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METHOD AND APPARATUS FOR ELECTROSTATICALLY COATING ARTICLES

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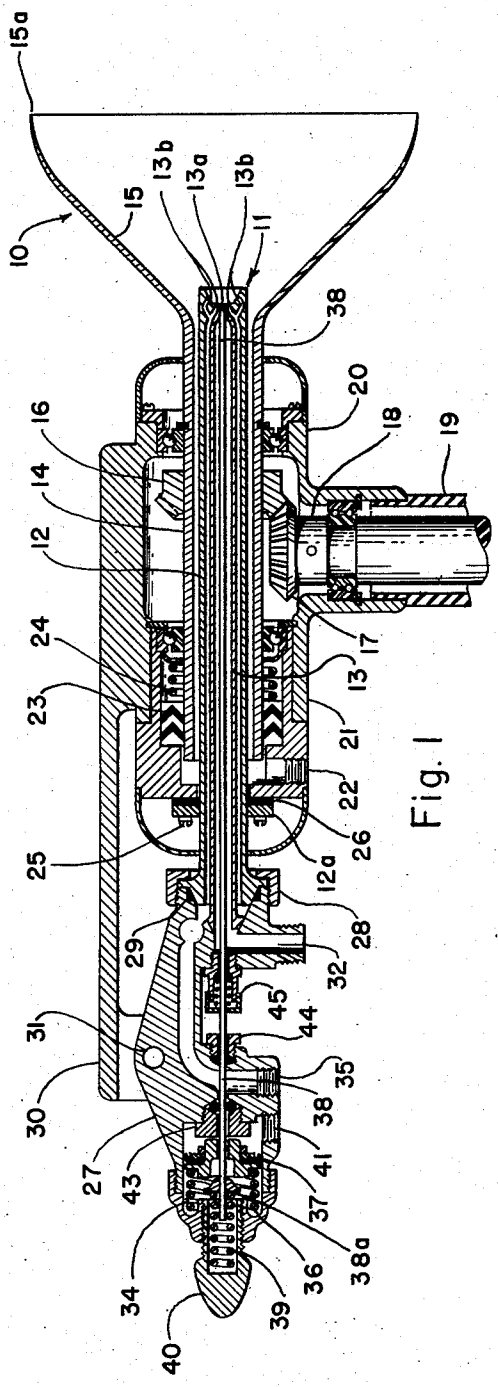

Fig. 1

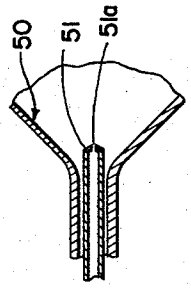

Fig. 3

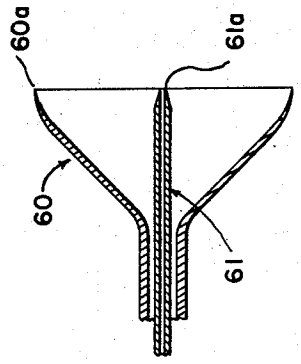

Fig. 4

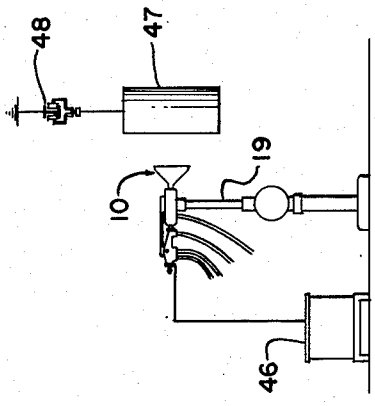

Fig. 2

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METHOD AND APPARATUS FOR ELECTROSTATICALLY COATING ARTICLES

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5 Claims. (Cl. 117—93)

This application relates to apparatus for atomizing liquid materials, and more particularly to apparatus for atomizing liquid coating materials for electrostatic deposition on an article.

Liquid atomizing devices known to the art include pressure atomizers making use of fluid pressure to effect the liquid atomization (with a separate fluid such as air, for example, or the direct pressure of the liquid material itself issuing from a small orifice); and, more recently atomizers which use electrostatic forces for providing a spray of liquid material from the atomizing zone.

The use of pressure atomizing devices to direct a spray of liquid coating material generally in the direction of articles or surfaces to be coated, with reliance on this general direction of movement of coating material particles to cause at least some of them to deposit upon a surface being coated, is of course, decades old. On anything except relatively large surfaces, however, such a spray coating arrangement is inefficient; and commercial operations using pressure atomizing devices for production coating have lost large percentages of the coating material in over-spray and have frequently had to resort to water-washed spray booths or other undesirable and expensive expedients to trap oversprayed liquid coating material and reduce contamination of the air.

In recent years a form of spray coating known as electrostatic coating has been developed where the spray issuing from an atomizing device is given an electric charge at the time it leaves the spraying device or shortly thereafter and deposition of the coating material particles is primarily the result of electrostatic forces attracting the particles to the article being coated. This is accomplished by creating an electrostatic field which includes the article being coated and the charged coating material particles moving generally toward such article. Coating systems of the electrostatic type, especially those using electrostatic atomization, have proved very satisfactory and extremely efficient commercially in coating various types of articles (even small articles or articles with large open spaces, as automobile steering wheels) which were considered extremely difficult to spray-coat before the advent of electrostatic coating.

One of the most efficient electrostatic atomizing heads heretofore developed, however, comprises a head with a circular atomizing edge, preferably the edge of a bell-shaped member which is rotated to improve the uniformity of delivery of liquid coating material in a thin film to the atomizing edge, an electrostatic atomizer of this type being disclosed and claimed in my copending application, Serial No. 143,994, filed February 13, 1950. However, the "natural pattern" delivered from an electrostatic atomizing head of this type is a "doughnut" or annular band having a central portion which is completely or relatively void of coating material. Reference to a "natural pattern," or for brevity merely the "pattern" of the atomizing head, is here intended to mean the pattern which the spraying device would provide on a relatively very large sheet of conducting material arranged normal to the general line of movement of the spray particles and at a distance corresponding to the spacing of the head from an article to be coated, with the respective electric potentials being the same as those which would be used with the articles.

Where an electrostatic atomizing head of the type just referred to is used the width of the annular band and the size of the central void of the pattern are determined, at least to some extent, by such factors as the diameter of the head, the spacing between the head and sheet, the voltage differential being used, the viscosity and other characteristics of the coating material, etc.; but the commercially practical spacings of at least several inches (and usually at least 6 or 8 inches), even for small circular electrostatic atomizing heads create an annular pattern in which the diameter of the central void may be as much as several inches. Under these conditions a small increment of area of article surface passing along a diameter of the pattern receives a lesser amount of coating than does a similar increment of area moving parallel to the diameter but along a line further out which does not pass through the central void of the pattern. With a single such head used alone, therefore, the coating thickness on an article having dimensions transverse to its line of movement of the same order as that of the outer diameter of the annular pattern band has been irregular, with an unnecessary thickness of coating having to be deposited on certain portions in order to secure sufficient thickness on other portions. On the other hand, use of pressure atomizer with a pattern size at least equal to or slightly greater than the maximum dimension of the article transverse to its line of movement entails some loss by way of over-spray even with the presence of electrostatic field forces for assisting deposition and, in addition, produces a coating frequently non-uniform in thickness.

The present invention provides a combination of a circular electrostatic atomizing head and a supplementary atomizing head in such a way that the extremely high efficiencies associated with electrostatic coating methods employing electrostatic atomization (of the order of 99% or even more) are retained, but with supplementary atomization employed to "fill in" what would otherwise be the pattern void and provide substantially uniform distribution of coating material within the limits of the pattern with the advantage of improving uniformity of coating thickness while retaining the high efficiencies characterizing electrostatic atomization.

The foregoing and other features and advantages of this invention will be apparent from the following specification and the drawings, in which:

Figure 1 is a longitudinal sectional view of an atomizing unit providing both electrostatic and pressure atomization in a suitable relationship.

Figure 2 is a diagrammatic view of coating apparatus incorporating the atomizing device shown in Figure 1.

Figure 3 is a fragmentary sectional view of an alternative combined apparatus wherein the pressure atomization of the liquid coating material is effected directly by the pressure of the liquid material itself; and

Figure 4 is fragmentary sectional view of still another alternative apparatus wherein two independent electrostatic atomizers are combined in a suitable relationship.

While three different forms of combined atomizing units are illustrated and will be described as useable for accomplishing the present invention, it will be understood that these are representative embodiments only; and it is to be understood that other embodiments may be utilized without departing from the contemplated scope of the present invention, and that no limitations are to be implied from such specific description as shall now be provided.

Referring now more especially to the particular embodiment of the invention illustrated in Figure 1, it will be seen that there are two coaxial atomizing heads of different types, the electrostatic atomizing head being identified in general as **10** and the pressure atomizing head being identified in general as **11**.

The inner pressure atomizing head is here shown as comprising an outer generally cylindrical member **12** and a concentric tubular member **13** therewithin. Liquid coating material is supplied within the tube **13** to issue from the small orifice **13***a* at the end of this tube; and air at suitable pressure is supplied through the annular passageway provided between the tubes **12** and **13** to issue through suitable orifices **13***b*, as illustrated, surrounding the liquid orifice **13***a*, the liquid coating material thus being air atomized and sprayed out as a generally circular spray.

The electrostatic atomizing arrangement comprises a tubular portion **14** concentric with and slightly spaced from the tubular member **12**, providing an annular passageway through which liquid coating material may flow in a manner hereafter more fully described; and a bell-shaped or generally conical member **15** terminating in a circular atomizing edge **15***a* which may, for example, be 6 inches in diameter. The bell-shaped member **15** is preferably rotated during operation of the electrostatic atomizing unit, and this is here shown as effected through meshed gears **16** and **17**, the former fixed on tube **14** and the latter being rotated by a shaft **18** of electrically insulating material and enclosed within a support column or tube **19** also of electrically insulating material. In a manner indicated diagrammatically in Figure 2 and more fully described in the earlier mentioned copending application, the atomizing heads are both electrically charged to a high potential with respect to ground (as 100,000 volts) by a connection to a suitable power pack **46**; and articles **47** are normally carried on a grounded conveyor **48** so that the desired electrostatic field would be set up between the atomizing heads and the articles themselves (if of conducting material), or conveyor support electrodes therewithin. The electrostatic field thus established, at a suitable spacing of the atomizing edge **15***a* from the articles being coated (as 8 or 10 inches) causes electrostatic atomization of liquid coating material from the edge **15***a*, resulting in an annular or doughnut-shaped spray pattern.

Since the heads are coaxial and normally both operative during coating, the resultant natural pattern at the coating plane is a single circular pattern without any void, with a distribution of coating material particles throughout the entire circle, the coating material particles atomized by the pressure atomizing head **11** filling in what would otherwise have been a void in the pattern of the electrostatic atomizing head. It will be understood that the heads are preferably so adjusted and operated that the periphery of the circular pattern of the pressure spray approximately coincides with the inner edge of the annular pattern of the electrostatically atomized spray. It may also be desirable to provide a somewhat less concentrated or "thinner" spray from the pressure atomizing head **11** than is provided by the electrostatic atomizing arrangement **10** in order to prevent undue thickness of coating of increments of surface area moving along or very close to the diameter of the combined patterns. Bearing in mind that the surface to be coated will be moving through the spray, it will be obvious that the distribution of the paint parallel to path of surface movement is immaterial, and that the pattern of the pressure spray need not be circular to produce a deposited coating of satisfactorily uniform thickness.

Again referring more particularly to Figure 1, it will be seen that the column **19** carries a housing or support member **20** which supports the tubular member **14** for rotation, as by the pair of ball bearing assemblies illustrated. An end member **21** carried by the member **20** provides a liquid coating material inlet **22** communicating with the annular passageway between the members **12** and **14** to supply liquid coating material to the inner surface of the bell-shaped member **15**. An appropriate fluid-tight seal is provided between the rotating member **14** and the stationary member **21**, this being here shown as comprising chevron packing members **23** held in sealing relation by a spring **24** bearing against a member carried by the stationary end member **21**.

The outer member **12** of the stationary pressure atomizing head is provided with a flange **12***a* bolted to the stationary end member **21**, as illustrated, by the studs **25**, a gasket **26** providing a suitable fluid-tight seal. The left hand end of this tubular member **12** (as the parts are viewed in the drawing) is attached in such a manner as to be sealed to and to mechanically support a passageway member **27**, this being here shown as having a tapered seat held on a tapered shoulder on the tubular member **12** by a screw cap **28**, the fluid seal being provided by an O-ring **29**. The support member **20** is also provided with an extending arm portion **30** also connected to and serving to act as a support for the member **27**, as by the connection provided by the pin **31**.

The passageway member **27** provides another liquid coating material passageway **32** communicating with the interior of the tube **13**, it being understood that the liquid material passageways **22** and **32** may be supplied with the liquid coating material through connection to the same conduit, or through separate conduits. In each case coating material would be suitably fed from some reservoir, as by a pump; and if separate control is desired, as is preferable, separate pumps and conduits may be used so that the regulation of supply of coating material to the two atomizing heads may be independently adjusted.

The passageway member **27** also provides a cylinder **34** for purposes to be hereinafter more fully described, and an air passageway **35** communicating with the annular passageway between the tubular members **12** and **13** to provide the atomizing air used in the particular pressure atomizing head illustrated. This air passageway **35** would, of course, be supplied with air under pressure from a suitable source, as a conventional air pump and pressure tank, with appropriate means for regulating the pressure.

Mounted within the cylinder **34** and urged toward the position illustrated by a spring **36** is a piston identified in general as **37**. Passing through the center of this piston and through the center of the tubular member **13** is a control valve or needle member **38** adapted to close the liquid orifice **13***a*, being urged to orifice-closing position by a spring **39** here illustrated as in a cap member **40** and bearing against a shoulder element **38***a* on a pin. As will be readily apparent, if air under pressure is admitted to the passageway **41** to the right (as the parts are illustrated) of the piston **37** the piston will move to the left against the spring **39** and force the needle valve member **38** to the left, insuring the passageway **13***a* being open as long as air pressure is present in the passageway **41**. Accordingly, connection of passageways **35** and **41** to the same conduit supplying air under pressure results in opening of the orific **13***a* upon a supply of air and automatic closing thereof when air pressure is turned off. This

enables the liquid supply pump or pumps to be started and any necessary adjustments made in the pattern provided by the electrostatic atomizing head; then air may be admitted to the passages **35** and **41** and suitable adjustments in its pressure (accompanied with adjustments in the rate of liquid supply to the passage **32**, if desired) to adjust the size and density of the pattern provided by the pressure atomizing head **11**. The needle member **38** would, of course, be suitably sealed in any wall openings through which it passes, this being here illustrated as effected by the gland packing arrangements **43**, **44** and **45**.

While the particular pressure atomizing head illustrated as a part of the apparatus shown in Figure 1 utilizes air pressure in conjunction with liquid flow, a similar solid circular spray pattern of the type obtained from this head may also be satisfactorily obtained from a pressure atomizing head utilizing no air but achieving its atomization directly by forcing the liquid coating material under considerable pressure through a fine orifice. Such an alternative arrangement is illustrated in Figure 3. In this case an electrostatic atomizing head **50**, which may be similar to that illustrated more completely in Figure 1, is combined with a pressure atomizing head **51** comprising the single tube illustrated, with a small end orifice **51***a*. Liquid coating material delivered through the center of the tube **51** would issue through the fine orifice **51***a* in a spray of particles which, because of the electrostatic field forces involved, would be attracted by and travel toward the coating zone. In utilizing such a pressure atomizing head there would, of course, be no need of an air supply passageway; and the automatically operated needle valve arrangement might be omitted to provide a simpler atomizing unit wherein feed of liquid coating material to the pressure atomization head might be manually stopped when desired.

Still another embodiment of my invention is illustrated in Figure 4. In place of the fluid pressure atomizing heads shown in Figures 1 and 3 a similar solid circular spray pattern of the type obtained from these heads is in the modification of Figure 4 obtained from a single orifice electrostatic atomizing head. More specifically, this apparatus comprises two electrostatic atomizing heads designated generally as **60** and **61** arranged coaxially and maintained at a high electrical potential by a suitable voltage source so that a field exists adjacent each head of sufficient strength to atomize liquid coating material. Head **60** may be similar to those illustrated in Figures 1 and 3 and is provided with discharge edge **60***a* from which liquid is electrostatically atomized to form a generally annular pattern. Head **61** comprises a relatively small diameter tube (on the order of 1/16" I. D. and 3/16" O. D.), one end of which terminates in the form of a small orifice **61***a* substantially and preferably in the same plane as that of the discharge edge **60***a*. Liquid coating material delivered to the orific **61***a* in any suitable manner such as by gravity feed or by a pump is electrostatically atomized in the form of a spray which substantially fills the void in the annular pattern which issues from head **60**. By this apparatus the use of pressures for obtaining atomization is completely avoided and a completely electrical atomizing apparatus is provided for obtaining supplies of coating material which may be utilized in obtaining coatings on various surfaces of improved uniformity.

The combination of two atomizing heads, respectively producing an annular and a "solid" pattern enables advantage to be taken of all the desirable features of electrostatic atomization, particularly its extremely high coating efficiency, and at the same time permits a single atomizing unit to provide a more uniform coating thickness than has heretofore been possible in an electrostatic coating system utilizing a single spray unit. Another advantage of my invention is that where the spray heads are arranged coaxially the outer annular spray has an electrostatic confining action on the inner spray which results in a denser spray than has been previously possible to obtain.

Whereas the apparatus of Figure 1 shows the shaft **18** and support column **19** as being made of insulating material so that the atomizing head assembly can be held at high potential, it is to be understood that these parts can be of conducting material if other means are provided for electrically insulating the head from its surroundings.

While I have shown and described certain embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims.

I claim:

1. A method for electrostatically coating an article, comprising providing a spray of coating material in a pattern which in a plane substantially normal to the general line of movement of spray particles, is an annular band; providing a second spray of coating material in a different pattern which supplements the first pattern to provide a substantially uniform distribution of coating material particles in said plane; and establishing an electrical potential difference between said spray particles and the article to be coated.

2. A method for electrostatically coating an article, comprising providing a spray of coating material in a pattern which, in a plane substantialy normal to the general line of movement of spray particles, is an annular band; and providing a second spray of coating material in a circular pattern having its periphery approximately coinciding with the inner edge of said annular pattern band at the coating plane to provide a substantially uniform distribution of coating material particles at such plane.

3. A method of coating an article, comprising forming first and second streams of liquid coating material, shaping said first stream into an annular film, electrostatically atomizing the coating material from the leading edge of said film to form an anular spray having a central void, passing the article through such annular spray along a diameter thereof whereby at least a portion of the surface of the article will traverse said void, atomizing said second stream to form a second spray and directing said second spray to impinge on that portion of the article surface which traverses said void.

4. A method for electrostatically coating an article, comprising providing a spray of liquid coating material having a pattern which in a plane generally normal to the line of movement of spray particles has a central portion substantially devoid of coating material particles, providing a second spray of liquid coating material in a pattern which supplements the first pattern to provide a substantially uniform distribution of coating material particles in said plane, and establishing an electrical potential difference between said spraying particles and the article to be coated.

5. Apparatus for electrostatically coating an article comprising: a first spraying means having a rotatable sharply defined annular atomizing edge positioned about a central axis, means for rotating said edge about said axis, a conveyor for moving an article to be coated along a path spaced from said first spraying means and transverse to and passing through said axis, means for feeding liquid coating material to the annular edge of said first spraying means for atomizing and projecting toward the article path a hollow spray of finely divided particles in a pattern which in a plane at the article path and normal to said axis is an annular band having a central area substantially concentric with said axis and substantially devoid of spray particles, means including a source of high voltage connected to said atomizing edge and said article for establishing between the spray particles projected from the first spraying means and the article to be coated a

particle-depositing electrostatic field, and a second spraying means including an air spray gun having a discharge orifice located coincident with said axis and within said annular atomizing edge for providing a spray of liquid coating material particles in a pattern which at said plane has a substantially circular pattern the periphery of which approximately coincides with the inner edge of said annular band pattern, said atomizing edge being located radially outward beyond the spray from said second spraying means.

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