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APPARATUS FOR ELECTROSTATIC ATOMIZATION AND COATING

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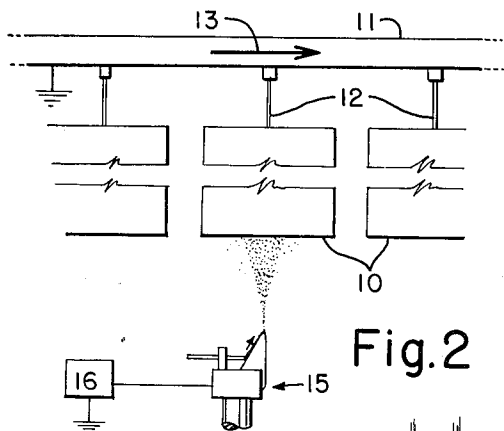


Fig. 2

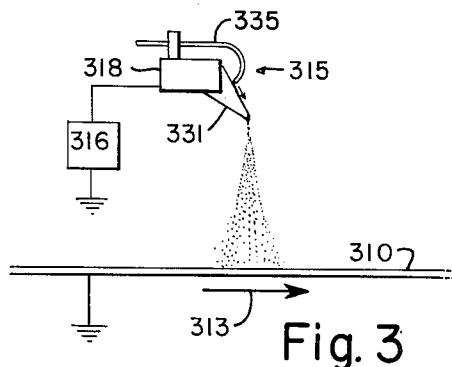


Fig. 3

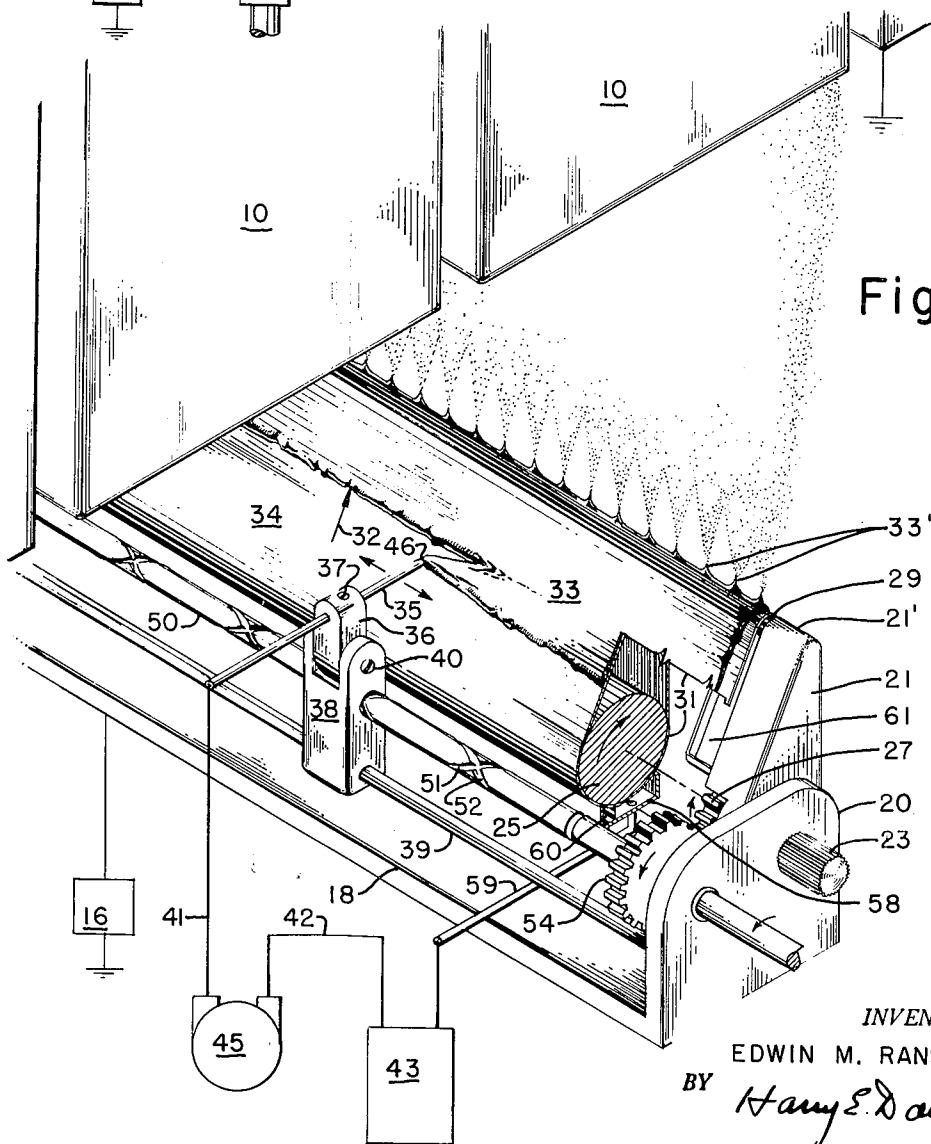


Fig. 1

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APPARATUS FOR ELECTROSTATIC ATOMIZATION AND COATING

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This invention relates generally to improvements in methods of and apparatus for effecting electrostatic atomization of liquids and especially to novel electrostatic atomizing methods and apparatus adapted for use in coating articles.

One object of the present invention is to obtain improved control of liquid material presented at a site of atomization.

Another object of the present invention is to provide novel method and apparatus adapted for electrostatically coating downwardly presented surfaces.

The above and other objects and advantages will appear more fully from the following detailed description, along with the accompanying drawings:

Fig. 1 is an isometric view partly in section showing apparatus embodying the invention as utilized in coating the bottom surface portions of a plurality of articles;

Fig. 2 is a side view of the apparatus shown in Fig. 1 and additionally shows the manner of supporting articles to be coated;

Fig. 3 is a side view of a modified form of my invention.

Referring to the drawing, articles 10 illustrated as cabinets are supported from conveyor 11 by article supports 12 and are moved by the conveyor in the direction of the arrow 13 over a predetermined path past and in spaced relation to an electrostatic atomizer 15. Electrostatically atomized liquid coating particles are discharged from the atomizer 15 for being deposited on the articles 10 as they move by the atomizer.

To effect electrostatic atomization and dispersion of liquid coating material and electrostatic deposition thereof on the articles 10, an electrostatic field of appropriate strength is maintained between the atomizer 15 and the articles 10. For this purpose the articles 10 may be grounded in any suitable manner and the atomizer 15 insulated from ground and connected to the ungrounded terminal of a high-voltage source 16 in the manner shown in Fig. 1.

The atomizer 15 comprises a supporting structure 18 provided with brackets 20. The structure 18 may be insulated from ground in any suitable manner. Wedge shaped end members 21 provided with threaded studs (not shown) are adjustably mounted on the brackets 20 so that they may be held in any desired fixed position by means of knurled nuts 23. A roller 25 is rotatably mounted in a suitable manner on the members 21. A gear 27 is fixedly connected to the roller so that, upon being driven, the roller 25 will rotate therewith. The manner of driving the gear 27 will be described hereafter. Above the roller 25 there is provided an idling roller 29 which is rotatably mounted on the members 21 near their apexes. An endless, flexible discharge member 31 desirably of electrical conducting material such as metal foil or conducting rubber is mounted on the rollers 25 and 29 and is adapted to move with and over them in the direction indicated by the arrow 32 when

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the roller 25 is driven to present a liquid film 33 distributed on surface 34 of the discharge member 31 to the site of atomization which is adjacent the roller 29 and in opposed spaced relation to the articles being coated.

The liquid coating material supplied to the surface 34 is distributed in the form of thin film 33 on such surface between more or less definite limits. To this end, the liquid-supporting surface 34 of the discharge member 31 is arranged at the most suitable angle of inclination to achieve this purpose. Although the film can be created and maintained by any suitable means, the coating material supply means shown comprises a reciprocating pipe 35 which is slidably mounted on block 36 and can be fixed by adjustment screw 37 in any desired position relative to the block 36 so that the pipe 35 is either in sliding engagement with the discharge member 31 or is spaced therefrom. The block 36 is adjustably mounted on the carriage 38 which in turn is slidably mounted on the rail 39. The block 36 may be held in any desired fixed position relative to the carriage 38 by means of adjustment screw 40.

One end of the pipe 35 is connected through a flexible hose indicated diagrammatically by lines 41 and 42 with a source of coating material in tank 43. A pump 45 provided between hoses 41 and 42 is adapted to positively supply the liquid coating material from the tank 43 to the pipe 35. The free end of the pipe 35 is provided with a suitable orifice 46 disposed adjacent the discharge member 31 and rearwardly from the site of atomization for supplying coating material to the surface of the discharge member 31 for distribution thereon in the form of film 33.

The means employed to reciprocate the pipe 35 may take various forms. In Fig. 1 such means is shown as comprising a cylindrical cam 50 with threads 51 and 52 which is rotatably mounted in the brackets 20. One end of the cylindrical cam 50 is adapted to be connected to a suitable motor (not shown) for rotating the cam 50. The carriage which is slidably mounted on the guide rail 39 includes a key (not shown) adapted to follow the threads 51 and 52 of the cam 50. As the cam 50 is rotated it reciprocates the carriage 38 and therewith the pipe 35 to distribute liquid on the discharge member 31 generally transverse to the direction of movement of the discharge member. The threads 51 and 52 in the cam 50 are of constant pitch so that the pipe 35 is reciprocated with a generally uniform rate of speed. If it is desired to vary this rate of speed, the threads 51 and 52 in cam 50 should be of variable pitch. The speed of reciprocation of the pipe 35 and the movement of the discharge member 31 are desirably coordinated with the angle of inclination of the discharge member 31 to effect the distribution of the liquid supplied to the member 31 in the form of film 33 prior to its presentation at the site of atomization.

At one end of the cylindrical cam 50 there is affixed a gear 54 which is arranged in driving engagement with the gear 27. Upon rotation of the cam 50 this train of gears drives roller 25 to move the discharge member 31 in the manner previously mentioned.

The atomizer 15 is provided with a trough 58 immediately below that portion of the discharge member 31 underneath the roller 25 to capture any liquid dropping from the discharge member. The trough 58 is inclined downwardly toward pipe 59 which connects the trough 58 with the paint tank 43 to which the captured liquid is returned. At this trough 58 there is provided a cleaning element 60 adjacent to and in engaging relation with the discharge member 31 for cleaning the surface 34 prior to the application of more liquid. Additionally, drain troughs 61 are provided at the opposite sides of

the discharge member 31 which are also connected with the tank 43 by pipes not shown. These troughs also serve to capture liquid dropping from the discharge member 31 and return it to the tank 43.

Considering the operation of the apparatus described, the articles 10 to be coated are moved past the atomizer 15 by the conveyor 11 and coating material supplied from the tank 43 by means of pump 45 to the reciprocating pipe 35 at a rate consistent with the conveyor speed is distributed over the surface 34 of the moving discharge member 31 generally transverse to its direction of movement. The force applied to the liquid by the reciprocation of the pipe 35 alone or in cooperation with the force of gravity spreads the liquid coating material applied to the discharge member 31 into thin film 33 on the surface 34 so that when it arrives at the site of atomization the potential gradient forms a series of cusps 33' and electrostatically atomizes the liquid from the tips of such cusps. The charged, atomized particles are then deposited on the articles 10 by the force of attraction between the charged liquid particles and the oppositely charged articles 10.

The radius of curvature of the discharge member 31 at the site of atomization should be sufficiently small so that the potential gradient adjacent the discharge member is adequate to perform its function of cusp formation and atomization. In practice it has been found that this radius of curvature should be less than one-quarter the distance between the surface being coated and the discharge member and desirably is made as small as structural characteristics permit. Also in practice it has been found that the voltage produced by the voltage source 16 in kilovolts and the radius of curvature of the member 31 at the site of atomization should be such that their ratio is greater than twenty kilovolts per inch and preferably is several or even many times that value. As either of the two ratios are approached atomization becomes coarse and uneven and the resultant coating is unsatisfactory.

In order to secure a spray pattern of maximum uniformity it is essential that the coating material be distributed uniformly to all points of the discharge member 31 at the site of atomization. This may be accomplished by properly coordinating the speed of movement of the discharge member, the rate of reciprocation of the pipe 35, the angle of inclination of the discharge member 31, and the distance between the pipe 35 and the site of atomization. However, satisfactory coatings can be produced even though these optimum conditions do not obtain.

Generally speaking, it is advisable that the breadth of the wetted surface of the discharge member 31 approximate the parallel dimensions of the surface or surfaces to be coated, although this breadth may, in many instances, be somewhat less than the parallel dimensions of such surface or surfaces without causing undue lack of uniformity in the coated product because of the dispersion the atomized particles undergo in moving toward such surface or surfaces. In many instances where, in addition, it is desired to apply some material to side surfaces of the articles, such as the side surfaces of articles 10 which are presented edge-wise to the atomizer 15, it will be advisable to space articles 10 sufficiently far apart to avoid electrical shielding and to employ a discharge member 31 having a wetted breadth greater than would be required for the application of a coating to the downwardly presented surface or surfaces alone.

To prevent a concentration of field strength at the opposite ends of the line of cusps on the discharge member 31, the atomizer 15 may include end members 21 of conducting material which are positioned adjacent the opposite edges of the discharge member 31 and project laterally therebeyond. Immediately adjacent the opposite edges of the discharge member 31 the end members 21 have a cross section corresponding to that of

the discharge member and outwardly beyond the forward edges of the discharge member the exposed edges of the end members 21 are rounded off as indicated at 21'.

Whatever other conditions obtain in the operation of the apparatus of Figs. 1 and 2, the rate of movement of the discharge member 31 must of course be greater than the rate at which the liquid material tends to run downwardly along such member under the influence of gravity so that an adequate supply of material at the site of atomization will always be maintained. The ability of apparatus embodying my invention to control or modify the effect of gravity on liquid supported on an inclined surface may have value in situations other than those in which the liquid is to be atomized upwardly. Thus, when it is desired to coat an upwardly presented surface, the arrangement shown in Fig. 3 may be utilized. In that arrangement sheet material 310 mounted on suitable rollers (not shown) is moved past the atomizer 315 in the direction of the arrow 313. The atomizer 315 is of similar construction to the atomizer shown in Figs. 1 and 2 except that the discharge member 331 is mounted on the supporting structure 318 in such a manner that it moves over a downwardly inclined path between the pipe 335 and the site of atomization adjacent the idling roller (not shown). As will be clear, the coating material is supplied to the discharge member 331 in the form of a film by means of a reciprocating pipe 335 and by means of the movement of the discharge member 331 the leading edge of the liquid film is presented at the site of atomization where the field adjacent the discharge member 331 forms a series of cusps along such leading edge from the tips of which liquid is electrostatically atomized, dispersed and deposited on the sheet 310. The field is established by connecting the ungrounded terminal of the voltage source 316 to the insulated supporting structure 318 and by grounding the sheet 310 as shown.

The voltage sources 16 and 316 utilized may provide full-wave or half-wave rectification or provide unrectified A. C. In general, the steadier the potential employed the better defined will the deposited pattern be and the more uniform and satisfactory will be the degree of atomization. The effectiveness of the electrostatic field in causing atomization and in promoting deposition of atomized material will vary in the same sense as the applied voltage, and it is therefore desirable in most instances to use voltages approaching the highest voltage consistent with freedom from possible sparking. Voltages which create between the atomizer and the article an average potential gradient of 8,000 to 10,000 volts per inch are very satisfactory. In most instances, I prefer to space the discharge member at about 10" from the surface being coated and to employ a potential of about 100,000 volts.

The invention can be practiced without reference to the polarity of the potential maintained on the discharge member or article. In coating, either the discharge member or the article can be grounded; but in most instances, it will be more convenient to ground the article. However, any arrangement which results in maintaining a sufficient potential difference between the article and coating material will be satisfactory. Articles of an insulating character can in many instances be coated without the necessity for a backing electrode so long as the surfaces are maintained at a different potential from the atomized material.

It is not essential that the discharge member or even that portion of it which supports the liquid film be made of conducting material. Most liquids, and especially most coating materials, are sufficiently conducting that if the discharge member is made of insulating material the potential can be applied to the film-edge through the film itself. Moreover the current consumed in the atomizing operation is so small that it can be conducted to the sur-

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face of the discharge member through materials of relatively high insulating properties. The degree of conductivity of the liquid material likewise determines how great the electrical losses will be along the liquid supply line 41, 42. If the liquid material has high conducting properties, the entire liquid supply system including the lines 41 and 42, tank 43 and pump 45 must be insulated. If, however, the liquid material has good insulating properties it may be only necessary to insulate the atomizer itself.

Fine atomization is promoted by moving the discharge member over a path having a small radius of curvature at the site of atomization. In addition to the radius of curvature of the discharge member, the applied voltage and the rate of liquid flow influences the fineness of atomization. Increasing the applied voltage tends to increase the fineness of atomization, while an increase in the rate of fluid flow tends to decrease it. Obviously the liquid should not flow to the site of atomization at a rate greater than that at which it will be electrostatically atomized therefrom.

While I have described the invention above as embodied in coating apparatus, it is to be understood that in its broader aspects the invention extends to the atomizing method and apparatus alone without regard to whether the atomized liquid is deposited electrostatically or otherwise to coat an article. When used as an atomizer, satisfactory atomization may be obtained from the discharge member at the site of atomization by impressing on the discharge member and the liquid supported thereby an appropriate potential with reference to its surrounding. On way of obtaining the necessary potential gradient at the surface of the discharge member at the site of atomization is to connect the discharge member and the liquid it supports to the ungrounded terminal of a high-voltage source, the other terminal of which is grounded. In such an arrangement, satisfactory atomization has been obtained with a voltage source of 100,000 volt output, but voltages as low as 10,000 volts have been used.

I claim as my invention:

1. In an electrostatic atomizer, an endless flexible member provided with a liquid-supporting surface and movable alternately over a rectilinear path portion and a curved path portion, means adjacent said member to provide on the rectilinear path portion a film of liquid material to be supported by the liquid-supporting surface, means including a high-voltage source for maintaining an electrostatic field over the surface of said film at and ad-

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jacent the curved path portion, the curvature of the member and the supported film at the curved path portion being sufficient to increase the potential gradient of the field at the curved path portion to a value at which the field is capable of electrostatically atomizing the liquid material from said curved path portion.

2. An atomizer as described in claim 1 with the addition that the voltage in kilovolts produced by said high-voltage source and the radius of said curved path portion are such that their ratio is greater than twenty kilovolts per inch.

3. In combination with an atomizer as described in claim 1, a conveyor for conveying articles to be coated past and in opposed spaced relation to said curved path portion, said high-voltage source having its opposite terminals connected respectively to the atomizer and the conveyor whereby such electrostatic field will exist between the articles and said curved path portion and will cause the atomized liquid material to be electrostatically deposited on the articles.

4. The combination described in claim 3 with the addition that the voltage in kilovolts produced by said high-voltage source and the radius of said curved path portion are such that their ratio is greater than twenty kilovolts per inch.

5. The combination described in claim 3 with the addition that said conveyor conveys the articles along a predetermined path disposed above the atomizer, the curved path portion of said liquid supporting surface constituting the highest portion of the endless flexible member.

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