ELECTROSTATIC ATOMIZER OF LIQUIDS

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

INVENTOR.
MERTON R. MILLER

ATTORNEY
ELECTROSTATIC ATOMIZER OF LIQUIDS

Merton R. Miller, Indianapolis, Ind., assignor to Ransburg Electro-Coating Corp., Indianapolis, Ind., a corporation of Indiana

Application June 24, 1959, Serial No. 170,188

11 Claims. (Cl. 118—51)

This invention relates generally to an electrostatic atomizer and more particularly to an atomizer capable of electrostatically atomizing liquids to produce a jet or spray having an elongated cross-section. It has heretofore been proposed to produce a jet or spray of elongated cross-section by electrostatically atomizing liquid emerging from an elongated orifice or a series of circular orifices, but difficulty has been encountered in maintaining a satisfactorily uniform distribution along the extent of an elongated orifice or among the several orifices arranged in a row. Such difficulty at least in part from the fact that the low rate at which a liquid can be electrostatically atomized necessitates orifices of small cross-sectional area and low rates of flow through such orifices, and clogging of the orifice therefore occurs frequently.

It has likewise been proposed to atomize a liquid from the edge of a free-surfaced supported liquid film, but the uniform distribution of liquid required to maintain such a film involves difficulties of much the same type as those mentioned above. A single feed nozzle reciprocating along a film-supporting surface parallel to the film-edge from which atomization takes place, may avoid the danger of clogging; but in many instances it is difficult to move such a nozzle in a manner which will result in a uniform distribution of liquid in the film. The dwell of such a nozzle at the opposite ends of its reciprocating path causes excess material to be delivered to those portions of the film-supporting surface opposite such ends. Further, the stopping of a reciprocating structure may jar the entire atomizer and cause a non-uniform distribution of material in the film which results in non-uniform atomization.

One object of the present invention is to produce an elongated spray pattern in which the particles are uniformly dispersed.

A further object of the present invention is to provide novel electrostatic atomizing apparatus which is simple in construction, the liquid passages of which may be maintained relatively free of obstructions and which combines the liquid distributing means and the liquid atomizing means in a unitary structure.

Another object of the present invention is to provide novel electrostatic atomizing apparatus in which liquid is supplied uniformly without undesirable ripple and concentrations.

Other objects and advantages will become apparent in the following description and from the accompanying drawings in which:

Fig. 1 is an isometric view partly in section illustrating an electrostatic atomizer;
Fig. 2 is an isometric view partly in section illustrating another embodiment of electrostatic atomizer;
Figs. 3, 4, 5 and 6 are schematic developments illustrating different types of ducts in both the discharge member and the distributing member and different arrangements of the respective ducts for each other;
Fig. 7 is an end elevation view and Fig. 8 is a side view partly in section illustrating different applications of the electrostatic atomizer.

In practice of the invention, there is provided a discharge member, a source of liquid and a distributing member for transferring the liquid from the liquid source to the discharge member for atomization therefrom. The distributing member may include a duct or series of ducts and a discharge portion for receiving liquid from the duct or ducts and presenting it to an atomizing electrostatic field. Desirably a liquid supporting surface is provided between the duct or ducts and the discharge portion so that the liquid will flow to the site of atomization as a supported free-surfaced film.

The distributing member may be movably mounted adjacent the discharge member and may be in the form of a duct or series of ducts extending along a line preferably helical in form at the surface of the rotor. The duct or ducts in the rotor are operatively associated with the liquid source and upon the rotation of the rotor, the duct or ducts of the rotor are brought into registry with the duct or ducts of the discharge member to form a port or ports of liquid discharge whereby the liquid is transferred to the discharge portion where it is presented to an electrostatic field for atomization thereby.

Now referring to the drawings and more particularly to Fig. 1, there is shown through embodiment of an electrostatic atomizer 10, constructed in accordance with my invention. This atomizer 10 comprises a discharge member 12, a distributing member 14, a motor 16 and a high voltage source 18.

The discharge member 12, as shown, is generally cylindrical in shape and is provided with an elongated internal cavity 20, a duct 22 in the form of an elongated slot communicating with the cavity 20 and a liquid supporting surface 24 aligned with the lower end of the slot 22 and extending outwardly and terminating in an elongated discharge portion 26, which is shown as a narrow edge. The opposite ends of the discharge member 12 are closed by sealed bearing plates 28 and 30. Discharge member 12 is adapted to be supported at any desired position by a suitable insulating structure which is not shown in Fig. 1 but one example of which is shown as 266 in Fig. 7. The discharge member 12 is connected to the ungrounded terminal of the high voltage source 18 by a conductor 32 for establishing a high gradient electrostatic field adjacent the edge 26.

The distributing member 14, which in this embodiment is shown as an elongated rotor, is provided with an axial liquid passage 34, and one or more radial holes 36 of circular cross-section communicating with the passage 34 and opening into an elongated helical groove 38 on the outer surface of the rotor. At least adjacent the slot 22, the outer surface of the rotor and the inner surface of the cavity 20 interengage in sealing relation, so that the liquid transfer to the discharge member 12 is limited only to the port of liquid discharge which is formed by the intersection of the slot 22 and the groove 38. The rotor 14 is rotatably mounted in the bearing plates 28 and 30 and is driven by an air motor 16 through worm 42 and worm wheel 44. The air motor is mounted on bracket 46 which is affixed to bearing plate 28 and is provided with compressed air from a suitable source through flexible insulating pipe 48. Liquid is supplied to the atomizer 10 from a suitable source through a flexible insulated hose 50 which feeds the liquid directly to the liquid passage 34 which extends to the liquid intake by means of a pump, by means of air pressure within a liquid storage tank or by gravity.

In operation of the insulated atomizer 10, the discharge member 12 is connected to the high voltage source 18 for establishing adjacent the discharge edge 26 a field of high potential gradient, the rotor 14 is rotated by the motor 16, and liquid is applied to the rotor through the pipe 50. Assuming the liquid disposed of in the rotor is rotated in a clockwise direction when viewed from the left side of the drawing, the port of liquid discharge formed by the intersection of the slot 22 and the groove 38 moves at a uniform speed from right to left along the liquid supporting surface 24. By the time the port of the discharge member has finished its sweep from right to left for transferring liquid to the liquid supporting surface 24 of the discharge member, the rotation of the rotor has brought the right end of the groove 38 into registry with the right end of slot 22 to form another port of
liquid discharge to sweep from right to left along the liquid supporting surface as the rotor continues to rotate. It will be seen that as the rotor is rotating, liquid will be transferred uniformly to the liquid supporting surface 24 of the discharge member progressively along its length. The discharge member is arranged so that liquid supporting surface 24 is inclined downwardly toward the discharge edge 26 to permit the liquid to flow over it to the discharge edge 26 from where it is collected and is dispersed into space by the high gradient field adjacent to the edge 26. The atomized liquid may be utilized for any desired purpose. Two such purposes are described in connection with Figs. 3-6 which illustrate coating apparatus and air treating apparatus, respectively.

The volume of liquid delivered by the atomizer per unit of time may be regulated by providing suitable means for controlling the rate of liquid supply from the pipe to the atomizer. The constancy of the supply of the liquid to the discharge edge is effected by the repetition rate of traversal of the port of liquid discharge along the liquid supporting surface 24.

In general, the constancy of supply of liquid to the atomizing edge 26 of the discharge member 12 has a tendency of improving as the repetition rate of traversal of the port of liquid discharge is increased. Rates in the neighborhood of one or two traversals per second are considered adequate; however, these rates may be critical. The rate of traversal of port of liquid discharge may be increased by increasing the speed of the rotor 14, by increasing the number of grooves 38 in the surface of the rotor, or by increasing both the speed and the number of grooves 38 on the rotor. For optimum uniformity of liquid distribution with a rotor having a plurality of grooves, such grooves should be so arranged that upon completion of traversal of the port of liquid discharge formed by the registry of one groove with the slot 22, simultaneously another port of liquid discharge is formed by the registry of the immediately succeeding groove with the opposite end of the rotor 14 to make the next complete traversal. In most instances, it is not desirable to use rotors with a groove pitch of which is such that it makes more than one revolution around the rotor from end to end. When a groove occupying more than one revolution is brought into registry with the slot in the discharge member, it forms simultaneously multiple parallel ports of liquid discharge. It is difficult to maintain equality of liquid impedance in such parallel ports of liquid discharge, and without equal liquid impedance in each such port of liquid discharge it is difficult to obtain uniform distribution of liquid.

The electrostatic atomizer shown in Fig. 2 is another embodiment of an atomizer constructed in accordance with my invention. In this embodiment, atomizer 210 comprises 212 and distributing member 214 which is in the form of a rotor. The discharge member 212 is similar in construction to the discharge member 12 illustrated in Fig. 1 except that additional liquid is supplied with liquid in any suitable manner from a source (not shown). This passage 222 extends along cavity 220 of discharge member 212 and diametrically opposite to slot 232 of this discharge member. The rotor 214 is similar to rotor 14 illustrated in Fig. 1 except that the radial duct 36 and axial liquid passage 34 are omitted.

In the operation of the atomizer 210 illustrated in Fig. 2, liquid is fed to passage 222 from a suitable source. Upon the rotation of the rotor 214 in a clockwise direction as viewed from the left hand side of the drawing, one portion of the groove 238 is brought into registry with the liquid passage 222 and another portion of the same groove 238 is brought into registry with the slot 222 for transferring liquid from the passage 222 to the slot 222 where it is distributed on the liquid supporting surface 224 of the rotor 214. Liquid flow in the form of droplets 226, where it is electrostatically atomized. Reference is made to the application of Edwin M. Ransburg, et al. Serial No. 155,892, filed April 14, 1950, which claims specific details of the features of the atomizer illustrated in Fig. 2 and which has just been described.

The broader aspects of that atomizer are within the scope of my invention and are being claimed herein. The atomizer described may vary in the type of ducts formed in both the discharge member and the rotor and the relative arrangement of the ducts in the discharge member and the rotor. Referring to Figs. 3-6 inclusive, there are illustrated schematic developments embodying different types of ducts in both the rotor as provided with different possible arrangements of these ducts relative to each other. In these figures, the ducts or discharge of the discharge member are shown in full lines as extending horizontally and the ducts of the rotor are shown in dotted lines, their relative arrangements in the development reflecting their helical distribution in the rotor surface.

Fig. 3 shows the duct arrangement previously described, the duct in the discharge member being an axially extending slot 322, and the duct in the rotor being the helical groove 338. The angle between groove 358 and slot 322 depends on the pitch of groove 358. As the rotor is moved downwardly (which corresponds to clockwise movement) the point of registry (indicated by stippling) of the groove 358 with the slot 322 shifts transversely from right to left during the movement of the rotor.

Fig. 4 also shows the discharge member duct as an elongated slot 422, while the rotor is provided with a series of radial ducts 458 of circular cross section distributed in a horizontal line and the rotor ducts provided with a series of grooves 458 at an angle to the horizontally arranged ducts 422. As the rotor surface is moved downwardly, different ports of the groove 458 are brought into registry with different successive ducts 422 from right to left to form a series of liquid discharge.

Fig. 5 shows the discharge member as provided with a series of ducts 522 of circular cross-section distributed in a horizontal line and the rotor ducts provided with a series of grooves 538 at an angle to the horizontally arranged ducts 522. As the rotor surface is moved downwardly, different portions of the groove 538 are brought into registry with different successive ducts 422 from right to left to form a series of liquid discharge.

Fig. 6 shows the discharge member as provided with a series of ducts 622 of circular cross-section distributed in a horizontal line and the rotor ducts provided with a series of grooves 638 of circular cross-section of the same size as that of ducts 622 and distributed in a line at an angle to the horizontally distributed ducts 622. As the rotor surface is moved downwardly, different successive ducts 638 from right to left are brought into registry with corresponding successive ducts 422 from right to left to form a shifting port of liquid discharge with each registry of corresponding ducts 422 and 638.

Fig. 7 illustrates a manner in which the atomizers previously described may be utilized in coating apparatus. In this apparatus, the article 769 on support 765 over a predetermined path and in spaced relation to the atomizer 10 suitably supported on bracket 766 made of insulating material. In operation, liquid is distributed in the form of a droplet to the discharge edge 26. Under the influence of the high potential gradient which exists at the discharge edge the liquid is atomized to form a cloud of finely divided charged particles in front of the atomizer. These particles are to be coated being grounded as through the conveyor 764 or otherwise maintained at a potential different from that of the charged particles, will attract the particles to their surface where they will deposit it to form a protective or decorative coating.

Fig. 8 illustrates the utilization of the atomizer 210 for treating air. There is shown a conduit 860 through which air is forced in the direction of the arrow 762 which is mounted and electrically connected to the high voltage source to discharge into the conduit 860 an atomized spray of liquid, for example, a bactericide for treating air moving therethrough.

The liquid used in the atomizers may be either of an electrical insulating or an electrical conducting character. The degree of conductivity of the liquid material determines how great the electrical losses will be among the conducting properties the entire liquid supply system must be insulated. If, however, liquid material has good insulating properties, it may be only necessary to insulate the atomizer features. Where the liquid has good insulating properties, the atomizer should be of conducting material. However, most liquids are sufficiently conductive that if the atomizer is made of insulating material the necessary potential gradient will still be established at the discharge edge by virtue of the conductivity of the liquid.
While the present invention is, of course, not restricted to the design of any particular atomizer or to any particular use of the atomizer, satisfactory results may be obtained in coating sheet steel plates 16 inches wide by apparatus illustrated in Fig. 7 and constructed and arranged in accordance with the following conditions:

Discharge member 12. Steel.
Discharge edge 26. Rounded at its edge to a radius of .005 inch, 16 inches long and adjustable at a 30 degree angle to the horizontal with its longitudinal axis.

Cavity 20. 1 inch in diameter and 16 inches long.
Slot 22. ¼ inch wide and 15 inches long.
Supporting surface 24. Sloped downwardly toward the discharge edge 26 and transverse thereto at an angle of 30 degrees to the horizontal.

Diameter of hole 36. ¼ inch.
Groove 38. ⅜ inch deep, ⅜ inch wide, 15 inch pitch, and one full turn and article 760. Potential of discharge 100,000 volts (negative).

Rate of rotation of distributing member 14. 2 revolutions per second.

Liquid coating material. Synthetic enamel, modified urea formaldehyde 20 secs. viscosity Zahn No. 2 cup, 75 degrees F.

In coating, either the atomizer or the article to be coated may be grounded or both may be maintained at a potential different from ground; but, in most instances, it will be more convenient to ground the article. However, any arrangement for insulating the coating material and which attracts the coating material to the article will be satisfactory. Any atomizer embodying my invention can be used otherwise than in the application of liquid coatings. In such other uses, atomizer may be supported spaced and insulated from grounded objects and connected to one terminal of a high-voltage source whose other terminal is grounded. In such use, it is unnecessary to provide any electrode (analogous to the articles in a coating process in space relation to the atomizer and of opposite electrical polarity thereto). The direction of such an opposed electrode, however, and raising it to a sufficient potential, atomization can be effected even with the coating material grounded.

From the foregoing, it will be evident that the present invention provides a novel means for distributing liquid uniformly and under controlled conditions for electrosed coating. The apparatus is simple in construction and may be easily cleaned and maintained in an operative condition.

What I claim is:

1. In an electrostatic atomizer, a discharge member, a distributing member, means for supplying liquid to said distributing member, and said distributing member, said members having interengaging sealing surfaces, said distributing member being movable to cause its sealing surface to move over the sealing surface of the discharge member, means for moving the distributing member, said distributing and discharge members respectively having inner and outer liquid-conveying ducts opening into the respective sealing surfaces for registry with each other, the openings of the inner and outer ducts being distributed in their respective surfaces along lines making different angles with the direction of relative motion of said sealing surfaces as said distributing member moves, and means for creating an electrostatic field for electrosed coating and interengaging sealing surfaces being whereby the position at which the inner and outer ducts register will shift transversely to the direction of relative motion of said sealing surfaces as said distributing member moves, and means for creating an electrostatic field for electrosed coating the liquid supplied to said discharge member.

2. In motorized atomizer 10 forth with in claim 1 with the addition that said discharge member being provided with a cylindrical cavity, said distributing member being cylindrical and received in such cavity.
the sealing surface of the discharge member, means for so rotating the distributing member, said distributing and discharge members having liquid-conveying ducts opening into their respective sealing surfaces for registry with each other, the openings of said ducts being distributed on their respective surfaces along intersecting lines for transferring liquid from the distributing member to the discharge member, whereby the point of intersection of said lines will shift axially of the distributing member as such member rotates, said discharge member having a blade-like liquid supporting element terminating in an extended discharge portion, said liquid supporting element being positioned and arranged to receive liquid discharged from the registering ducts and to spread such liquid into an extended thin film flowing to the discharge portion for atomization, and means including a high voltage source for establishing the liquid on said discharge member as one terminus of an electrostatic field of sufficient potential gradient to electrostatically atomize and disperse the liquid into a spray.

9. In an electrostatic apparatus for atomizing liquid material, an elongated lip-like discharge member, means for maintaining on said discharge member a thin film of liquid extending in the direction of elongation of said discharge member, said means including a cylindrical feed member mounted for rotation about its longitudinal axis lying parallel to the extent of said discharge member for supplying liquid to said elongated discharge member, and means including a high voltage source for establishing the liquid on said discharge member as one terminus of an electrostatic field of sufficient potential gradient to electrostatically atomize and disperse the liquid into a spray.

10. The apparatus of claim 6 including means for conveying a plurality of articles past and in spaced relationship to said discharge member, and means connected to said conveying means to maintain an article carried by said conveying means at an electrical potential to attract and cause the deposition thereon of liquid atomized from said body.

11. The apparatus of claim 6 including a support position in spaced relationship to said discharge member, said support being adapted to support an article to be coated and means connected to said support to maintain an article on said support at an electrical potential to attract and cause the deposition thereon of liquid atomized from said body.

References Cited in the file of this patent

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,191,483</td>
<td>Thomas</td>
<td>July 18, 1916</td>
</tr>
<tr>
<td>1,410,312</td>
<td>Huffman</td>
<td>Mar. 21, 1922</td>
</tr>
<tr>
<td>2,109,733</td>
<td>Pormhals</td>
<td>Feb. 22, 1938</td>
</tr>
<tr>
<td>2,209,790</td>
<td>Yeomans</td>
<td>July 21, 1942</td>
</tr>
<tr>
<td>2,302,183</td>
<td>Campbell</td>
<td>Nov. 17, 1942</td>
</tr>
</tbody>
</table>