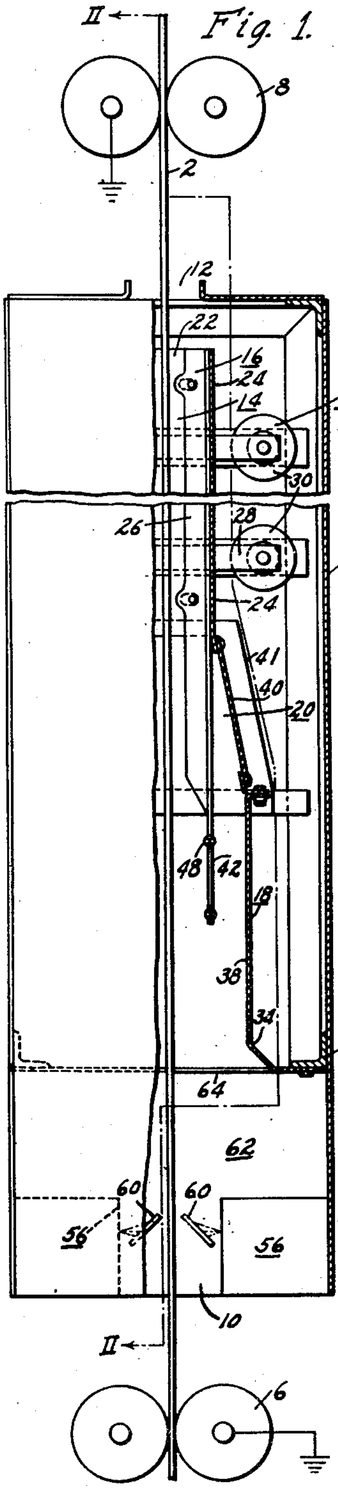
Aug. 24, 1948. E. H. R. PEGG 2,447,664

ELECTROSTATIC COATING APPARATUS AND METHOD

Filed Feb. 1, 1945 2 Sheets-Sheet 1



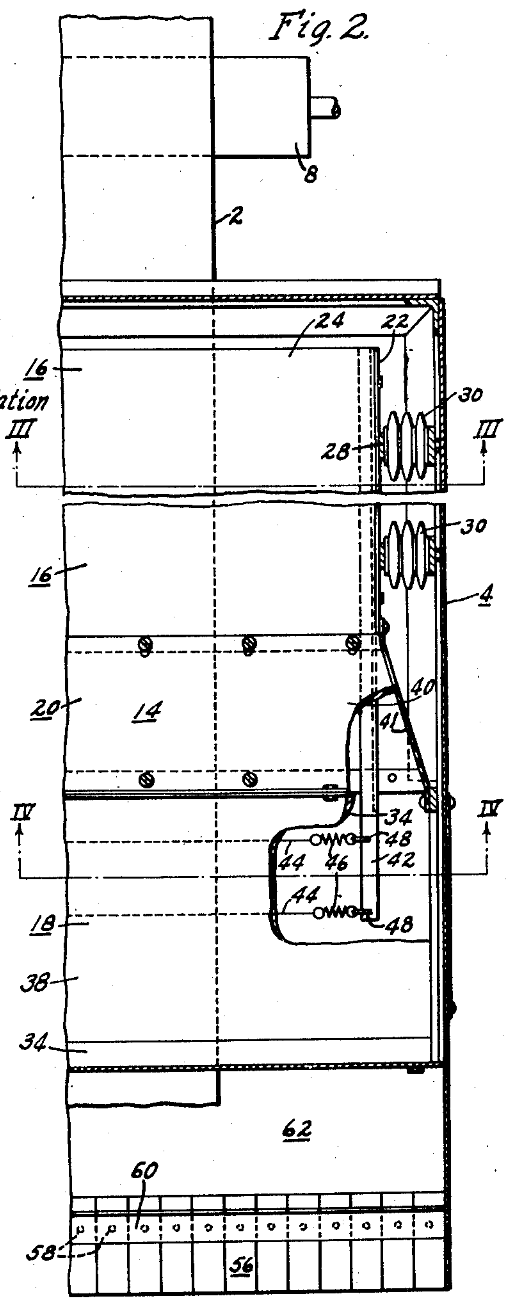


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Fig. 3.

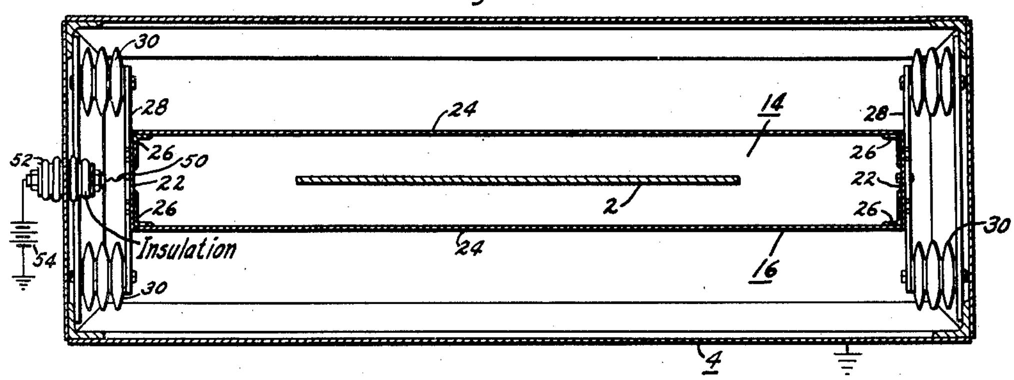


Fig. 4.

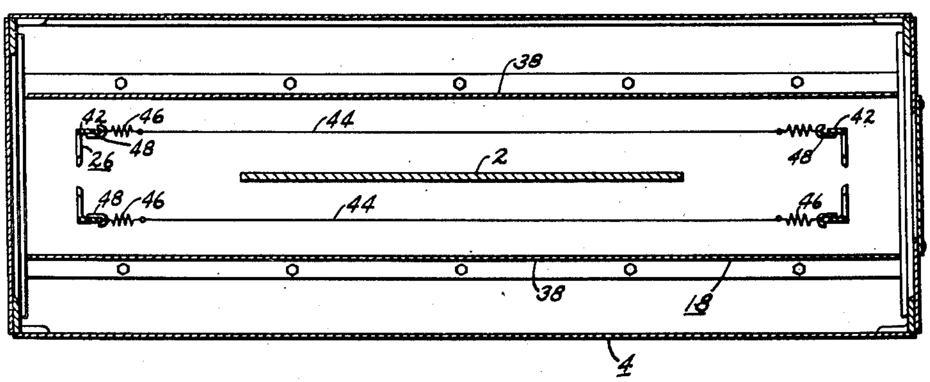
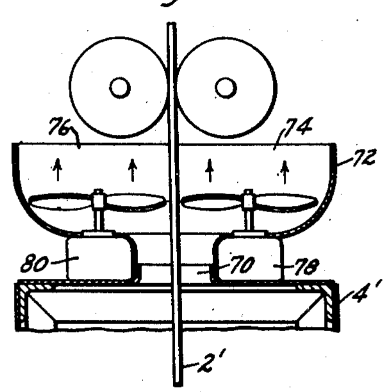


Fig. 5.



WITNESSES:

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UNITED STATES PATENT OFFICE

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ELECTROSTATIC COATING APPARATUS AND METHOD

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24 Claims. (Cl. 117—93)

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This invention relates to the application of electrical means and methods to coating of materials, and relates especially to coating apparatus through which materials, to be coated, are conveyed continuously.

In a general sense, it is among the objects of my invention to provide means and methods for electrically applying substances to the surfaces of things or materials; in a less general sense, to provide means and methods for electrically coating a thing or material while it is traveling in a production line; and in a more specific sense, to provide means and methods for electrically covering moving metallic materials, such as sheets, strips, bars, and the like, with a very thin, even layer or coating of oil or similar substance.

It is a further object of my invention to electrostatically apply a uniform layer or coating to a material having surfaces of relatively large expanse.

In a preferred embodiment for illustrating my invention, my novel apparatus is incorporated into a modern production line in which tinplate is made from raw strip metal in any known manner and in which the strip, before and after tinning, moves continuously at relatively high speeds. My invention is given a most severe test in this connection because the oil-coating on tinplate must meet rigid requirements. Such coatings must be very thin, not more than a few microns in thickness and less for some purposes, generally ranging from about 1½ microns as a minimum for tinplate subsequently to be lacquered, to about 3 to 6 microns for tinplate which is to be fabricated by cutting or drawing or similar operations in which the oil-coating also serves as a lubricant.

Mechanical spraying of tinplate is not satisfactory because the spray drops do not deposit readily on the moving tinplate when the spray is made fine enough for a thin coating. The deposit obtained is commonly uneven and irregular, with spots of the tinplate entirely uncovered or covered either too thinly or too thickly. This can be explained by the fact that strip (or other object or material to be coated) moving at high speeds carries the atmosphere along its surface with it, causing a layer of the atmosphere to move in the general direction in which the strip moves; a common phenomenon which I hereinafter call "windage." Such windage impedes the depositing of fine spray drops on the surface to be coated.

In accordance with a form of my invention, I provide, briefly, means for creating a confined charged spray or cloud of discrete particles which

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moves in a desired direction in proximity to the surface of the strip to be coated, and means for subsequently electrostatically precipitating the spray drops or particles onto the strip. Specifically, the spray drops which are carried along with the strip, are electrically precharged in one region and then are passed into a region of an electrostatic field of proper polarity and suitable intensity and length. The electrostatic forces, arising out of the reaction between a charged particle and an electrostatic field, forcibly move the charged spray drops to the strip, overcoming any windage forces opposing such movement.

Generally, an object of my invention is to provide an electrical apparatus and method for precharging and then precipitating particles onto displaceable collectors, or materials, and especially those which are moving at such speeds as to introduce windage currents of sufficient strength to deflect or pick up fine particles, and to carry the particles alongside the collector, or turn them away from the collector.

It is an object of my invention to provide means and methods for applying a uniformly-distributed coating to strip material, or the equivalent, as a collector of coating particles; the coating being applied in such a manner that, if desired, the strip material can, for practical purposes, be fully and microscopically coated with neither uncoated spots nor relatively heavier, or more thickly, coated spots.

In addition to the foregoing objects and features of my invention, other objects, features, methods, combinations and innovations will be discernible from the following description of a preferred embodiment thereof, which is to be taken in connection with the accompanying somewhat diagrammatic drawings.

In the drawings:

Figure 1 is a vertical view, partly in section and partly in elevation, of apparatus in accordance with my invention;

Fig. 2 is a partial sectional view, taken substantially along the line II—II of Fig. 1;

Figs. 3 and 4 are sectional views, on another scale, across the apparatus of Figs. 1 and 2, taken substantially on the lines III—III and IV—IV, respectively; and

Fig. 5 is a partial view of a modified form of apparatus.

Referring to the drawings, an elongated strip of tinplate comprises any portion 2 which is moved upwardly, in tension, through a hollow metal casing 4 by means of electrically-grounded metallic guiding and driving apparatus of any suitable kind, shown schematically as lower drag rollers 6 and upper driving rollers 8. The casing 4 has a generally rectangular prismatic form and is provided with a central lower opening 10 and a central upper opening 12, extending across the width of the casing 4. The openings are opposite ends of an unobstructed central work-passage through which the tinplate moves through the casing.

The work-passage is surrounded by a hollow open-ended tubular structure inside the casing 4, this tubular structure being indicated in its entirety by the reference numeral 14. The tubular structure 14 comprises an upper metal section 16, a lower metal section 18 and an intermediate section 20 of insulating material.

The upper section 16 comprises a rectangular prismatic arrangement of flat narrow sides 22 and flat stiff wide planar sides 24 held in assembled relation by four similar angle members 26 extending longitudinally along the edges of this section. The angle members 26 include portions passing through the intermediate section 20 and into the lower section 18. In a practical apparatus, the spacing between the wide sides 24 can be adjusted, and to this end the narrow sides 22 may be provided with elongated openings so as to permit the angle members 26, which carry the sides 24, to be slid therealong and bolted in different positions thereon. The angle members 26 may be provided with lugs or ears for covering the elongated openings.

The upper section 16 is carried by spaced bars 28, each of which is supported by a pair of insulators 30, as many pairs of insulators 30 being carried by the casing as is considered necessary for centrally supporting and positioning the section 16 symmetrically inside the casing 4 with adequate air insulation between the metal of this section and that of the casing.

The lower section 18 comprises a pair of stiff wide sides 34 extending substantially for the full width of the casing 4, and supported at their lower ends by angles 36. The sides 34 have planar portions 38 which are substantially parallel to the planar sides 24 of the upper section 16, but are adjustably spaced a greater distance apart. In the embodiment shown, the portions of the narrow sides of the casing 4, at the lower section 18, may be considered as providing narrow sides for this section, but separate sheet metal may be used, if desired, to provide a peripherally closed hollow rectangular lower section. Contrariwise the portion of the casing 4, along this ionizing region, may be used to provide all the sides for the lower section 18.

The intermediate section 20 comprises a hollow truncated rectangular pyramidal arrangement of opposite flexible wide sides 40 of insulating material and opposite flexible narrow sides 41 of insulating material supported in any suitable manner to allow for adjustments of the position of the sides 24 of the upper section 16, while keeping the hollow inner tubular structure 14 relatively tight with respect to fine particles permeating the interior of the structure.

Each of the portions of the angle members 26 which extend into the lower section 18 has one leg cut away so as to provide a bar portion 42. Between laterally opposite pairs of bar portions 42, a plurality of ionizing wires 44 may be strung in the width direction of the work-passage, paralleling the face of the tinplate 2 and the side-portions 38, substantially mid-way therebetween. As may be seen in Figs. 2 and 4, each bar portion 42 is also spaced from the proximate side of the tinplate 2 and is, therefore, electrically insulated therefrom. The ionizing wires 44 may be secured to the bar portions 42 in any suitable manner, metal springs 46 being shown which engage metal hooks 48 fastened to the bar portions 42. Preferably, sufficient tension should be provided in the springs 46 to keep the ionizing wires taut.

In general, the apparatus described is substantially symmetrical with respect to both of the longitudinal planes bisecting it.

As shown in Fig. 3 the insulated metal section 16 of the tubular structure 14 has one terminal of a high-voltage direct-current source of power connected thereto by means of a conductor 50 passing through an insulating bushing 52 supported in a side of the outer casing 4. The other end of this source of power, shown schematically as a battery 54, is grounded or directly connected to the casing 4 which is grounded. It should be noted that the tinplate 2 is also at ground potential because it is in direct contact with the grounded roller sets 6 and 8. The angle members 26 conduct high potential to the ionizing wires 44; the voltage of the battery 54 being high enough to cause the ionizing wires to discharge and provide a stream of charged matter moving to or toward the oppositely charged tinplate 2 and to or toward the metal side portions 38 of the lower section 18, both of which are at ground potential. Hence the ionizing wires are discharging electrodes. It is clear that the ionizing wires may be separately energized so as to have a potential different from that of the upper section 16. In such case the ionizing wires would be electrically insulated from the section 16.

Accordingly, a definite electrically-stressed region is provided inside the lower section 18, which is substantially permeated by an ionized electrostatic field for ionizing particles moving through this region.

An electrical stress also exists in the region between the insulated metal of the upper section 16 and the grounded tinplate 2, thereby providing a substantially non-ionized, precipitating field embracing substantially the full inside of the upper section 16. This field will react with precharged particles passing into it, and cause them to migrate in the vector-direction of the field. In order to cause the precharged particles to deposit on the surface of the tinplate in this region, the particles should be charged with a polarity opposite to that of the tinplate. This means that the ionizing wires and the section 16 should be both positive or both negative, if unidirectionally energized. General principles underlying the separate charging and precipitation of particles, including factors for determining the length of a precipitating field, are known, one source of information being an article by G. W. Penney, entitled "A new electrostatic precipitator," published in the January 1937, issue of "Electrical Engineering."

Accidental contact of the high-potential parts of the apparatus by a person is prevented by the grounded casing 4.

Any suitable spraying means 56, or the equivalent, is provided in the casing 4 below the tubular structure 14 for providing the particles for coating the tinplate. A type found to be satisfactory comprises a spraying mechanism including a cylinder rotating in a float-controlled pool of oil below its center. Air is blown across the top of the cylinder for wiping off oil carried up by the rotation of the cylinder, the air passing through nozzles 58. A very fine cloud-like spray is formed. Heated dispersion plates or baffles 60 help deflect the spray upwardly and further break up the spray-particles into smaller ones. Spraying mechanism of this type is well known in the art.

The spray fills a space 62 between the spraying means 56 and the lower end of the tubular structure 14. Any suitable frame 64, which may include the angles 36, can be provided to prevent spray drops from passing on the outside of the tubular structure.

In the operation of the apparatus described, the tinplate moves upwardly centrally through the work-passage inside of the tubular structure 14. It should at all times be adequately spaced from the insulated high-potential parts, taking into consideration edgewise weaving and broadside slapping of the strip, which should preferably be kept to a minimum. The portion of the tinplate moving through the space 62 is enveloped by spray drops which it carries, by windage, first into the lower section 18 where the spray drops are charged as they pass through the ionized field around the ionizing wires 44, then into the intermediate section 20 that converges toward the upper section 16, and finally into the upper section 16. The sides 24 of the upper section 16, at high potential, function as plate electrodes with respect to the grounded tinplate, thereby establishing a precipitating electrostatic field which causes the charged spray drops passing into it to precipitate onto the tinplate. The sides 22 also coact with the tinplate, particularly its edges, to provide a similar electrostatic precipitating field.

The thickness and continuity of a precipitated coating or deposit will depend on a number of obvious factors, including the density and velocity of the spray, the size of the spray particles, the velocity of the tinplate as it passes through the different electrostatic fields, its windage effect, and the strength and length of the fields. I am not prepared to advance rules for determining the relation of these factors, but satisfactory results can be readily obtained, especially with adjustable apparatus.

In the coating of material with a liquid such as oil or paint, it is desirable to use a liquid which will break up into spray drops that retain a degree of fluidity, at least until they are precipitated, and perhaps while they are passing through the region of the precipitating field, because I believe that the precipitating field not only forcibly precipitates charged particles, but also can have a spreading action on liquids on the surface of the strip or other material coated with liquid.

My invention is not necessarily limited to liquid-coating. Any coating material can be used which either has adhesive qualities of its own which will cause it to stick to the surface being coated, or, if without such qualities, will stick to a surface which has been treated or prepared for holding the particles electrically precipitated thereto.

In the specific application disclosed, which I believe to be entirely novel and useful in and of itself, the spray drops should be extremely fine, with sizes comparable to the extremely thin layers to be applied to the tinplate. Any kind of suitable oil can be used for coating tinplate, palm oil being commonly used, but the particular kind can be chosen in accordance with the subsequent use of the tinplate.

As a rule, coatings much thicker than that applied to tinplate are desired, and can be obtained with a spray providing discrete particles in proper quantity. A spray of coarser drops or particles will make a thicker coating, so that exceptionally minute particles are not an essential characteristic of the broad aspects of my invention.

Obviously, making the apparatus described upstanding simplifies problems of supporting and guiding the material to be coated, such problems being specifically distinct from the principles of the invention disclosed. It is also obvious that individual sheets can be substituted for continuous strip, especially if the apparatus is arranged for material moving downwardly, as by reversing the apparatus of Fig. 1, so that the top becomes the bottom and vice versa.

In the special case of oil-coating tinplate, such as described, the velocity of the windage-carried coating particles is tied up with the movement of the tinplate. However, separate means may be used for causing a positive and controlled movement of the coating particles until they are precipitated onto a material. Fig. 5 indicates such an embodiment.

Referring to Fig. 5, an outer casing 4' has an opening 70 through which tinplate 2' passes. Associated with the outlet 70 of the casing 4' is a duct 72 around the tinplate. The tinplate divides this duct into two gas-passages 74 and 76 which are separated except at the edges of the tinplate. Blower means 78 for the passage 74 and blower means 80 for the passage 76 create a suction for pulling spray drops formed in the casing 4' in the direction toward the opening 70. The blowers 78 and 80 can be used to provide the necessary movement of the spray drops through the ionizing region and the precipitating region in the casing 4', either aiding or going against the windage forces of the tinplate. In the former case, the ionizing and precipitating regions would be arranged as shown in Fig. 1, with the blower means at the top, associated with the upper opening. In the latter case, the tinplate could actually move downwardly in apparatus such as that of Fig. 1, having a blower means at the top. Such additional blower means is desirable where the material to be coated does not move at speeds sufficient to establish spray-moving windage forces of sufficient value for the coating purposes desired.

As an indication of the application of my invention, an apparatus was operated in which tinplate was continuously passed, at 600 feet per minute, through a casing in which a pair of 15-mil ionizing wires were spaced 3" apart and arranged substantially in the plane of the equivalent of the wide sides 24. These sides were approximately 23" long, with their edges about 8½" from the nearest ionizing wire. The insulated wide sides 24 were spaced 3" apart, and the uninsulated wide sides, equivalent to the grounded side-portions 38, about twice this distance. This apparatus could treat tinplate having thicknesses from about .001" to .015" and widths up to 38". The width of the insulated inner section was 55", so as to allow for a 4" weaving either way in the plane of the tinplate and a minimum of about 4" for insulation. A direct current voltage of 15,000–16,000 volts was connected between the grounded parts and the insulated electrodes comprising the ionizing wires and the inner section 16, with the insulated electrodes negative. Feeding a spray at a rate of .2 gram of palm oil per base box yielded an oil coating on the tinplate of about 1½ microns in thickness. Increasing the spray feed increased the layer thickness. A base box is considered to have 31,360 square inches per face of tinplate or 62,720 square inches total for both faces.

It is likely that some of the spray coats the tinplate before it reaches the ionizing region including the ionizing wires. Some oil may be precipitated in this region also, but the evidence I have seems to indicate that most of the oil is caused to precipitate onto the tinplate in the precipitating region comprising the upper section 16. In one test, a coil of strip was passed through the apparatus with the electrodes deenergized, and the oil deposit showed .06 gram per base box; but with the electrodes energized, a similar coil showed an average thickness deposit of 0.27 gram per base box with a maximum variation between plus .113% to minus .22%.

From two to four times the coating weight was obtained by the use of the electrostatic forces, and the coating thickness was consistently uniform, much more so than that obtained without the energization of either or both of the electrodes 16 or 44.

While I have described my invention in a preferred form, it is obvious that it has greater application, and is subject to considerable modification for adapting it to different shapes, sizes and kinds of materials, and is subject to the substitution of different embodiments of ionizing or particle charging means and of precipitating means for purposes similar to that described.

I claim as my invention:

1. A method of applying a coating to elongated material moving in the direction of its length, which comprises relatively progressively moving the material through a plurality of zones in a first of which a portion of the material is substantially enveloped by a liquid spray and by an ionizing electrostatic field, and in a second of which a portion of the material is substantially enveloped by a distinct precipitating electrostatic field, and continuously forcibly moving the spray successively through said zones.

2. A method of applying a microscopic layer of oil to flat metal, such as strip, sheet or the like, which method comprises progressively moving the metal centrally through an ionized electrostatic field and a distinct precipitating electrostatic field, with the metal being a terminating potential-boundary of said fields, introducing a fine spray of oil into said ionizing field for charging spray drops, and after introduction of the spray into the ionized field, applying a force to the spray for moving charged spray drops into said precipitating electrostatic field for precipitation onto the metal.

3. Apparatus for treating a moving collector having a surface for receiving a coating, comprising casing means providing a predetermined path through which the collector can be removably conveyed successively through a plurality of spaced regions along said predetermined path, an ionizing wire in one of said regions, insulation supporting means for supporting said wire insulated from said casing, with the wire spaced from the path of movement for the collector and extending transversely across said path, extended precipitating electrode means in another of said regions, and insulation supporting means for supporting said precipitating electrode means insulated from said casing, with the electrode means spaced from the path of movement for the collector, and means for providing a spray of coating material in the region including said ionizing wire.

4. Apparatus for precipitating particles onto a moving collector, comprising a casing providing a predetermined path through which the collector can be successively conveyed through a plurality of spaced regions along said predetermined path, spraying means in a first of said regions, ionizing means for producing an ionized electrostatic field in a second of said regions, said ionizing means comprising a discharging member in said second region, precipitating means for providing a substantially non-ionizing precipitating electrostatic field in a third of said regions, said precipitating means comprising a field-establishing member in said third region, and insulating means for insulating said members.

5. Apparatus of a type described, comprising means providing a work-passage for removably receiving a material for electrostatic coating-treatment, and successively along said work-passage: a spray means, a discharging electrode, and an extended electrode means comprising a field-establishing precipitating plate electrode.

6. Means for coating an elongated metallic material, comprising means including a casing for providing a work-passage through which the material can be progressively passed, electrode means comprising a discharging electrode at one side of said work-passage, an extended electrode means comprising a substantially non-discharging field-establishing precipitating electrode spaced from said discharging electrode in a direction in which said extended electrode means extends, grounding means for grounding the material passing through the work-passage, and means for supporting said electrodes in insulated relation with respect to said grounding means.

7. Apparatus of a type described, comprising means providing a work-passage for receiving a material for electrostatic coating-treatment, electrode means comprising a discharging electrode at one side of said work-passage, an extended electrode means comprising a field-establishing precipitating electrode spaced from said discharging electrode in a direction in which said work-passage extends, the first said means comprising a metallic casing around said electrodes, and insulating means for supporting said electrodes inside said casing in insulated relation thereto.

8. Apparatus of a type described, comprising a pair of spaced substantially parallel plate electrodes, an ionizing electrode spaced from an edge of each of said plate electrodes, means for guiding the movement of material centrally between said ionizing and between said plate electrodes so that the material is insulated therefrom, means for establishing a spray of discrete particles, and means for causing spray particles to move successively between the spaced ionizing electrodes and the spaced plate electrodes.

9. Apparatus of a type described, comprising a pair of spaced substantially parallel plate electrodes, an ionizing electrode spaced from an edge of each of said plate electrodes, means for guiding the movement of material between said ionizing and between said plate electrodes so that the material is insulated therefrom, means for passing a spray of discrete particles in proximity to said ionizing electrodes, a casing around said electrodes, said casing having a tunnel-like passageway through which the material is adapted

to pass, and means for supporting said electrodes inside said casing.

10. Apparatus of a type described comprising an elongated hollow tubular structure having a central work-passage, said structure having a pair of spaced metallic sections and an insulating section therebetween, and ionizing electrode means inside of said structure in insulated discharging relation to one of said metallic sections.

11. Apparatus of a type described comprising an elongated hollow tubular structure having a central work-passage, said structure having a pair of spaced metallic sections and an insulating section therebetween, one of said sections being wider than the other, and ionizing electrode means inside of said structure.

12. Apparatus of a type described comprising an elongated hollow tubular structure having a central work-passage, said structure having a pair of spaced metallic sections and an insulating section therebetween, ionizing electrode means inside of said structure in insulated discharging relation to one of said metallic sections, spraying means, and means for causing a spray, produced by said spraying means, to move through said structure from the region of said ionizing electrode means to the other of said metallic sections.

13. Apparatus of a type described comprising an elongated hollow structure having a central work-passage, said structure having a pair of spaced metallic sections and an insulating section therebetween, and ionizing electrode means inside of said structure in insulated discharging relation to one of said metallic sections, said structure being generally rectangular in cross-section, with the metallic section associated with said ionizing electrode means being wider than the other of said metallic sections, said ionizing electrode means comprising an ionizing electrode on each side of a medial plane of the work-passage thereat.

14. Apparatus of a type described comprising an elongated hollow structure having a central work-passage, said structure having a pair of spaced metallic sections and an insulated means therebetween, ionizing electrode means inside of said structure in insulated discharging relation to one of said metallic sections, means for applying an electrical potential to the other of said metallic sections and to said ionizing electrode means, and a protective casing around said other metallic section, said casing being open for the passage of material therethrough.

15. Apparatus for protectively coating wide, thin metal, comprising an elongated hollow structure having a work-passage with openings at both ends for the passage of the metal therethrough, said structure having insulated flat metallic portions on both sides of the work-passage, spaced to provide an air clearance to the metal, and insulated ionizing electrodes on both sides of the work-passage in discharging relation to opposite faces of the metal, said ionizing electrodes being longitudinally spaced from said insulated metallic portions.

16. Apparatus for protectively coating wide, thin metal, comprising an elongated hollow structure having a work-passage with openings at both ends for the passage of the metal therethrough, said structure having insulated metallic sheet-like portions on both sides of the work-passage, spaced to provide an air clearance to the metal, insulated ionizing electrodes on both sides of the work-passage, in discharging relation to opposite faces of the metal, said ionizing electrodes being longitudinally spaced from said insulated sheet-like portions, said structure further comprising sheet-like portions in discharging relation to said ionizing electrodes on the outer sides thereof with respect to the metal, spraying means, and means for causing a spray, produced by said spraying means, to move through said structure on both sides of said ionizing electrodes.

17. Apparatus for protectively coating wide, thin metal, comprising an ionizing electrode-means lying on opposite sides of a work-passage for the metal, in discharging relation thereto, other electrode-means on the outside of said ionizing electrode-means with respect to the metal, means for insulating said ionizing electrode-means with respect to said metal and other electrode means, and means for applying a voltage between said ionizing electrode-means and said other electrode means and between said ionizing electrode-means and metal passing through said work-passage.

18. Apparatus of a type described comprising a hollow section having a work-passage, ionizing means in said section, spray-producing means for introducing a spray of particles in the region of said ionizing means, and means for creating a draft through said section carrying spray-particles of said spray, the last said means being initially operable on said spray-particles after they leave said spray-producing means.

19. Apparatus of a type described comprising a hollow member having electrode means providing an electrostatic precipitating field, ionizing means spaced from said electrode means, means for introducing a spray of particles into the region of said ionizing means, whereby spray-particles are charged by said ionizing means, and means for establishing a draft in said hollow member for forcibly moving spray-particles of said spray into said precipitating field.

20. Apparatus for treating a collector movable successively through a plurality of spaced regions along a path, the collector having a surface for receiving a coating, comprising means for providing, in a first of said regions, a spray of coating particles which are electrically charged, electrode means for providing a precipitating electrostatic field in a second of said regions, said electrode means being spaced from the first said means, and a blower for producing a forced draft in a direction from the said first region to said second region.

21. Apparatus of a type described for coating a collector, comprising a longitudinally extended substantially non-discharging electrode means for providing a precipitating electrostatic field, ionizing means comprising a discharging electrode means, means for guiding said collector for movement past said ionizing means and said electrode means, means for establishing a spray of discrete particles, and means for causing spray particles to move successively past said ionizing means and said electrode means in the order named.

22. The invention of claim 21 characterized by said discharging electrode means comprising a plurality of substantially parallel ionizing wires in spaced relation at opposite sides of the path of movement for the collector.

23. Apparatus of a type described comprising a hollow section having a work-passage having a work-entrance and work-exit, charged-spray-producing means for producing, at said work-

passage, a spray of particles and for electrically charging particles of the spray, electrostatic precipitating means in said section, and separate means for creating a draft in said section capable of carrying said particles in said section so that they will be subjected, in said section, to electrostatic forces produced by said precipitating means, whereby said particles can be precipitated out of said draft by said precipitating means, said separate means comprising a fan device for inducing a draft through said section, and a casing-means associated with said work-passage in which the fan device is located.

24. A method of applying a coating to the surface of elongated electrically conductive sheet material moving in the direction of its length, which comprises establishing an ionized electrostatic field and a distinct precipitating electrostatic field in successive portions of a path of movement of the material, introducing a spray of fine cloud-like particles into the ionized electrostatic field, and moving the material at a high speed, whereby a windage effect is created and substantially all of the charged spray particles

are carried from said ionized electrostatic field into said precipitating electrostatic field substantially entirely by the windage action of said material, and are electrically precipitated onto said material through the action of said precipitating electrostatic field.

EDWARD H. R. PEGG.

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