conforming to the bottom and sides of the article being coated.

The electrostatic field is established between the insulated discharge electrodes 15 and the

grounded articles by connecting them to a s
able high voltage source. The source her
disclosed and indicated at 16 consists of a h
wave, over controlled, limited current recti
capable of converting normal line voltage
pulsating high voltage direct current. One t
minal of this source is connected by an insula
lead 17 to the electrode system and the oth
terminal is grounded. Since the conveyor, a
thus the articles, are grounded, such a sou
will establish an electrical field of considera
strength between the discharge electrode wi
15b and the surface of the articles. The lead-
conductor 17 between said source and the d
charge electrode should be of reasonable s
(3/8" or larger) in order that parasitic coro
losses will be reduced to a minimum.

The conveyor guide rail 11 is of the ordina
I-beam type and is electrically grounded. In
path through the booth it makes a 90° horizo
tal turn, entering through the entrance 12 d
scribed above, and leaving through the op
booth exit. The conveyor system mounted
the booth is surrounded with a grounded co
ducting shield 25 which insures that it will n
have any material electrically precipitated up
it as it passes through the booth.

Suitable hooks 26 depend from a convey
chain 27 of the conveyor system at regular i
tervals to support the articles in columnar space
relation. The hooks are so designed that the
are free to rotate on a bearing situated in
spinner 28 near the top. Below this spinner an
arranged to idle on the shank of the hook is a
idler guide wheel 29. The wheel 29, together wit
its depending sleeve 29a, is arranged to act as
locking collar and shield over a splice in th
shank of the hook 26. The splice is so arrange
that the shank of the hook is continuous whe
the wheel is in place, but when it is raised th
lower portion of the hook may be readily re
moved. This permits removal of the expose
portion of the hook from the conveyor so tha
it may be easily cleaned of excess coating mate
rial accumulation. Said wheel, in addition t
supplying mechanical rigidity, also electricall
shields the splice of the two sections of the hoo
shank to prevent it from becoming coated an
thus insures continuous and certain electrica
contact between the two sections.

When a hook bearing an article enters the
spray booth, the spring guide plates 23 insure
that the article enters without swinging. The
friction spinner wheel 28 pinned to the upper
section 26a of the hook shank for rotating the
article during its travel through the coating
zones contacts the shoe 32 to rotate the article
in accordance with its linear movement through
the pre-coating zone of the electrostatic field.
In actual practice the article will be rotated dur-
ing its pre-coating operation at about one to
one and one-half revolutions per foot of linear
movement. While the spinner 28 is in contact
with shoe 32 the idler wheel 29 is in contact with
pressure bar 30a located on the opposite side of
the conveyor from the shoe 32. Thus the bar 30a
insures frictional contact of the spinner 28 with
the shoe 32 and also prevents lateral swinging of
the article due to rotation. This swinging must be
avoided in order to maintain the distance be-
tween the article and the discharge electrodes
to avoid sparking therebetween.

As the article is conveyed into the straight
exit portion of its path, comprising the finish
coating zone, said wheel 28 will contact and be

rotated by an endless movable belt 33 driven independently of the conveyor. Depending upon the linear speed of the movable belt the rate of rotation of the article will be increased as it passes through the finish coating zone. Its rate of rotation along this portion of its travel is preferably about four to six times per foot of forward motion. The speeds of rotation through these two zones may be varied according to the surface being coated. While spinner 28 is in contact with belt 33, idler 29 is in contact with pressure bar 30 to insure frictional contact and to prevent swinging.

The spinner belt 33 is driven by the motor 34 through the speed reduction gear box 35, drive shaft 36 and driven pulley 37, which, with its idler pulley 38 is supported by the shield 25. The spinner belt passes around these two pulleys and over suitable guide surfaces or pulleys indicated at 39 to insure that the passing spinner wheels will contact it. This guide surface will be mounted so as to insure some degree of contact flexibility between the spinners and the belt.

This entire drive unit, as well as the conveyor, is enclosed in the conducting shield 25 mentioned above to insure that during operation no coating material will be deposited upon them by the electrostatic field. This shield protects the conveyor over its entire path through the spray booth. It isolates the conveyor, spinners and idler wheels from the forces of the electrostatic field, since the lines of force thereof will terminate on its surface.

The spray gun 14 is arranged at the open or exit end of the booth where it will be readily accesible for adjustment by the operator. It is supported on suitable rigid supports 40, 41, and is situated to distribute its discharged material in a fairly uniform manner into the finish zone of the electrostatic field established between the discharge electrode and the article. The gun is maintained at ground potential which permits free adjustment during operation without hazard, and also permits it to be placed as close as needed to the article itself. If the gun is not positively grounded, it, as a free conducting body, would accumulate a charge proportional to its electrical capacity, and this charge would be liberated as a hazardous spark when it is approached by an operator or an article.

The gun is connected by suitable hose 42 to the appropriate sources 45 of coating material, operating air and atomizing air. The operating air, atomizing air, and fluid pressure are controlled in turn by suitable controls situated in the control panel 18. The gun is operated, fluid pressure adjusted, atomizing air controlled, and electrical devices activated from this one position. The electrical circuit is so arranged that switches for the conveyor, ventilating fan, and voltage supply are all located on the panel. The operator in this position thus has immediate control of all phases of the operation.

As shown in Fig. 5 and as has previously been mentioned, the article supporting hooks comprise two parts, a lower shank portion 26 and an upper shank portion 26*a*. Both portions are removably connected to each other as by a splice indicated at 43. Thus, the upper portion of the shank 26*a* is permanently connected with the spinner wheel 28 and protected from the coating material by the conducting shield 25 and the shank 26 is removable from shank 26*a* for cleaning as above described by sliding upwardly the idler wheel 29 with its depending sleeve 29*a*. Supporting pin 44 extending through the shank 26 supports said sleeve in position to embrace the splice 43. Thus, the idler wheel with its depending sleeve not only serves to guide and steady the hook and its supported article to prevent swinging, but also to lock the two portions of the shank together when in operative position.

By suitably cross connecting the various electrical circuits, as shown in Fig. 7, the unit is so arranged that power will not be available to the voltage source until after the ventilating fan is running. This insures adequate removal of inflammable materials before the voltage source can be turned on. A limit switch ahead of the booth is also installed to shut off the conveyor and voltage source in case an article which is too large to enter the silhouetted entrance should be hung on the conveyor. A safety gate switch is also installed on the entrance gate of the field isolating shield 21 that surrounds the booth, which electrically turns off the voltage when this gate is opened. This guards against a person entering the area when the field is on. Warning lights in parallel with those in the control panel are located on the front of the booth which constantly warn of the operating or non-operating condition of the unit.

In the wiring diagram shown in Fig. 7, the lead-in wires 46 are connected with the usual 220 volt electric current. They are connected through a normally open fan starter switch 47, a normally closed fan stopping switch 48 and solenoid 49 with the motor for driving the ventilating fan 19. The solenoid 49, upon being energized by closing switch 47, moves the contact members 50 to circuit closing position, thereby not only closing the circuit to the ventilating fan, but also energizing the circuit 51 connected to the circuit 52 through the switch 53 and thence to the control panel 18 for operating the source of high voltage 16. The control panel 18 is provided with a switch 54 to control the source of voltage 16. The power lines 46 are also connected through the manually operated switch 55 with a circuit leading to the manually operated switch 55*a* for energizing the motor 57 which drives the conveyor. Upon switches 55, 56 being closed, a solenoid 58 is energized to close switch 53, as well as switch 59 in the conveyor drive motor circuit 60. The solenoid energizing circuit is provided with normally closed switches 61, 62 and 63. Switch 61 is conveniently located for manual operation to break the circuit through the solenoid 58 for stopping the conveyor and simultaneously breaking the circuit to the high voltage source 16. The switch 62 is a limit switch mounted in the entrance opening 12 of the booth for stopping the conveyor and breaking the circuit through the high voltage source in event one of the articles is not properly mounted on the conveyor, or is of improper size. The switch 63 is mounted upon the gate indicated at 65 in Fig. 3 and is so arranged that when the gate is open the conveyor and high voltage source are inoperative. Also, in the circuit of the high voltage source there is a signal lamp 66 mounted in a conspicuous position upon the isolating fence 21, such as to provide a warning signal when the source of high voltage is on.

With this safety circuit the electrostatic field cannot be established until after the ventilating fan 19 is placed in operation by closing switch 47, and then only after closing the switch 55, the gate for actuating switch 63 and starting the conveyor by closing switch 56. Additionally,

switch 54 in the control panel 18 must be closed, whereupon signal light 66 will give warning. Thus, before the electrostatic field can be established, all parts of the apparatus must be functioning and the personnel warned thereof. Switch 55a permits the operation of the voltage pack without the conveyor being in operation. However, the electrostatic field may be disconnected at the control panel by opening switch 54 while the remaining apparatus will continue to function, the conveyor being controlled independently of the ventilator fan.

As mentioned above, the isolating fence is of conducting material and is maintained at ground potential so that it provides a means of effectively restricting and isolating the electrostatic field. In most factories there are a large number of dust particles constantly circulating in the air. As these approach a spray booth, even though the discharge electrode may have substantial insulation surrounding it, they will pick up a charge. Because of this, they are precipitated onto grounded items in the area and in sustained production the zone or area of an electrostatic spray unit by reason of these charged dust particles, will be dirtier and require more maintenance than other portions of the factory. We have found that an isolating fence such as the one herein described, will effectively minimize the precipitation of dust particles onto other items in the vicinity and will itself become the collector of these particles. This isolating fence will perform such functions completely if it encloses the booth about the top and sides. However, it has been found that one partially enclosing or surrounding a spray zone performs sufficiently well so that complete enclosure is not always necessary.

Furthermore, when ungrounded conducting items are stationed near the coating zone, such items, unless the electrostatic field is intercepted, will pick up a charge which will be discharged when these items are contacted by any grounded object including plant personnel. The above described fence eliminates this difficulty by intercepting and isolating the electrostatic field.

In actual operation this equipment functions as follows. Material, which is atomized at a somewhat higher velocity and pressure than has been used in the past in electrostatic spray operations, is sprayed into the finish coating zone of the electrostatic field established between the discharge electrodes and the articles. Some material will be deposited onto the articles immediately as they enter the pre-coating zone and the coating will be completed as the article makes the turn and moves through the finish coating zone out of the booth past the spray guns.

The spray, as it leaves the gun, is far from homogeneous in particle size and velocity. It will contain both small and large particles which may be moving at low or high velocity. These various particles are likewise not all moving in uniform direction. Due to the spread of the spray pattern, the turbulence created by the articles passing close to the gun, and the rebounding after successive contacts, there will exist in the booth particles having wide variation in direction.

The individual particles of this inhomogeneous spray which are introduced into the field and ionized by the action of the discharge electrode have their motion controlled by three forces. They are projected away from the gun in a direction substantially tangential to the surface to be coated by the atomizing forces. The forces

of the electrostatic field urge them toward article. The force of gravity constantly te to pull them downward. If the atomizing fc is too large relative to the other forces, the p ticle will be blown through the field. If the el trostatic field is not continuous about the it but there exists regions where this force is or zero, particles in these voids will be carr away from the article by the other two forc If the gravitational force is not properly b anced by the action of the other two, many p ticles will fall away from the article as unu material.

The degree to which a given particle of co ing material will be influenced toward an effe tive deposition by the electrostatic field will d pend upon its velocity, size and direction a upon the proper correlation of the above thr forces. It is therefore the purpose of the prese invention to provide a method and apparatus f regimenting these particles whereby they becor effective as coating material and will be event ally deposited upon the article.

The larger particles and those with the grea est velocity will not be deposited as readily will those which are smaller and slower. The larger or higher velocity particles will travel greater distance before their velocity has d creased to the point where the field can depos them. We are able to assure the deposition a much larger percentage of these particles b constructing the conveyor so that it enters th booth at the side and follows the path show through a pre-coating zone. With this arrange ment many of the particles, aided and directe by the force of the field, will be deposited b direct impact upon the article shortly after enters the booth. Others which pass betwee the articles when they are in this coating zon will be reionized by the discharge electrode, an after having their direction reversed, will b returned to the article for deposition. The articl is rotated to insure uniformity of this rathe light pre-coating. The rate of this rotation mus be relatively low to prevent undesirable turbu lence but still high enough to insure a uniform deposit of the material.

As the article proceeds on its path through the booth it is carried around the curved path and into the finish coating zone of the field in which the spray of coating material is progressively more dense. In this disclosure the direction of travel of the articles in these two zones is shown to be substantially at right angles. Other angles either greater or less than 90 degrees can be used to realize the advantages herein disclosed in cases where they are more suited to the conveyor travel before and after the coating operation. It is in this zone that those particles which have reasonable velocity and are small are deposited. Because of the increased density of sprayed material the articles in this zone must be rotated more rapidly to obtain uniformity. This is permissible because the turbulence is not as objectionable inasmuch as particles lost from the process here will be precipitated later in the pre-coating zone where the rate of rotation is not large. Furthermore the size and velocity of the particles precipitated here is such that the field is more effective and greater turbulence can be tolerated.

The mutual action of the three forces mentioned above is accomplished by the form and arrangement of the discharge electrode. Being constructed of fine wire elements with small radii

which surround the article on three sides, it forms an electrostatic trough, so to speak, inside of which the electrostatic field will be continuous and complete and inside of which the ionization of all particles will be assured and maintained. Since the gravitational force is downward into this trough, and since the electrostatic forces are all directed toward the item, coating material in this trough will be maintained therein until effective precipitation results. Particles which rebound from the surface or have their ionization neutralized by collision, are reionized and redeposited by successive elements of the U-shaped discharge electrode as they are carried along this trough by the velocity given them by the atomizing means.

This type of electrode is of particular benefit for the deposition of that material which is atomized into the field intended for coating the bottom of an article. The natural tendency of the material to fall away from the surface for which it is intended is overcome by the increased electrostatic forces created on this surface. This unobstructed upward force due to the bottom section of the electrode also aids materially in counteracting the normal settling tendency of the coating material which is in position for deposition on the sides of the article because it allows the mutual repulsion of the charged particles to be effective in a vertical direction.

From the above description it will be evident that the coating obtained from the application of this method and apparatus will result from a gradual accumulation of material over a relatively long period of time. Whereas the article to be coated is shown and described herein as a bucket, it may be of any character comprising either conducting or non-conducting material. In either case so long as the material is precipitated onto the article, the article is herein considered as comprising the collecting electrode on which the coating material is gradually accumulated. Such gradual application of coating material permits one to obtain a finish film which is more uniform, heavier and consequently of greater hiding power. It is a one operation process which is superior in economy, durability and appearance to the coating normally applied by hand operation where a dust or mist pre-coat is first applied to the article before the application of the final or finish coat.

The invention claimed is:

1. The method of electrostatically coating articles consisting in conveying the articles through a pre-coating zone into a finish coating zone wherein said zones extend substantially at right angles to each other and one is a continuation of the other, revolving said articles at a greater speed of rotation during their passage through said finish coating zone than during their passage through said pre-coating zone, establishing an electrostatic field in said zones wherein said articles comprise the collecting electrode, and directing atomized coating material into and substantially longitudinally of said finish coating zone, counter to the direction of movement of the articles conveyed therethrough, and toward and into said pre-coating zone for electrostatic deposition on said articles passing through both of said zones.

2. The method of electrostatically coating articles consisting in conveying the articles through a coating zone from an inlet end to an exit end, revolving said articles at a greater speed of rotation toward the exit end of said coating zone than nearer the inlet end thereof, establishing an electrostatic field in said zones wherein said articles comprise the collecting electrode, and directing atomized coating material into said coating zone in a direction from the exit end toward the inlet end for electrostatic deposition on said revolving articles.

3. Apparatus for electrostatically coating articles, comprising a discharge electrode mounted to provide an L-shaped coating zone having an inlet portion and an exit portion extending substantially at right angles thereto, a conveyor operable to convey said articles into the inlet portion of said zone and through a curved path into and through said exit portion thereof, means for establishing an electrosatic field between said electrode and articles and an atomizing means mounted to direct a spray of coating material into and longitiudinally of the exit portion of said coating zone toward the transverse inlet portion thereof for electrostatic deposition on said articles as they pass therethrough.

4. Apparatus for electrostatically coating articles, including a discharge electrode having a pre-coat section extending in a curve to a finish section thereof, a conveyor conforming to said electrode operable to convey said articles in a direction to first pass adjacent to said pre-coat section and then said finish section and in predetermined spaced relation thereto, means for establishing an electrostatic field between said electrode and articles, and an atomizing means mounted adjacent the end of said finish section to direct said material adjacent thereto and toward said pre-coat section for electrostatic deposition on said articles.

5. Apparatus for electrostatically coating articles, including a spray booth having an inlet opening in the side wall thereof and an open exit end, means for conveying the articles to be coated into said booth through said inlet opening and in a direction substantially at right angles thereto through said exit end, a substantially L-shaped discharge electrode mounted in said booth to conform with the path of travel of said articles through said booth in spaced relation thereto, means for establishing an electrostatic field between said electrode and articles, and an atomizing means mounted adjacent the exit end of said booth operable to direct a spray of coating material therein along the adjacent path of said articles toward their angularly disposed path for electrostatic deposition thereon.

6. Apparatus for electrostatically coating articles including a spray booth having an inlet opening in the side wall thereof and an open exit end, a substantially L-shaped coating zone therein extending from adjacent said inlet opening to said exit end defined by spaced discharge electrodes mounted in said booth, means for conveying the articles to be coated in a path leading from the inlet opening to the exit end of said booth substantially medially of said zone and electrodes, means for establishing an electrostatic field between said electrodes and articles throughout said coating zone, and an atomizing means positioned to direct a spray of coating material through that portion of said coating zone extending to and terminating with the exit end of the booth, and toward the portion thereof extending from said inlet opening.

7. Apparatus for coating articles, including an elongated discharge electrode generally trough-like in form having a series of U-shaped corona

discharge elements, means for conveying a column of articles to be coated through said trough-like electrode, said articles having bottom and side surfaces to be coated, means for suspending said articles from said conveyor to present an unobstructed bottom surface in predetermined spaced relation to the bottom portion of said electrode with the side surfaces thereof similarly spaced from the side portions of said electrode, a source of high voltage having one terminal connected with said electrode and the other terminal with said conveying means to establish an electrostatic field having lines of force directed upwardly to terminate with the bottom of each of said articles and lines of force directed laterally to terminate with the side surfaces thereof, and an atomizing means adapted to direct a spray of coating material into said field for electrostatic deposition over the surfaces of said articles.

8. Apparatus for coating articles including a spray booth having enclosing and confining walls, one of said walls being provided with a restricted inlet opening, a conveyor having means for suspending articles therefrom to be coated, said conveyor extending through said booth for conveying the articles to be coated into said booth through said restricted inlet opening and through an outlet opening out of the booth, a pair of yielding guide members mounted in said inlet opening spaced from each other to permit passage of said articles therebetween to steady said articles and prevent lateral swinging thereof upon entering said booth, a coating zone through which said articles are conveyed in said booth, means for establishing an electrostatic field in said zone, and an atomizing means for atomizing a coating material into said field for electrostatic deposition onto said articles.

9. Apparatus for coating articles including a conveyor including means for suspending articles therefrom for conveying the articles to be coated through a coating zone, means including a discharge electrode for establishing an electrostatic field in said zone between said electrode and articles, a guide rail extending along and adjacent said conveyor in fixed spaced relation to said electrode, a guide roller associated with said first mentioned means engageable with said guide rail to maintain said articles in a predetermined path of travel through said zone and prevent swinging movement thereof toward said electrode, and an atomizing means for atomizing a coating material into said field for electrostatic deposition onto said articles.

10. Apparatus for coating articles including a conveyor for conveying the articles to be coated through a coating zone, a series of hooks depending from said conveyor means for removably suspending said articles therefrom, each of said hooks having a spliced shank to permit removal of the lower shank portion from the upper shank portion, a protective shielding sleeve slidably supported to envelop the spliced portion of said shank when in lowered position to prevent accumulation of coating material thereon, said sleeve being slidable upwardly to permit removal of the lower portion of the shank from the upper portion thereof, means for establishing an electrostatic field in said coating zone, and an atomizing means for atomizing a coating material into said field for electrostatic deposition onto said articles.

11. Apparatus for coating articles including a conveyor for conveying the articles to be coated

through a coating zone, a series of hooks depending from said conveyor means for removably suspending said articles therefrom, each of said hooks having a spliced shank to permit removal of the lower shank portion from the upper shank portion, a protective shielding sleeve slidably supported to envelop the spliced portion of said shank when in lowered position to prevent accumulation of coating material thereon, said sleeve being slidable upwardly to permit removal of the lower portion of the shank from the upper portion thereof, a guide rail extending along said conveying means, an idler roller rotatably mounted on said sleeve engageable with said guide rail to guide said articles along their path of travel, means for establishing an electrostatic field in said zone, and an atomizing means for atomizing a coating material into said field for electrostatic deposition onto said articles.

12. Apparatus for coating articles including a spray booth, means for conveying said articles through said spray booth, a discharge electrode mounted in said booth in spaced relation to the path of travel of said articles, a source of high voltage having one terminal connected with said electrode and the other terminal connected with said articles to establish an electrostatic field therebetween, an atomizing means mounted to direct a spray of coating material into said field for electrostatic deposition on said articles passing through said booth, an isolating fence surrounding said booth and extending therefrom, said fence being of conducting material electrically connected with said last-mentioned terminal of the source of high voltage, a gate in said fence to permit access therethrough, and a control switch operable by said gate to break the circuit between said source of high voltage and said electrode when said gate is in open position.

13. Apparatus for electrostatically coating articles including a spray booth having enclosing and confining walls, a conveyor extending through said booth for conveying the articles to be coated therethrough, a fan for exhausting said booth, a discharge electrode extending along the path of travel of said articles and spaced therefrom, a source of high voltage having one terminal electrically connected with said electrode and the other terminal with said conveyor to establish an electrostatic field between the articles carried thereby and said electrode, an atomizing means for atomizing a coating material into said field for electrostatic deposition onto said articles, a motor for driving said fan, a motor for driving said conveyor, electric circuits interconnectng a source of current with said motors and source of high voltage, and control switches in series in said circuits operable to maintain the circuit to said high voltage source open until said motor circuits are closed.

14. Apparatus for electrostatically coating articles including a spray booth, a shielding fence surrounding and spaced from said booth having a gate for permitting access thereto, a conveyor extending through said booth for conveying articles to be coated therethough, a motor for driving said conveyor, an exhaust fan for said booth, a motor for driving said fan, a discharge electrode mounted in said booth extending in spaced relation to said conveyor and the articles conveyed thereby, a high voltage source having one terminal electrically connected with said electrode and the other terminal with said conveyor for establishing an electrostatic field between said electrode and the articles carried

by said conveyor, an atomizing means for atomizing a coating material into said field for electrostatic deposition on said articles, electric circuits interconnecting a source of current with said motors and high voltage source, a switch in said circuits operated by the gate of said shielding fence for controlling said circuits, and control switches in said circuits in series with said first switch arranged to maintain the circuit to the high voltage source open until said motor circuits and gate switch are closed.

15. An apparatus comprising a booth having an air exhaust at one end, a discharge electrode providing an L-shaped coating zone having an inlet portion adjacent said air exhaust and an exit portion extending substantially at right angles thereto, a conveyor operable to move articles through said zone, means for establishing an electrostatic field between said electrode and articles, and atomizing means to direct a spray of coating material through said zone.

16. Apparatus for electrostatically coating articles, including a discharge electrode having a pre-coat section extending at an angle to a finish section thereof, a conveyor conforming to said electrode operable to move said articles in a direction to first pass adjacent to said pre-coat section and then said finish section, means for establishing an electrostatic field between said electrode and articles, an atomizing means mounted adjacent the end of said finish section to direct coating material adjacent thereto and towards said pre-coat section for electrostatic deposition on said articles, and means for exhausting air from the finish section through the pre-coat section.

17. An apparatus comprising a generally U-shaped discharge electrode, conveyor means to move a column of articles having bottom and side surfaces to be coated through said U-shaped electrode, means for suspending said articles from said conveyor means to present an unobstructed bottom surface in predetermined spaced relation to the bottom portion of said electrode with the side surfaces thereof similarly spaced from the side portions of said electrode, a source of high voltage having one terminal connected with said electrode and the other terminal with said conveyor means to establish an electrostatic field having lines of force directed upwardly to terminate with the bottom of said article and lines of force directed laterally to terminate with the side surfaces thereof, and means for introducing finely divided coating material into said field for electrostatic deposition over the surfaces of said article.

18. Apparatus for coating articles, comprising a booth having confining walls and provided with a main air-inlet opening, means for drawing air into said inlet opening and through the booth, one of said booth walls being provided with an auxiliary air-inlet opening materially smaller than said main opening and located between said main opening and said air-drawing means, a conveyor for moving articles to be coated through said booth over a path extending through said auxiliary opening and including a portion extending generally normal to the path of air flow between the main opening and said air-drawing means, a discharge electrode having a portion spaced laterally from said path-portion, means for creating an electrostatic field between said electrode portion and the articles conveyed past it, and means located near the main inlet opening for discharging finely divided coating material into said field.

19. An apparatus comprising means for supporting in a coating zone an article to be coated, an ionizing electrode having a portion disposed at one side of and spaced from an article on said support, a source of high electrical potential having opposite terminals respectively associated with the article and electrode to create an electrostatic field therebetween, and means for introducing into such field finely divided coating material for electrostatic deposition on the article, said electrode having a generally horizontal portion disposed below the article to repel upwardly coating material particles which tend to settle from the coating zone under the influence of gravity.

20. Apparatus for coating articles, comprising a conveyor having two portions arranged at an angle to each other, a discharge electrode disposed at one side of one of said conveyor portions in spaced relation to articles carried thereby, a discharge electrode disposed at the opposite side of the other of said conveyor portions, means for establishing an electrostatic field between said electrodes and articles conveyed past them by the conveyor, means for spraying finely divided coating material into the space between the first mentioned electrode and its adjacent conveyor portion and toward said other conveyor portion and its adjacent electrode, the latter serving to repel coating material particles carried through said space.

21. Apparatus for electrostatically coating articles, including a discharge electrode having a pre-coat section extending at an angle to a finish section thereof, a conveyor conforming to said electrode operable to move said articles in a direction to first pass adjacent to said pre-coat section and then said finish section, means for establishing an electrostatic field between said electrode and articles, and atomizing means mounted adjacent the end of said finish section to direct said material adjacent thereto and towards said pre-coat section for electrostatic deposition on said articles.

22. An apparatus comprising a discharge electrode, means for conveying articles in spaced relation to said electrode, a source of high voltage having one terminal connected with said electrode and the other terminal connected with said articles to establish an electrostatic field therebetween, atomizing means mounted to direct a spray of coating material into said field, an isolating fence for said electrode electrically connected to said articles, a gate in said fence, and a control switch operable by said gate to disestablish said field between said electrode and said articles when the gate is open.

23. An apparatus comprising an electrode frame carrying a plurality of fine wires adapted to be connected to a high voltage source to provide an ionizing discharge, means to move an article past said wires, the spacing between the wires on the frame being about two thirds the minimum distance between a wire and a surface of an article to be coated, and means for atomizing a coating material in said discharge for electrostatic deposition onto said article.

24. Apparatus for coating articles including a conveyor for moving the articles through a coating zone, a series of hooks depending from said conveyor, each of said hooks having a shank including upper and lower interlocking portions to permit removal of the lower portion from the

upper portion, said hook-portions being of electrically conductive material, and a sleeve enveloping the interlock of said shank, said sleeve being slidable along the shank to permit removal of the lower portion of the shank from the upper portion thereof, an electrode disposed in the coating zone in spaced relation to articles conveyed by said conveyor, a source of high-voltage having its terminals connected respectively with said electrode and with the upper hook-portions for establishing an electrostatic field in said coating zone, and means for atomizing a coating material into said field for electrostatic deposition onto said articles.

25. An apparatus comprising electrode means for producing an ionizing field, a conveyor operable to move articles to be coated through said field, means outside of said field for revolving said articles at a predetermined speed of rotation while conveyed through said field, guide means between said latter means and said field, and atomizing means mounted to direct a spray of coating material into said field for electrostatic deposition on said articles.

26. Apparatus for coating articles including means for establishing an electrostatic field, a conveyor extending through the field, a series of hooks depending from said conveyor for carrying articles to be coated through said field, each of said hooks having a shank including upper and lower interlocking portions to permit removal of the lower portion from the upper portion, a sleeve enveloping the interlock of said shank, said sleeve being slidable along the shank to permit removal of the lower portion of the shank from the upper portion thereof, an idler wheel mounted upon said sleeve, guide means extending substantially parallel to the conveyor at said field in position to be engaged by the idler wheels associated with articles passing through the field whereby to restrict lateral swinging of the hooks supporting such articles, and means for atomizing a coating material into said field for electrostatic deposition onto said articles.

27. Apparatus for electrostatically coating articles, including a discharge electrode having a pre-coat section and extending in a curve to a finish section thereof, a conveyor operable to convey said articles through said sections, means for revolving said articles while conveyed around said curve, means for establishing an electrostatic field in said sections with said articles comprising a collecting electrode therein, and atomizing means mounted to direct a spray of coating material into said finish section for electrostatic deposition on said articles.

28. Apparatus for coating articles including a spray booth having confining walls and an exit, one of said walls being provided with an inlet opening, a conveyor extending through said booth for conveying the articles to be coated into said booth through said inlet opening and out of said booth through said exit, means for establishing an electrostatic field in said booth, means mounted adjacent said opening for limiting lateral movement of said articles, as they are conveyed toward the field, and means for atomizing a coating material into said field for electrostatic deposition onto said articles.

29. Apparatus for electrostatically coating articles, including a discharge electrode, a conveyor operable to convey articles in a curved path to pass adjacent to said electrode, means for establishing an electrostatic field between said electrode and articles, and atomizing means mounted to direct said material into said field on the concave side of the conveyor for electrostatic deposition on said said articles.

30. The method of coating articles which comprises moving the articles in spaced relation in a column over a predetermined path, discharging finely divided coating material on one side of the article-column for deposition on the articles, withdrawing air from the region on the opposite side of the article-column whereby to induce a flow of air generally transversely of the column and to cause some of the finely divided coating material to pass by the articles through the spaces therebetween to the opposite side of the column, and maintaining on such opposite side of the column and spaced therefrom a plurality of ionizing zones to charge and redirect such by-passing coating material back toward the column for electrostatic deposition on the articles therein.

31. Apparatus for electrostatically coating articles, comprising a discharge electrode providing a coating zone having an inlet end and an exit end, a conveyor operable to convey said articles through said zone from the inlet to the exit end thereof, an atomizing means arranged at one end of said coating zone to direct a spray of coating material thereinto for electrostatic deposition on the articles, means for revolving said articles at a relatively high rate of speed at the end of the zone where the concentration of coating material is highest, and means for revolving said articles at a relatively low rate of speed at the other end of the zone.

HAROLD P. RANSBURG.
RICHARD E. HELMUTH.

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