

Nov. 10, 1953

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2,658,472

ELECTROSTATIC COATING APPARATUS

Filed Oct. 29, 1948

3 Sheets-Sheet 1

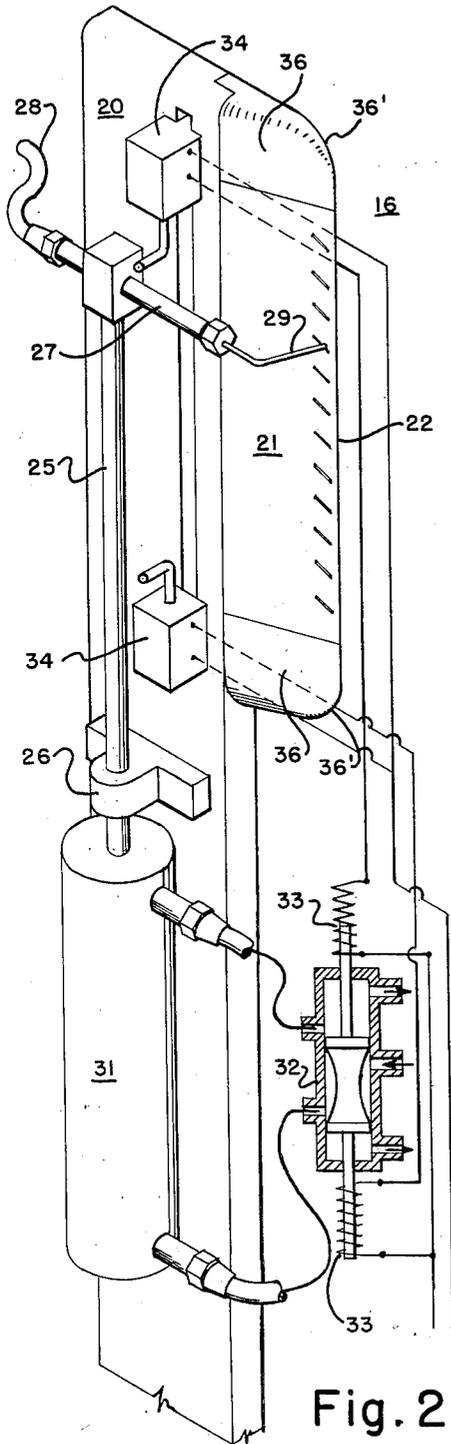


Fig. 2

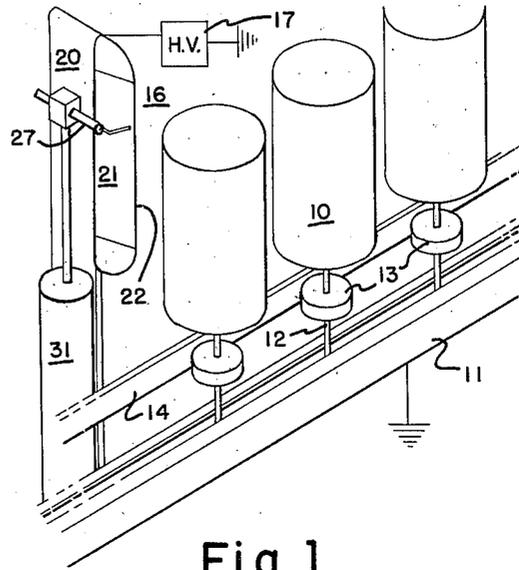


Fig. 1

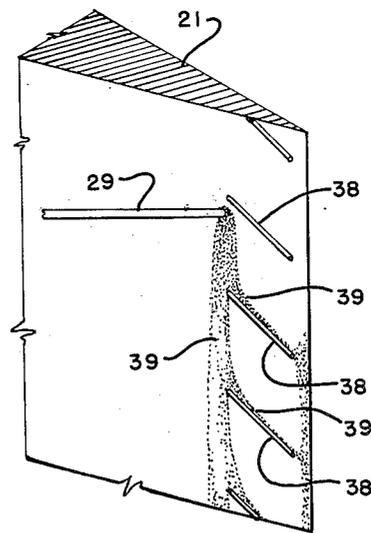


Fig. 3

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3 Sheets-Sheet 2

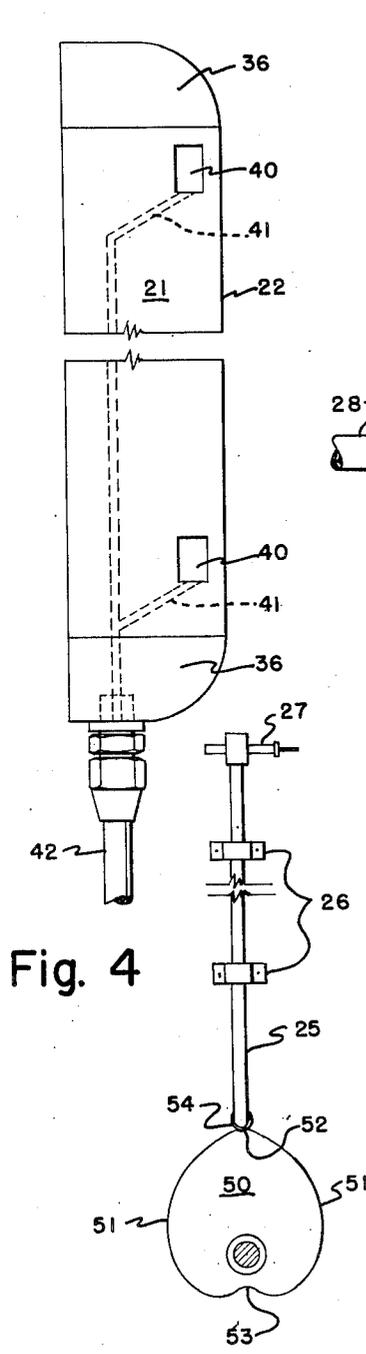


Fig. 4

Fig. 6

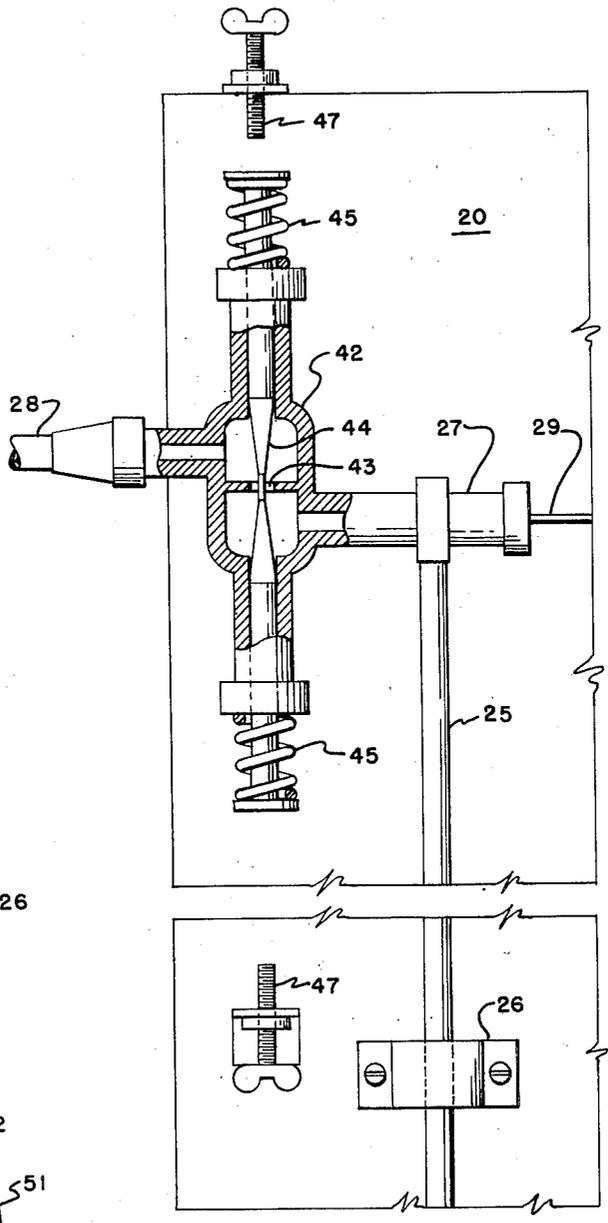


Fig. 5

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3 Sheets-Sheet 3

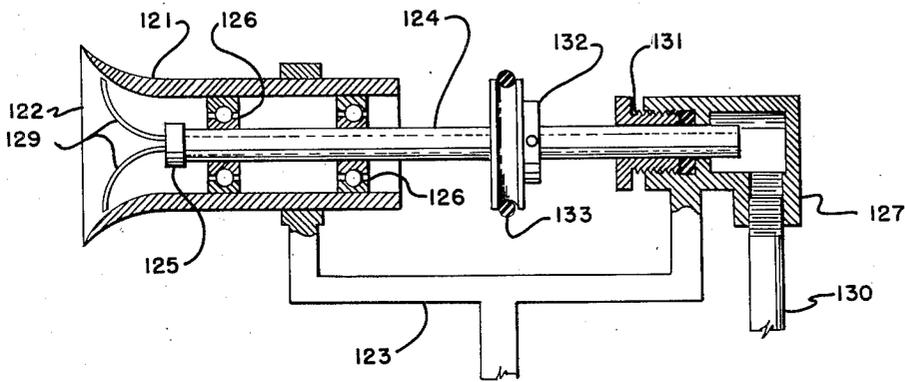


Fig. 7

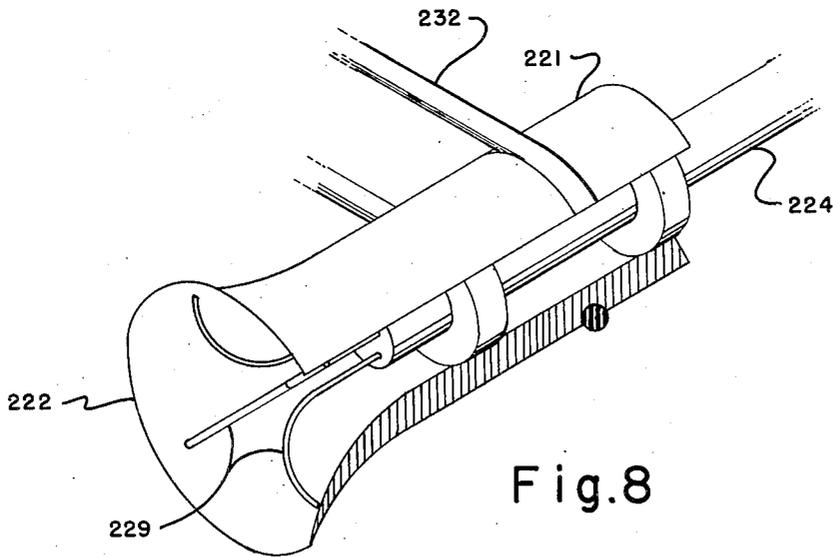


Fig. 8

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2,658,472

ELECTROSTATIC COATING APPARATUS

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Application October 29, 1948, Serial No. 57,260

14 Claims. (Cl. 118—51)

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This invention relates to the electrostatic deposition of liquid coating materials and more particularly to an improved coating apparatus in which the liquid coating material is both electrostatically atomized and electrostatically precipitated or deposited upon the article to be coated. Coating methods and apparatus embodying the electrostatic atomization and electrostatic deposition of liquid coating materials are shown in the prior application for U. S. Letters Patent, Serial No. 556,390, filed September 29, 1944, by Edwin M. Ransburg and William A. Starkey.

In apparatus employed for applying a liquid coating to discrete articles, whether or not the coating is electrostatically deposited, it is common to move the articles through a coating zone in which the coating is applied to them. Similar practice is followed in the coating of sheet material, the coating being applied as the sheet moves progressively through a coating zone. Satisfactory coating of articles and sheets can be obtained by prior processes embodying both electrostatic atomization and electrostatic deposition of the coating material when the dimensions of the article or articles being coated in a direction transverse to the path of article-movement through the coating zone is not too great; but some difficulty has been experienced in the past in electrostatically atomizing and precipitating liquid coating materials on surfaces of considerable extent transversely of the path of article-movement through the coating zone. In the prior application above referred to, it was proposed to atomize the coating material from an elongated head having an atomizing surface or surfaces to which the coating material was fed through a series of restricted orifices. One disadvantage of such an atomizing head arises from the difficulty of maintaining the rates of flow through the orifices co-ordinated in the desired manner, with the result that the spray pattern produced was not of uniform density throughout its extent.

It is an object of this invention to overcome the disadvantages heretofore attendant upon the electrostatic atomization of coating material from an extended atomizing head. More particularly, it is an object to facilitate the attainment of a uniform distribution of coating material to an elongated, atomizing head, whereby to increase uniformity in density in the resultant spray.

In carrying out the invention, the coating material is atomized from an extended edge of an

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atomizing head and is fed to such edge by a nozzle which is moved relatively to the edge and parallel thereto to distribute the coating material therealong in a uniform fashion. Where the edge from which atomization takes place is straight, the nozzle is reciprocated along it; and provisions may be embodied in the apparatus for preventing the change of nozzle velocity at and near the ends of the stroke from interfering with uniform distribution of the coating material along the edge. Where the atomizing head is disposed vertically or at any substantial inclination to the horizontal, it may be provided with means for directing coating material discharged from the nozzle toward the atomizing edge of the head as such coating material flows generally downwardly under the influence of gravity. Other features of the invention will be apparent from the specification and claims.

In the accompanying drawing, Fig. 1 is a fragmental isometric view illustrating a coating apparatus; Fig. 2 is an isometric view, on a somewhat larger scale, illustrating the atomizing head, a reciprocating coating-material nozzle, and means for reciprocating such nozzle; Fig. 3 is a fragmental isometric view of the head of Fig. 2 on a still larger scale; Fig. 4 is an elevation of a modified form of head; Fig. 5 is a fragmental elevation, in partial section, illustrating a means which may be employed to counteract the effect of velocity changes at the ends of the stroke of a reciprocating coating-material nozzle; Fig. 6 is an elevation of a modified nozzle-reciprocating mechanism; Fig. 7 is an axial section through a circular atomizing head embodying my invention; and Fig. 8 is an isometric view, in partial section, illustrating a modified form of circular atomizing head.

In Fig. 1 I have illustrated an arrangement of apparatus suitable for coating discrete cylindrical objects 10. Such apparatus embodies a conveyor 11 carrying an endless series of vertically disposed, rotatable spindles 12 each of which is adapted to support one of the articles 10. Each spindle 12 has rigid with it a wheel 13 adapted to engage a stationary rail 14 as the spindle moves through the coating zone, whereby to rotate the spindle and the article 10 it carries. Disposed at one side of the path of article-movement through the coating zone is a vertically positioned atomizing head 16 from which the liquid coating material is electrostatically atomized. To effect atomization of the coating material and electrostatic deposition thereof on the articles 10 as they pass the head 16, an electrostatic field of appropriate

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strength is maintained between the head and the articles. For this purpose, the articles may be grounded through the conveyor while the atomizing head is connected to one terminal of a high-voltage source 17 the other terminal of which is grounded.

The atomizing head 16, which is shown in greater detail in Figs. 2 and 3, comprises a vertical support 20 to one side of which there is affixed in any convenient manner an elongated member 21 which is preferably of electrically conducting material and connected to the ungrounded terminal of the high-voltage source 17. The member 21 is shown as shaped in cross-section to present toward the articles 10 a relatively sharp edge 22. An average potential gradient of the order of 10,000 volts per inch is maintained between the member 21 and the articles 10 moving past it, and as a result liquid coating material fed to such edge will be electrostatically atomized and electrostatically precipitated on to the articles 10, as more fully set forth and described in the prior application above referred to. In order to secure a spray pattern of uniform density, it is important that the coating material be distributed uniformly to all points along the edge 22; and it is to apparatus for accomplishing that purpose that this invention is especially directed.

The coating-material distributing means shown in Fig. 2 comprises a rod 25 mounted for vertical reciprocation in appropriate guide means 26 and carrying at its upper end a short length of tube or pipe 27 disposed transversely of the rod. One end of the tube 27 is connected, as through a flexible hose 28, with a source of coating material which is adapted to be fed to the tube 27 either by gravity or by positively produced pressure. To the opposite end of the tube 27 there is connected a nozzle 29 having its outer end disposed close to the edge 22 of the discharge head but spaced rearwardly a short distance from such edge so as to be electrically shielded thereby.

The means employed to reciprocate the rod 25 and nozzle 29 may take various forms. In Fig. 2, such means is shown as comprising an air cylinder 31 having a piston (not shown) mounted on the lower end of the rod 25. A four-way valve 32, operated by solenoids 33, controls the admission and discharge of air or other fluid under pressure alternately to opposite ends of the cylinder 31. Conveniently, the valve 32 is arranged to be automatically reversed when the rod 25 reaches the end of its stroke in either direction. To this end, the solenoids 33 may be respectively controlled by limit switches 34 positioned to be engaged by the tube 27 to reverse the valve as the rod 25 reaches each end of its stroke.

In operation of the apparatus shown in Figs. 1 and 2 the articles to be coated are moved past the head 16 and coating material is supplied through the flexible hose 28 to the nozzle 29 while the rod 25 reciprocates to distribute such coating material along the discharge edge 22 of the head. Coating material applied to the member 21 in rear of the discharge edge 22 spreads to the discharge edge, and is electrostatically atomized and precipitated upon the articles passing the head 16 by the action of the electrostatic field which exists between those articles and the head. The rate at which coating material is supplied to the nozzle 29 is controlled so as to insure that the member 22 will not receive more coating material than can be atomized from its discharge edge. The rate of reciprocation of the

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rod 25 and the nozzle 29 can be controlled by controlling the rate at which fluid under pressure is supplied to the cylinder 31, such rate of fluid-supply being adjusted as necessary to maintain a supply of coating material for electrostatic atomization at all points along the desired extent of the edge 22.

Generally speaking, it is advisable that the length of the discharge edge 22 approximate the parallel dimension of the surface or surfaces to be coated, although the length of the discharge edge may in many instances be somewhat less than the parallel dimension of such surface or surfaces without causing undue lack of uniformity in the coated products. In most instances, where the article or articles to be coated have surfaces, such as the upper and lower surfaces of the articles 10, which are presented edgewise to the discharge head, it will be advisable to employ a member 21 having a discharge edge 22 longer than would be required for the application of a satisfactory coating to a surface or surfaces extending parallel to the head.

In many instances, it will be advisable to utilize substantially less than the full length of the discharge edge 22 for the electrostatic atomization of the coating material, for end portions of such edge to which coating material is not supplied serve to reduce spreading of the spray pattern in a direction parallel to the discharge edge. To prevent a concentration of field strength at the ends of the discharge edge 22, the head 16 may include end pieces 36 of conducting material which are secured to the support 20 in any convenient manner and extend outwardly therefrom to the respective ends of the edge 22. Immediately adjacent the ends of the edge 22, the end pieces 36 have a cross section corresponding to that of the member 21, but outwardly beyond the ends of the edge 22, the exposed edges of the end pieces 36 are rounded off as indicated at 36'.

Where the head 16 is so disposed that the edge 22 is vertical or inclined to the horizontal at such angle that the coating material discharged from the nozzle 29 does not tend to flow unaided to the discharge edge under the influence of gravity, the member 21 may be provided adjacent the edge 22 with flow directing elements designed to divert toward the edge 22 any coating material which flows downwardly over the surface of the member 21 generally parallel to that edge. Such flow-directing elements may take the form of wires 38 which are secured, as by soldering, to the face of the member 21 in inclined positions. The elements 38, if used, desirably terminate in rear of the edge 22, as will be clear from Fig. 3, in order to avoid interference with the uniform distribution of field strength along such edge.

In a vertically disposed head provided with flow directing elements 38, a reasonably satisfactory distribution of coating material along the edge 22 may sometimes be obtained without reciprocating the nozzle 29. For example, if the nozzle 29 were held in the fixed position indicated in Fig. 3, it would discharge on to the adjacent face of the member 21 a stream of coating material 39; and as such stream of coating material ran down the face of the member 22 under the influence of gravity, portions of it would be successively diverted by the members 38 to form branch streams 39 which the members 38 direct to the discharge edge 22. Obviously, the extent of the discharge edge 22 which can be satisfactorily supplied with coating material in this manner from a single discharge orifice is limited; but there are situa-

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tions in which this expedient could be utilized to supply coating material to an edge 22 of limited extent.

The relatively simple arrangement illustrated in Fig. 2 for distributing coating material along the member 21 in rear of the discharge edge 22 has a disadvantage due to the rapid velocity changes which occur at the ends of the stroke of the nozzle 29. To overcome this disadvantage, the arrangement illustrated in Fig. 4 may be employed. As there indicated, the member 21 is provided adjacent the path of the reciprocating nozzle 29 with pockets 40 into which such nozzle discharges when near the ends of its stroke. Any inequality of coating-material distribution occurring as a result of severe accelerations at the ends of the nozzle-stroke take place when the nozzle is opposite one or the other of such pockets. The pockets are formed to trap coating material discharged into them and to prevent it from escaping on to the side surface of the member 21 where it might find its way to the discharge edge 22. To prevent an accumulation of coating material in the pockets, they may be provided with drain passages 41, and such drain passages may communicate with a drain conduit 42 through which the coating material may be conducted for reclamation.

Adverse effects of extreme accelerations on the discharge of coating material at the ends of the stroke of the nozzle 29 might be eliminated by employing a nozzle-reciprocating means which would not result in the existence of those extreme accelerations. In such a case, however, if the rate of flow through the nozzle were maintained constant, the end portions of the edge 22 would receive proportionately more coating material than would the mid-portion of such edge. In Fig. 5, there is illustrated an arrangement by which accelerations at the ends of the nozzle stroke may be reduced without causing the deposit of excessive quantities of coating material at the ends of the nozzle stroke. In that arrangement, the pipe 27 is provided intermediate its length with a valve 42 formed to provide an orifice 43 through which the coating material flows in its passage from the flexible tube 23 to the nozzle 29. The orifice 43 is arranged with its axis parallel to the path of reciprocation and receives a double-ended needle valve 44 which is reciprocably mounted in the valve body 42 and the opposite ends of which project outwardly beyond the valve body. Springs 45 acting oppositely between the valve body and the needle valve tend to maintain the needle valve in a normal central position in which its smaller-diameter portion is disposed within the orifice 43. The support 20 carries abutments 47 which are disposed adjacent the ends of the stroke of the tube 27 in position to engage the ends of the needle valve 44. Conveniently, the abutments 47 are adjustable and are so positioned that as the nozzle 29 begins to decelerate near the end of its stroke in either direction the needle valve 44 will engage the adjacent abutment 47 and will be moved thereby to cause the tapered portion of the needle valve 44 to enter the orifice 43 and reduce the rate of flow of coating material to the nozzle 29. If desired, the parts can be so arranged that at the end of the stroke the supply of material to the nozzle 29 is completely shut off but ordinarily this will not be necessary.

Means for reciprocating the nozzle 29 in a manner which will not involve extreme accelerations at the end of the stroke may take the form shown in Fig. 6. Such mechanism comprises a cardioid

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cam 50 having opposite peripheral portions 51 of substantially constant spiral pitch and smoothly curved connecting portions 52 and 53 joining adjacent ends of the portions 51. The cam 50 is mounted for rotation on an axis perpendicular to the rod 25, and such rod is provided with a cam following roller 54 which engages the cardioid peripheral surface of the cam. During the mid portion of the stroke of the rod 25, the roller 54 is engaged by one or the other of the uniform-pitch cam portions 51, and the nozzle moves with uniform velocity. As the rod 25 and nozzle 29 near the end of the stroke, the roller 54 is engaged by one of the connecting cam portions 52 and 53, and the direction of movement of the rod and nozzle is gently reversed.

In the form of the invention shown in Fig. 7, the discharge head is of circular form to create a circular pattern in the atomized coating material which is discharged from it. Conveniently, the head is in the form of a hollow sleeve 121 provided at one end with an attenuated discharge edge 122 and stationarily supported in any convenient manner from a support 123. Rotatably mounted within and co-axial with the sleeve 121 is a hollow tube or pipe 124 the front end of which is located rearwardly of the discharge edge 122 and closed by a cap 125. The cap rigidly supports one or more discharge nozzles 129 which communicate with the interior of the tube 124 and extend forwardly and outwardly to discharge against the inner face of the sleeve 121 a short distance in rear of the discharge edge 122. The pipe 124, which may be rotatably supported from the sleeve 121 through anti-friction bearings 126, extends rearwardly beyond the tube and into a fitting 127 the hollow interior of which communicates through a hose 130 with a source of coating material. The fitting 127 is provided with a stuffing box 131 to prevent the escape of coating material around the tube 124; and between the sleeve 121 and fitting 127 the tube 124 is provided with a pulley 132 adapted to receive a belt 133 by which the tube and nozzles 129 are rotated.

In use, the head of Fig. 7 is supported opposite a surface to be coated, the tube 124 and nozzle 129 are rotated, and liquid coating material is supplied to the fitting 127 from which it flows through the tube 124 to the nozzles 129. The rate at which fluid is discharged from the nozzles 129 is regulated so as not to exceed the rate at which it can be electrostatically atomized from the edge 122.

The modification of the invention illustrated in Fig. 8 is similar to that shown in Fig. 7 except that relative movement between the circular head and the nozzles is obtained by rotating the head while the nozzles remain stationary. As will be clear, the coating material is supplied to the head through a stationary pipe or tube 224 which extend into the head and rotatably supports a sleeve 221. The sleeve 221 has an exterior annular groove adapted to receive a belt 232 by means of which it may be rotated. Within the sleeve 221 the tube 224 communicates with an annular series of discharge nozzles 229 adapted to discharge immediately in rear of a discharge edge 222 on the sleeve 221. Coating material is supplied to the head through the tube 224 and is discharged through the nozzles 229 at a rate no greater than that at which it can be atomized from the discharge edge 222. As the sleeve 221 rotates while the nozzles 229 remain stationary, the coating material discharged from the nozzles is evenly distributed along the edge 222. If the

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inner surface of the sleeve 221 is bell-mouthed in rear of the edge 222, the centrifugal action of the coating material discharged from the nozzles 229 will aid in feeding such coating material to the discharge edge 222 for electrostatic atomization therefrom. It may be noted that in using a rotating discharge element the structure of Fig. 8 embodies an invention broadly claimed in my patent application Serial No. 57,259, now abandoned, of even filing date herewith and my application Serial No. 143,994, filed February 13, 1950.

In both of Figs. 7 and 8, it is contemplated that the hollow sleeve, or at least that portion of it on which the discharge edge is provided, will be made of electrically conducting material and that such conducting material and the article or articles being coated will be associated with opposite terminals of a high-voltage source capable of producing at the discharge edge a field-strength great enough to produce electrostatic atomization of the coating material. As previously indicated, it is preferred to employ a high-voltage source capable of producing between the atomizing head and the article or articles being coated an electrostatic field having an average potential gradient of the order of 10,000 volts per inch. In most cases it will be convenient to ground the articles being coated and insulate the discharge head; but this arrangement may be reversed if desired. Where the head is insulated and charged and an electrically conductive coating material is being used, the source of such coating material should also be insulated from ground, as more fully set forth in my aforesaid patent applications Serial No. 57,259, now abandoned, and Serial No. 143,994. Where the coating material being employed is electrically conductive in character, it is not essential that the member from which atomization takes place also be conductive; for the coating material on the discharge edge could be connected to the high-voltage source otherwise than through the discharge member.

In all modifications shown the discharge edge of the atomizing head is shown as smooth and continuous. This is not an essential, however; as, if desired, such discharge edge might be serrated.

What is claimed is:

1. In an electrostatic atomizing head for use in the electrostatic deposition of liquid coating material, a discharge member having an extended edge, and means for distributing liquid coating material to said edge for electrostatic atomization therefrom, said means comprising a discharge nozzle disposed to discharge on the discharge member adjacent said edge, and mechanism for reciprocating said nozzle over a path generally parallel to and spaced from said edge.

2. In an electrostatic atomizing head for use in the electrostatic deposition of liquid coating material, a discharge member having an extended annular discharge edge, and means for distributing liquid coating material to said edge for electrostatic atomization therefrom, said means comprising a discharge nozzle mounted for rotation about the axis of the annular discharge edge and disposed to discharge directly on to the discharge member adjacent said edge, and mechanism for rotating said nozzle about its axis.

3. The invention set forth in claim 1 with the addition that said discharge member is of electrically conducting material, the edge of the discharge member continuing outwardly beyond each end of the stroke of the reciprocating nozzle.

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4. The invention set forth in claim 1 with the addition that said discharge member is of electrically conducting material.

5. The invention set forth in claim 1 with the addition that said discharge member is provided with means for guiding to said edge liquid coating material discharge by said nozzle.

6. The invention set forth in claim 1 with the addition of means for trapping and diverting from said edge coating material discharged from the reciprocating nozzle near the ends of its stroke.

7. The invention set forth in claim 1 with the addition of means operative when the reciprocating nozzle is near the ends of its stroke for reducing the rate at which the coating material is discharged.

8. In an electrostatic atomizing head for use in the electrostatic deposition of liquid coating material, a discharge member having an extended edge, and means for distributing liquid coating material to said edge for electrostatic atomization therefrom, said means comprising a plurality of discharge nozzles spaced from each other along said edge and disposed to discharge coating material directly on to the discharge member adjacent the edge, and means for producing relative movement of said nozzles and discharge member in a direction parallel to said edge.

9. In electrostatic coating apparatus, a movable discharge nozzle, means for supplying liquid coating material to said nozzle, means for moving said nozzle over a predetermined path, a discharge member extending generally parallel to and adjacent said path for receiving coating material discharged from the nozzle, a support for supporting an article to be coated in spaced relation to said member, and means including a high voltage source for maintaining between an article on said support and the coating material on said member an electrostatic field capable of atomizing such material and precipitating it on the article.

10. The invention set forth in claim 9 with the addition that said nozzle reciprocates over said predetermined path, and means operative when the nozzle nears the ends of said path for reducing the rate at which the coating material is discharged.

11. In an electrostatic atomizing head for use in the electrostatic deposition of liquid coating material, a discharge member having an extended edge, means including a movable flow directing element for supplying a stream of liquid coating material to said member for distribution along said edge and electrostatic atomization therefrom, and means for moving said element to cause said stream to move along said member in a direction generally parallel to said edge.

12. In an electrostatic atomizer, a discharge member extended in a direction transverse to that in which atomized particles are to be projected from it, movable flow-directing means for supplying liquid sequentially to points distributed along such discharge member in the direction of its extent, and means including a high-voltage source for maintaining adjacent the liquid on said member an electrical potential gradient of sufficient strength to electrostatically atomize and project finely divided liquid particles from such member.

13. In an electrostatic coating apparatus in which particles of liquid coating material are atomized from an extended circular edge of a discharge member and are precipitated under the influence of an electrostatic field onto an

article spaced from said edge, a nozzle, means for supplying liquid coating material to said nozzle, said discharge member being disposed to receive the liquid coating material discharged from the nozzle, said edge having an extent many times the diameter of the nozzle, and means for producing relative movement of said nozzle and discharge member over a predetermined circular path parallel with but smaller in diameter than said edge to distribute the coating material on said discharge member for substantially uniform flow to said edge.

14. In electrostatic coating apparatus, a support for an article to be coated, a discharge member having an extended edge presented toward and in spaced relation to an article on said support, a nozzle, means for supplying liquid coating material to said nozzle for discharge therefrom as a jet stream, an extended surface adjacent the discharge edge and disposed to receive directly the jet stream discharged from the nozzle, said surface having an extent many times the diameter of the jet stream, means for producing relative movement of said jet stream and said surface over a predetermined path along which said member extends and for a distance which is also

many times the diameter of the jet stream to distribute the coating material substantially uniformly on said surface for flow to said discharge edge for atomization therefrom, means including a high voltage source for creating between the article on said support and the atomized coating material particles an electrostatic field for electrostatically precipitating the particles on the article, said discharge edge being sufficiently spaced from the article on said support to permit the particles atomized therefrom to be widely dispersed by the action of the electrostatic field during their movement to the article.

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