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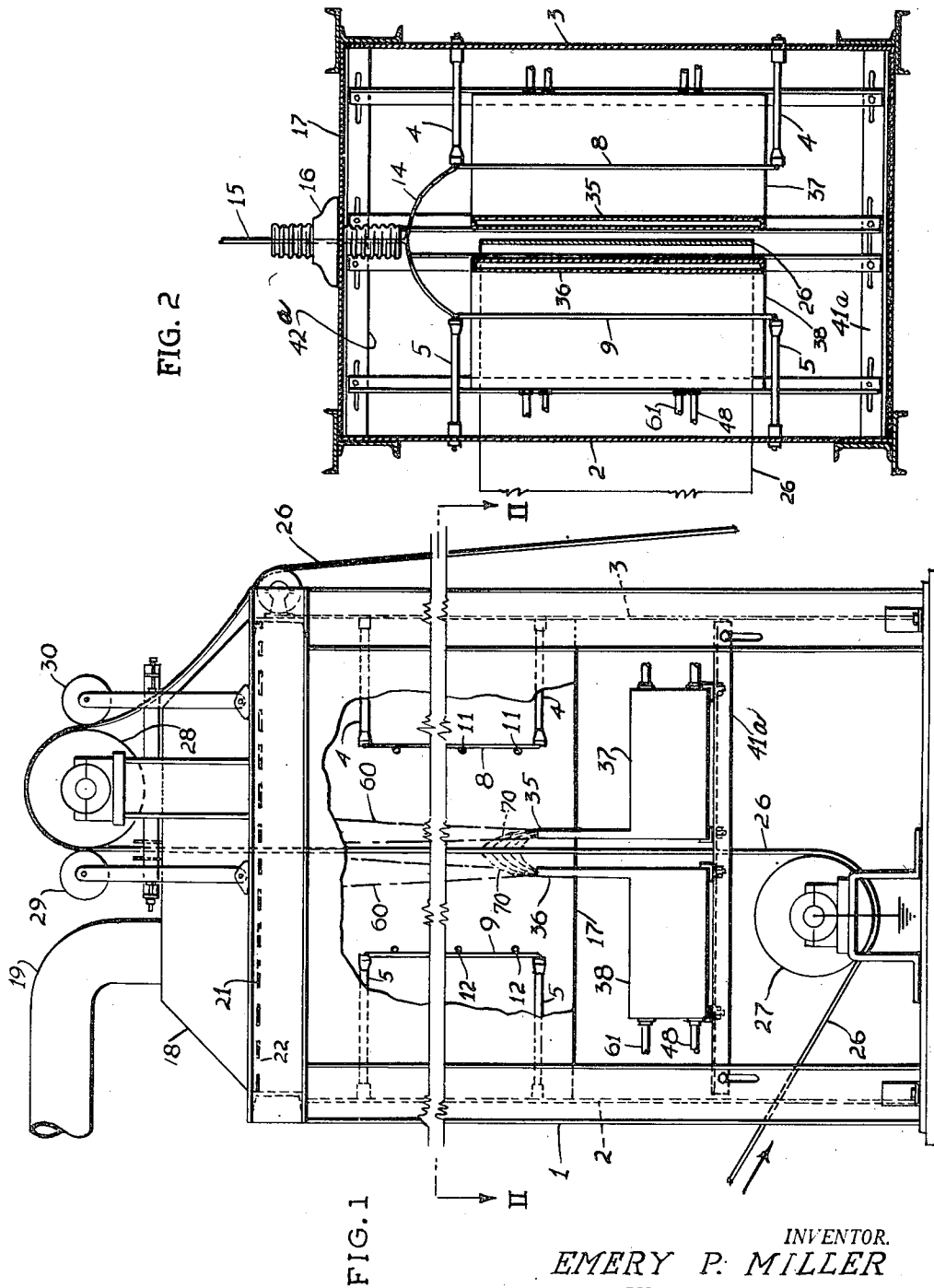
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2,770,210

APPARATUS FOR COATING

Filed Nov. 5, 1945

2 Sheets-Sheet 1



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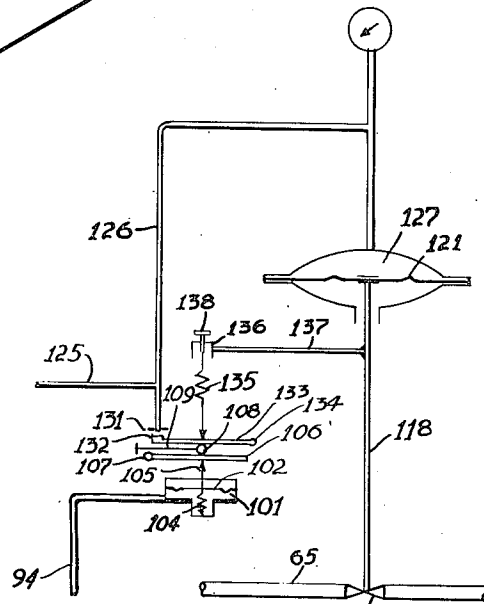
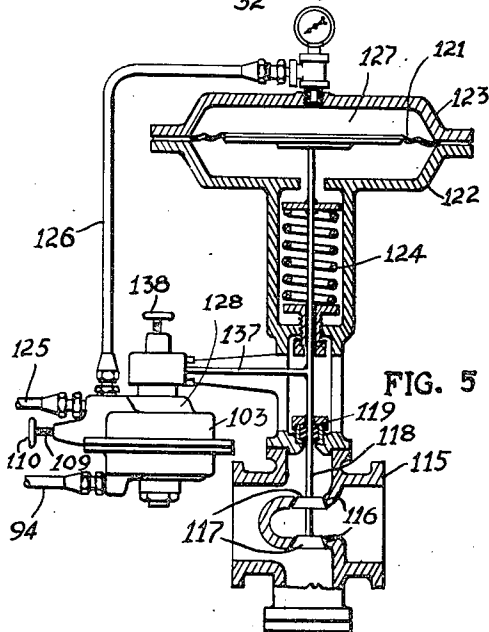
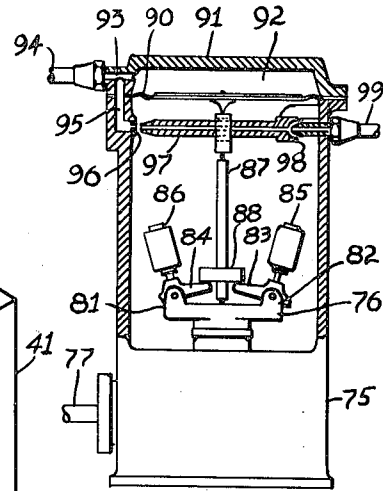
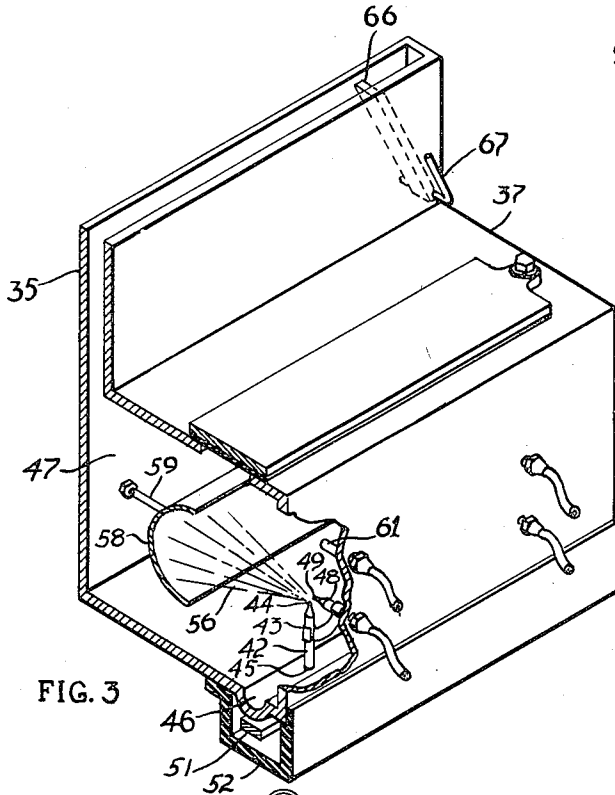
BY

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APPARATUS FOR COATING

2 Sheets-Sheet 2



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APPARATUS FOR COATING

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7 Claims. (Cl. 118—7)

This invention relates to the deposition of finely divided material upon an object in an electrostatic field.

In the manufacture of tinned sheet steel, commonly known as "tin plate," used extensively for making soldered seam cans, it is the practice to apply a thin coat of oil to the tinned surface of the tin plate, this coating generally being applied to the tinned plate or strip before it is cut into blanks for the forming presses. The coating of oil is desirable as an aid in separating the sheets from the stack and as an aid in securing proper printing in the subsequent lithographing operation. An excessive coat of oil on the tin plate interferes with the proper stacking of the blanks by causing the sheets to offset, interferes with the subsequent operations of soldering or lithographing, and has other disadvantages.

It is an object of the present invention to apply to the surface of an article, a thin coating of liquid.

Another object is to apply to an article a thin continuous coating of liquid.

Another object is to apply to a continuous web of material a coating which is maintained substantially uniform over large areas.

Another object is the treatment of an article having spaced droplets or particles of liquid having dielectric properties on the order of vegetable, mineral or animal oils or molten waxes thereon to cause spreading or coalescence of the droplets or particles.

Another object is the provision of an improved process of introducing liquid coating material into an electrostatic field for deposition thereby.

Another object is the proportioning of the speed of a web with relation to the quantity of coating material deposited thereon.

In accordance with one feature of the present invention, a coating is deposited upon a surface in the form of discrete spaced particles of liquid, and the coated surface is subjected to an electrostatic field of sufficient intensity to spread or coalesce the particles. Preferably the coating is obtained by precipitating liquid particles upon the surface in an electrostatic ionizing field or zone, and the coated surface is exposed to an electrostatic field for a sufficient length of time to secure the desired degree of spreading of the particles. By depositing the particles upon a moving sheet or article adjacent one end of an ionizing electrostatic field, the field serves the dual function of precipitating the particles onto the surface and acting on the deposited particles as the surface moves therethrough to increase or assist spreading and coalescence of the particles.

The suspension of particles preferably is introduced at such velocity as to form an elongated stream or blanket of substantially uniform width and thickness in the absence of the electrostatic field, and the particles are electrostatically deflected toward the object to be coated and are deposited thereon. By employing a low velocity carrier air stream for the particles I am able to reduce or eliminate ambient air currents caused by the carrier stream, which may cause adventitious deposits of parti-

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cles, and insure that the particles are deposited on the sheet adjacent the leading edge of the field so that the deposited particles will remain under the coalescing action of the field for a sufficient length of time to insure adequate spreading or flow.

The spacing of the deposited particles will depend on their distribution in the stream, and the relative movement between the stream and the object to be coated. When the sheet or object to be coated is moved past the stream of particles, the density or thickness of the coat applied is determined by the rate at which the material is supplied and the speed of the web or object to be coated.

In the practice of the present invention I am able to obtain a continuous liquid coat on the surface of the sheet which is thinner than any continuous coat heretofore obtained by spray methods. This result I believe is in part due to the nature of the stream or blanket of mist which in the absence of an electrostatic field, retains its cross sectional shape for some distance; to the substantially uniform and unidirectional deflecting and depositing action of the electrostatic field on the mist stream; to the traveling of the web which increases the dispersity of the particles deposited; and to the deforming or spreading action of the electrostatic field on deposited particles which causes them to spread and to tend to coalesce and form a continuous coat. The deforming action of the field will vary, depending on the dielectric properties of the liquid particles, their size, the time of exposure, the strength of the field, and other factors. Under comparable conditions of deposit without an electrostatic field and under the spreading influence of gravity, the particles would form a non-continuous coating. To obtain a continuous coat in the absence of an electrostatic field it would be necessary to deposit a sufficiently large number of particles in overlapping relation so that resultant contact between particles would induce subsequent flow to an even film. Such a film would contain more material and therefore would be thicker than that obtained with the same size particles in an electrostatic field where a greater dispersity of deposit can be secured and be coalesced, in accordance with the present invention. This feature of the invention is of particular value in instances where excessive coating is deleterious.

I prefer to bring the particle suspension into the field through an induction nozzle opening upwardly and which extends generally in the direction of movement of the object to be coated. This arrangement employs the force of gravity to oppose the upward momentum of the particles introduced into the electrostatic field; assists in minimizing the agitating effect of ambient air currents; and has the further advantage of avoiding dripping from the nozzle onto the sheet to be coated. In treating sheets of material the induction nozzle is preferably of about the same width as the sheet to be coated, and the nozzle opening may be made adjustable so that the apparatus is suitable for treating sheets or webs of various widths. However, I do not intend to exclude the application of a low velocity diverging stream of atomized liquid in carrying out the invention.

The preferred embodiment of the atomizer or dispersion producing unit consists of an air stream type of fluid disintegrator in which intersecting streams of air and liquid are mingled in a plenum chamber, which may, if desired, contain a baffle or separator unit to break up or eliminate the large particles from the air stream. Where the larger size particles are not a disadvantage the baffling and separation may be omitted.

According to another feature of the invention, the nebulizing of the liquid takes place in a plenum chamber at super-atmospheric pressure, and the stream of nebulized particles then is introduced into the electrostatic field, which is in effect in the free atmosphere.

The plenum chamber may be located in or outside the electrostatic field. The provision of a plenum chamber in which the pressure is maintained intermediate between the pressure of the atomizing liquid or air supply and the atmospheric pressure provides a space in which the air and the liquid particles are brought more nearly into velocity equilibrium and makes it possible to introduce the stream of nebulized liquid into the electrostatic field at a lower velocity than is possible with air atomizers which carry out the atomization in a one step pressure reduction. This feature of the invention is not limited to the deposition of a coating of spaced particles, and may be employed for depositing a continuous or heavy coat in an electrostatic field, and results in better uniformity of coating, more complete utilization of coating material, and a higher output of liquid for each dispersion unit. If it is desired to have the atomization occur in the vicinity of the field, the walls of the plenum chamber may serve as a shield against action of the electrostatic field.

Where an air stream is employed for producing the dispersion it may serve as a carrier for the dispersed particles, and if desired, this air stream may be augmented by a supplementary air stream. Also it is of advantage in some cases to provide an auxiliary air stream through the electrostatic field which serves as an envelope for the stream of dispersed particles introduced therein. When employing an exhaust fan or the like for this purpose, there is provided a sub-atmospheric pressure area in the coating and spreading zone, which is of benefit in connection with the introduction of the low velocity nebulized liquid from the plenum chamber into the electrostatic field.

Where the sheet or article to be coated is to be moved through the coating zone at a speed which may vary from time to time I prefer to employ a governing arrangement whereby the quantity rate of flow of the nebulized liquid is proportioned with respect to the rate of travel of the sheet or web to be coated. In the preferred embodiment this is accomplished by controlling the flow of air to the atomizer in accordance with the rate of travel of the web or object being coated. The preferred embodiment employs a valved orifice to control the air supply to the atomizer which is designed so that the flow through the orifice bears a predetermined relation to the position of the valve therein. I prefer to employ a pilot loading source of air pressure to govern the position of the valve, which pressure in turn bears a predetermined or proportional relation to the speed of travel of the web or sheet to be coated. The pilot loading pressure preferably is obtained by the back pressure effect in a stream of air flowing or bleeding through an orifice, and is varied by varying the flow through the orifice by a damper or valve which is positioned by an air pressure which bears a predetermined relation to the lineal speed of the sheet or web to be treated. The governing arrangement above described is not limited to use with an electrostatic field.

The invention is applicable to the coating of webs or objects with various kinds of adherent liquid materials. As examples of the liquids which may be applied, there are cited mineral, vegetable or animal oils; molten or dissolved natural or artificial waxes or other liquids having dielectric properties which are of the order of these materials.

In particular, when applying a coating of non-drying or slowly drying oil, I am able to deposit a thinner film in a given time in an electrostatic field than when the force of gravity or velocity of a carrier air stream is employed as the depositing force without the aid of an electrostatic field. I believe this is due partly to the atomizing or nebulizing of the liquid in a plenum chamber and introduction of the nebulized liquid into the electrostatic field and partly to the action of the electrostatic field in precipitating and spreading the dielectric oil to cause the deposited particles to merge or coalesce on the surface to be coated. It thus is possible to cause particles of

dielectric oil to coalesce on a surface in an electrostatic field which if deposited without an electrostatic field would remain as discrete spaced articles. The invention therefore is not limited to simultaneous precipitation and coalescence, but in its preferred embodiment the two steps are carried out together.

The web or object to be coated may be of conducting or non-conducting material, and may be of any desired surface texture, although it will be understood that the nature of the coating applied will be modified depending on the porosity of the web or object, the relative adhering or wetting nature of the web or object and the coating material for each other; and other factors. Thus, for example, the invention is applicable to the coating of sheet steel with vegetable oil to produce an extremely thin oil coating thereon, to coating paper with a colored or pigmented molten wax for the production of copying paper, or coating of cellophane (regenerated cellulose sheet or film) with a siccative oil or composition for rendering it moisture proof, or the waxing of fruit. Where a non-conducting sheet or object is to be coated, it will be understood that a conducting backing therefor should be provided.

The invention will be described in greater detail in connection with the accompanying drawings wherein a preferred embodiment of the invention is disclosed by way of example, and wherein,

Figure 1 is a side view of a preferred embodiment of the invention,

Figure 2 is a cross sectional view on line II—II of Figure 1,

Figure 3 is a perspective view with parts broken away of a preferred form of atomizer or disperser,

Figure 4 is a partly diagrammatic view of an air pressure transformer for converting rotational motion into a proportional gas pressure,

Figure 5 is a fragmentary view of an air valve controller, and

Figure 6 is a diagram for explaining the operation of the controller shown in Figure 5.

Referring to Figure 1, there is shown a framework or housing 1 constructed of channel members and sheets or the like, and extending from the side walls 2 and 3 are sets of insulator bars 4 and 5 (Figures 1 and 2) which are secured to the side walls 2, 3 in any suitable manner. The insulator bars support metal electrode frames 8 and 9, respectively, which are suitably spaced apart, and each frame supports one or more suitable ionizing electrodes 11 and 12, respectively, which in the preferred embodiment comprise fine wires stretched taut on the frames. However, any suitable construction of ionizing electrodes may be employed, which are connected by frames 8 and 9 and wires 14 and 15 (Figure 2) to one output terminal of a high voltage pack (not shown), the wire 15 passing through the insulator bushing 16 in the end wall 17 of the housing. The other terminal of the high voltage pack is grounded. There is thus applied to the electrodes a sufficiently high electrical potential to produce an ionizing discharge. At the top of the housing is located a hood 18 to which is connected an exhaust duct 19 leading to an exhaust fan (not shown) of any suitable type. The hood is divided from the electrostatic field by a distributor or header baffle 21 which has a series of perforations 22 to distribute the suction action of the hood over the electrostatic field and thus produce a relatively uniform flow of auxiliary air through the field.

A strip 26 of cleaned tinned steel passes below and part way around a grounded idler roll 27 suitably journaled in the housing 1, and the strip passes upwardly through the housing between the electrode frames 8 and 9, and at the top passes between a driver roll 28 and hold down rolls 29, 30, then downwardly to a flying shear and roller leveler (not shown). The strip may also be driven by a drive bridle (not shown) in advance of roller 27.

The apparatus shown is adapted to apply a coating to

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both sides of the strip 26 and includes a pair of induction nozzles 35 and 36 on opposite sides of the strip. However, where coating on only one side of the strip is desired, it will be understood that only one induction nozzle is employed. The induction spouts or nozzles 35 and 36 receive a supply of dispersed particles from dispersion units 37 and 38 adjustably mounted upon adjustable support bars 41a and 42a (Figures 1 and 2). The spouts or nozzles 35, 36 extend in substantially a vertical direction and open upward, so that condensation that occurs within the spouts drips back to the oil supply, and no dripping can occur from the spouts onto the sheet to be coated. As the dispersion units are alike in construction only one will be described in detail.

Referring to Figure 3, the dispersion unit 37 comprises a container 41 of suitable form, such as a box or tank adapted to contain a liquid. Within the tank are one or more vertical tubes 42, suitably supported in a bracket 43, which provides a small aperture at its upper end 44 and has its lower end 45 extending into a sump or trough 46 containing liquid to be atomized. The level of liquid will be maintained at a fairly uniform level below the upper end 44 of tube 42, by manual or automatic replenishing means (not shown), and the space 47 above the liquid level serves as a plenum chamber. An air jet pipe 48 enters the tank 41 and supplies a jet of air at its nozzle end 49 at a suitable pressure across the reduced end 44 of tube 42, whereby a stream of liquid is sucked up into the air jet and is disintegrated or atomized to form a spray. If desired, a heating element 51 of any suitable type may be located in an insulated housing 52 below the sump to maintain a relatively uniform temperature therein and thus keep the liquid at a relatively uniform viscosity. Additional insulation of the walls of chamber 37 may be provided, if desired.

The spray 56 is composed of liquid particles of diverse sizes intermingled with air which imparts to the particles a forward velocity. Preferably, a baffle 58, which may be curved as shown, supported by brackets 59 on the wall of the tank, is interposed in the path of the spray, so that the larger particles in the spray impact against the baffle and are disrupted into finer particles, or condense thereon and drip down into the tank. As a result of the baffling and disrupting action of baffle 58 and the change of direction of flow of the stream in passing into the nozzle 35, the particles which are included in the air stream issuing from the induction nozzle 35 are in the form of a fine mist or fog. By bringing about atomization of the liquid in a plenum chamber, prior to introduction of the dispersion into the electrostatic field, I am able to step down the air velocity issuing into the electrostatic field to reduce or eliminate turbulence therein. The size of the plenum chamber and of the nozzle opening may be varied depending on the pressure gradient desired between the supply pressure and the pressure or velocity of the stream of dispersed particles. The size opening of nozzle 35 to the air volume introduced preferably is such as to provide a substantially non-divergent stream of the dispersed particles passing therethrough as indicated by the dot and dash lines 60 (Figure 1) so as to minimize disruption of the stream issuing from the mouth of the nozzle. This flow is aided by the auxiliary air stream in the electrostatic field induced by exhaust duct 19, which sets up in the field an enveloping, slowly moving stream of air.

While for certain uses the fog thus produced may be carried into the induction nozzles, I prefer to first dilute the fog by an auxiliary air stream which enters the tank 41 by pipe 61 above the liquid level and at a sufficient velocity to agitate and dilute the fog, and assist in a further separation of larger particles. In the preferred embodiment, the air streams in pipes 48 and 61 receive their supply from a common conduit 65 (Figure 6), and are proportioned by suitable manually controlled valves (not shown). Any number of atomizer units desired may be contained within the confining chamber 41, two being em-

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ployed in the embodiment shown. The application or induction nozzle 35 preferably is elongated to about the width of the sheet to be coated, or slightly wider, and if desired, dampers 66 at each end may be provided, the dampers being manually positioned by handles 67 to adjust the width of the fog stream issuing from the spouts. These dampers may be locked in position during operation by any suitable means (not shown). The ionizing zone extends between the ionizing electrodes 11 and 12 and the sheet 26, and it is preferred to have the openings or mouths of the induction spouts 35, 36 located within this zone.

The operation of the apparatus so far described now will be explained. The sheet 26 of tinned steel is driven through the apparatus at a uniform speed. Streams of oil dispersed in air issue from the spouts 35 and 36 at a comparatively low rate of flow and the particles of oil therein are deflected by the electrostatic field and caused to deposit on the moving steel strip. Because of the low velocity of the fog or mist entering the electrostatic field and the substantial absence of turbulent flow between the end of the spout and the deposition area of the moving sheet, the particles are moved uniformly toward the sheet by the electrostatic force, and deposited on the sheet adjacent the edge of the field, as indicated at 70. The dispersity on the sheet depends on the density and velocity of the fog and speed of the sheet. For a given stream of dispersed particles, a higher sheet velocity will cause the particles to be deposited in a more disperse spacing. By employing a plenum chamber in which a reduction of pressure of the stream of dispersed particles occurs I am able to introduce the fog into the electrostatic field at a reduced velocity. As a consequence the electrostatically charged particles flow in a curved stream or wall indicated at 70 (Figure 1) which intersects the strip to be coated near the leading edge of the field, and the particles coming into contact with the strip are held thereon by their own wetting action and by the attractive force of the charge of opposite polarity carried by the strip. Furthermore, in the case of fog particles of a liquid which is a relatively poor conductor, the outer surface of the particles after being deposited may remain charged at the same polarity as the ionizing source, which would assist in repelling any floating particles in the field and would cause such floating particles to be deposited on a portion of the strip not previously coated lying between or adjacent particles already adhering to the strip. In addition the surface charge upon the free surface of such particles will cause the free surface to be attracted to the sheet and thus the droplet will be spread so long as this charge is maintained. Furthermore, the action of the electrostatic field in lowering the surface tension of the liquid particles deposited on the strip assist in causing relatively poor wetting liquids or liquids of relatively good dielectric properties to adhere to and spread over and coalesce on the surface of the strip. Thus there is obtained an extremely thin coating of oil on the tinned strip. In explaining the theory of operation of the apparatus and method, I do not wish to be confined to such theory in claiming my invention.

While ordinarily the strip travels at a uniform rate through the coating machine, there are times, for example, during the automatic welding of the ends of two successive strips in the continuous type strip steel mill, when the travel speed is reduced by about one half. Also when starting or stopping the operation, there is a gradual deceleration or acceleration of the strip. In the preferred embodiment of the invention herein disclosed, I regulate or control the volume rate of flow of the fog blanket issuing from the induction nozzle proportionately with the lineal speed of the steel web, so that a relatively uniform deposition of the particles will be made regardless of variations in the rate of travel of the steel strip. The mechanism by which this is accomplished now will be described.

Referring to Figure 4 there is partly diagrammatically shown a "Transometer" 75 which comprises a vertical shaft carrying a plate 76 which is rotatably driven by horizontal shaft 77 in any suitable manner, and which in turn is suitably driven by a part of the drive mechanism for sheet 26, such as the drive bridle. Plate 76 carries two yokes 81 and 82 in which are pivoted two rocker arms 83 and 84 carrying weights 85 and 86 at their ends. A push rod 87 is suitably supported in the housing 75 and at its lower end carries a collar 88 adapted to be engaged by the ends of rocker arms 83 and 84. At the top of the housing, a diaphragm 90 is suitably secured by a cover 91 to provide a pressure chamber 92 with a port 93 having a conduit 94 connected thereto. Port 93 connects with a passage 95 through the clamped periphery of the diaphragm and terminates in an orifice 96. A nozzle 97 is disposed opposite the orifice 96 and is connected by a suitable flexible coupling 98 to a conduit 99 which supplies to the nozzle a stream of air at a constant pressure. As this apparatus is commercially available a more detailed description of its construction is not required.

The operation of the apparatus so far described in connection with Figure 4 now will be explained. At a given sheet speed air issuing from nozzle 97 will enter orifice 96 and through passage 95 will develop a pressure in chamber 92 and conduit 94. Nozzle 97 will assume a position relative to orifice 96 such that the force of the air pressure in chamber 92 on diaphragm 90 counterbalances the upward thrust on rod 87 due to centrifugal force on weights 85, 86. The pressure in chamber 92 is at all times proportional to the speed of the shaft 77 or strip 26 (Figure 1) and therefore the pressure supplied to conduit 94 is also proportional to the speed of strip 26.

The pressure in conduit 94 is transmitted to the chamber 101 (Figures 5 and 6) under a diaphragm 102 contained within a housing 103, a spring 104 exerting a bias on the diaphragm. A push rod 105 engaging diaphragm 102 engages a lever 106 pivoted at 107, which is urged against a bearing member 108. A threaded rod 109 engages the bearing 108 and by means of a hand wheel 110 thereon, the bearing member can be moved toward or away from the pivot 107 to vary the mechanical advantage of lever 106.

As previously mentioned, the conduit 65 supplies air to the atomizing device illustrated in detail in Figure 3. This conduit contains a valve indicated generally at 115 which embodies a seat or orifice 116 (Figure 5) and a valve closure member 117, the seat and closure being of such form that the flow through the seat is proportional to the position of the closure. The closure is secured to a stem 118 passing through a sealing device 119 of suitable construction and abutting a diaphragm 121 held between the housing 122 and a cover 123. A spring 124 urges the diaphragm 121 upward and urges valve 117 into closed position. A conduit 125 supplies a constant pressure flow which is conducted by a conduit 126 to pressure chamber 127 and tends to oppose spring 124 to open valve 115.

The housing 128 which receives the conduit 125 provides a bleed orifice 131 (Figure 6) by which air is bled to the atmosphere and a closure 132 secured to lever 133 pivoted at 134 controls the bleed therethrough. Lever 133 and closure 132 are urged to open position by a spring 135, and a spring ferrule 136 is secured to a bar 137 which in turn is secured to valve rod 118. The lever 133 is urged by spring 135 into engagement with bearing member 108. A finger wheel 138 permits manual adjustment of spring 135.

The operation of the control apparatus now will be described. Assuming the sheet 26 is moving at a constant speed, the pressure in chamber 92 (Figure 4) and in conduit 94 is constant and is proportional to the speed

of sheet 26. Under influence of the pressure in chamber 101 conducted thereto by conduit 94, the diaphragm 102 will take up a position of balance determined by the pressure in chamber 101 opposed by the bias of spring 135 which in turn depends on the position of valve rod 118 and valve 115. The position of closure 132 relative to orifice 131 will similarly be established by these two conditions. Under conditions of fixed bleed at orifice 131 the pressure in chamber 127 will determine the position of valve 115 and thus determine the rate of flow of air through conduit 65 to the pipes 61 and 48. When the sheet 26 assumes a lower speed, the change in centrifugal force on weights 85 and 86 causes them to move inward and allows nozzle 97 to take up a new position of balance with orifice 96 so that the pressure in chamber 92, conduit 94 and chamber 101 drops to a different value. This allows spring 135 to pivot lever 133 downward to move closure 132 further from orifice 131 to allow a greater bleed therethrough, which results in a reduction of loading pressure in chamber 127 and a further restriction of valve 115 to reduce the flow of air through conduit 65 to the atomizing device. Valve 115 under such conditions will reach a new position of balance in which the flow of air to the atomizing device 37 is proportional to the new speed of sheet 26. When speed of sheet 26 increases, an action reverse to that above described will again establish the proper relation between the speed of the sheet and the flow of air to the atomizing device. By correlating the flow of air to the atomizing device with the speed of the sheet, the flow of atomized material issuing from nozzle 35 is likewise correlated or proportioned to the sheet speed to obtain a consistently uniform deposit of material independent of the sheet speed.

Various modifications may be made in the invention described without departing from the spirit or scope thereof.

I claim:

1. An apparatus comprising, means for moving an object to be coated, ionizing means in proximity to at least one surface of said object, means for producing a dispersion of liquid particles in a gas stream, a conduit for introducing a stream of dispersed particles between said object and ionizing means, said conduit terminating in the ion path between the ionizing means and object to release said stream in the ion path, and means coordinating the rate of flow of said stream of dispersed particles with the speed of said object.

2. An apparatus comprising means for moving an object presenting a surface to be coated, electrostatic ionizing means in proximity to said surface, means for introducing finely divided material into the electrostatic field for deposit upon said surface, and means coordinating the speed of said surface and rate of flow of said finely divided material.

3. An apparatus comprising means for moving an object presenting a surface to be coated, gas atomizing means for producing a suspension of finely divided particles in a gas stream, a gas conduit for supplying gas to said atomizing means, valve means in said conduit to control the flow of gas in predetermined relation to the position of the valve thereof, a gas pressure control chamber for said valve, and means responsive to the speed of said surface to control the pressure in said control chamber.

4. An apparatus comprising means for moving an object presenting a surface to be coated, gas atomizing means for producing a suspension of finely divided particles in a gas stream, a gas source for supplying gas to said atomizing means, valve means in said source to control the flow of gas in predetermined relation to the position of the valve thereof, a gas pressure control chamber for said valve having a bleed therefrom, means connected to said valve to vary said bleed, and means

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responsive to the speed of said surface and connected to said last named means to vary said bleed.

5. An apparatus comprising, means for moving an object to be coated, ionizing means in proximity to at least one surface of said object for producing and moving ions in a path toward said surface, means for producing a dispersion of liquid particles in a gas, a container surrounding said dispersion-producing means, an induction nozzle extending from said container into said ion path, said container and nozzle being of electrically conducting material and serving to electrically shield said dispersion as it is produced and conducted in the gas stream from the container to the ion path.

6. In an electrostatic coating apparatus in which electrically charged particles of liquid coating material in a coating zone are electrostatically deposited on the surface of an object passing through such coating zone, means for moving the object through the coating zone, coating-material supply means, a high-voltage source for creating electrical charges of opposite signs on the object and coating material particles, and a control device responsive to the rate of movement of said object through the coating zone and controlling said supply means to maintain a predetermined ratio between the speed of said surface and the rate of coating-material supply.

7. In an electrostatic coating apparatus in which elec-

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trically charged particles of liquid coating material in a coating zone are electrostatically deposited on the surface of an object passing through such coating zone, means for moving the object through the coating zone, coating-material supply means having a discharge orifice, a high-voltage source for creating electrical charges of opposite signs on the object and coating material particles, and a control device controlling said supply means and coordinating with the speed of said surface both the velocity and quantity-rate at which coating material is discharged through said orifice.

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