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ELECTROSTATIC COATING APPARATUS

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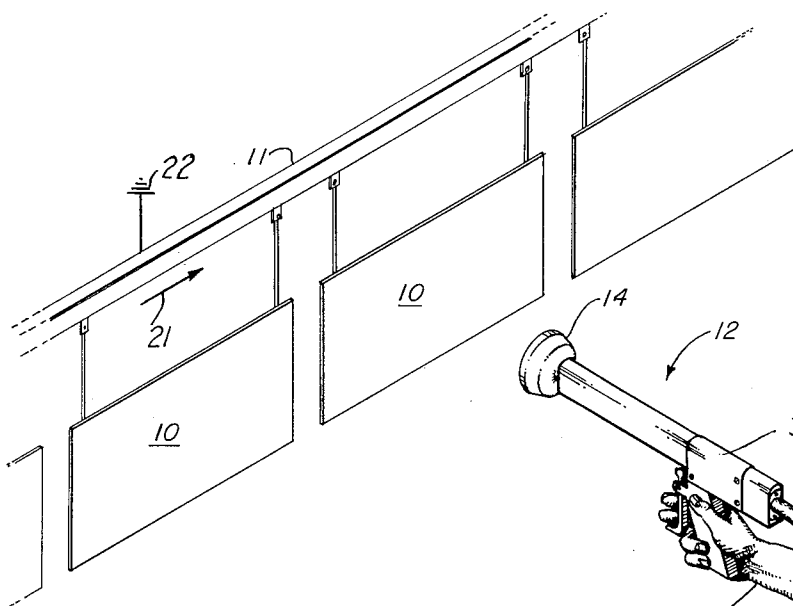


Fig. 1

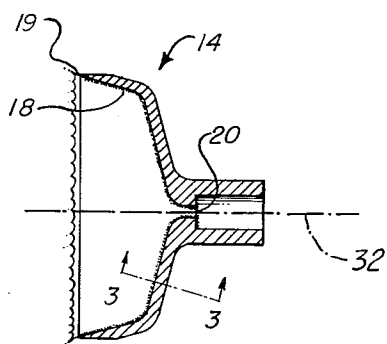


Fig. 2

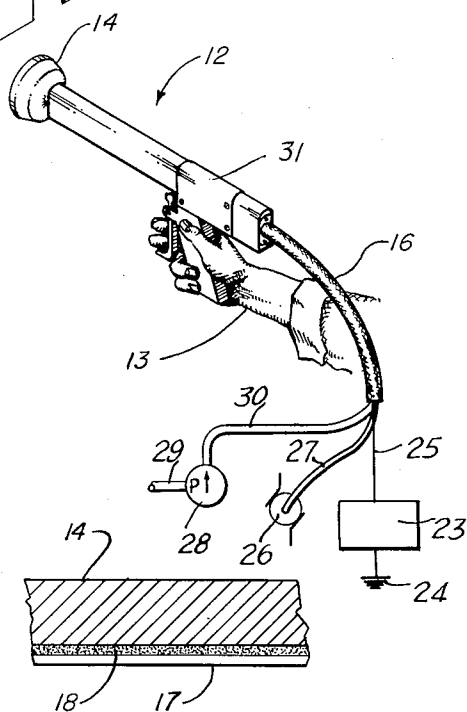


Fig. 3

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1

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## ELECTROSTATIC COATING APPARATUS

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This invention relates to apparatus for electrostatically affecting the deposition of finely divided particles of a coating material upon surfaces to be coated. While in no way limited thereto, the invention is particularly adapted for use with apparatus for electrostatic spray coating described in the co-pending application of J. W. Juvinall and J. C. Marsh, Serial No. 572,752, filed March 20, 1956. The application of Juvinall and Marsh describes a manually operable airless electrostatic spray gun having a rotating bell-shaped atomizing member which emits a spray of electrically charged, finely divided paint particles for spray coating articles. The invention here is particularly concerned with the construction of such an atomizing member.

It is an object of the present invention to provide an improved atomizing member having a predetermined, readily reproducible surface resistivity as the means for presenting the liquid for atomization and for impressing the desired electrical potential to the liquid to be atomized.

Another object of the invention is to provide an improved atomizing member made largely of electrical insulating material and provided with a surface of known electrical resistivity and possessing at the same time high mechanical and chemical resistance, particularly as to the ingredients of liquid coating materials.

A further object is to provide a conductive member of considerable size having an extremely low effective (instantly dischargeable) electrical capacitance when maintained at high voltage in an electrostatic coating system.

Other objects and advantages of the invention will be apparent from the following description. One embodiment of the invention will now be described in detail in conjunction with the accompanying drawings, in which:

FIG. 1 is an isometric, partially schematic view of a coating apparatus embodying the invention;

FIG. 2 is a vertical axial sectional view through the atomizing bell shown in FIG. 1; and

FIG. 3 is a magnified sectional, elevational view, taken along line 3—3 of FIGURE 2 but with parts enlarged for clarity of illustration.

A typical apparatus embodying the invention is shown in the accompanying drawings. In FIG. 1, a series of panels 10 to be coated are suspended from a suitable conveyor 11 and moved in the direction of the arrow 21. An atomizing device or gun indicated generally as 12, adapted to be held by an operator whose hand is shown as 13, is maintained in spaced relation to the articles 10 which are normally grounded as at 22 through their conveyor 11.

The details of the atomizing device are fully set forth in the aforesaid application of Juvinall and Marsh and will not be repeated here since these details form no part of my present invention. It is sufficient to say that the atomizing device includes a rotatable bell 14, which may be of nylon or the like, rotated about its axis 32 by power supplied from appropriate motor means 26 and transmitted to bell 14 through a suitable shaft 27 and linkages contained within a conduit 16 and the housing 31 of the atomizing device.

Liquid coating material from a remote source is fed at 29 into a pump 28 and then through a hose 30 within conduit 16 and thence through suitable couplings and

2

passageways within the atomizing device and thence axially to the inner surface of the rotating atomizing bell 14. Rotation of the bell causes the liquid to form into an outwardly moving, thin film indicated as 17 in FIG. 3, but greatly magnified therein for purposes of illustration, which is raised to a high electrical potential by contact with an inner surface layer 18 on the bell 14. This inner surface layer 18, like the liquid film 17 is shown greatly magnified in FIG. 3 for purposes of illustration. This inner surface layer 18 actually forms the inner surface of bell 14 and is permanently bonded to the bell as more particularly hereinafter described.

High voltage is applied to the liquid on the atomizing bell from a suitable source such as a power pack 23, grounded at 24 and delivering in the order of 100 kilovolts to the atomizing device 12 by means of a high voltage lead line 25 also within conduit 16. A high resistance element, which may be in the order of 1000 megohms, within the body of atomizing device 12, provides a high resistance path to the high voltage which is then applied to the atomizing bell and more particularly to the highly resistive coating 18 on the inner surface of the bell. An additional voltage drop is provided by this coating and, at a 12 inch atomizer-to-article spacing and 100 cc. of a common synthetic enamel delivered to the atomizer, approximately 85 kilovolts are impressed upon the liquid film at the forward atomizing edge 19 of the atomizing bell to provide an electrostatic field between the charged bell edge and the grounded article to be coated.

Turning now to FIG. 2, liquid coating material supplied to the atomizing bell flows through a central channel or passageway 20 axially of the bell and thence over its inner surface layer 18 to atomizing edge 19, where under the influence of the electrostatic field the liquid is formed into a series of small, regularly spaced liquid cusps. Finely divided liquid particles are atomized from these cusps along the edge of the liquid film in the manner illustrated in greatly magnified form in FIG. 2 and these atomized particles are moved as a spray through the electrostatic field to be deposited on the surfaces of the moving panels 10. The electric field is concentrated between the liquid cusps adjacent to the atomizing edge 19 of the bell 14 and the panels 10.

In electrostatic hand spray operations as illustrated, as well as in certain automatic conveyorized operations, it is desirable to construct the atomizing member so that it will have an extremely low effective, that is, instantly dischargeable, electrical capacity and yet it will have sufficient conductivity to carry the necessary current required for atomizing, charging and depositing the paint particles and to maintain the desired electrostatic field between the atomizing device and the articles. At the same time the atomizing member must be chemically and physically inert, particularly to the highly abrasive action of many common liquid coating materials and to the destructive chemical action of solvents, thinners and other chemicals of which coating materials are formulated. In accordance with the invention atomizing bell 14 is made of a wear-resistant electrically insulating material such as nylon and provided with an electrically conducting surface layer having predetermined electrical resistivity with both layers inert to their environment, including the coating material and the fumes evolved therefrom.

The predetermined resistivity of surface layer 18 may be accomplished by making layer 18 of a solid binder material substantially impervious chemically and physically to the liquid coating material and containing an electrically conducting solid of fixed, readily determinable resistivity. In the preferred embodiment this electrically conducting solid is finely divided carbon and the im-

pervious binder material is a synthetic resin, preferably predominately a thermosetting resin which has been set to an irreversible stage by heat and in which stage is substantially chemically and physically inert to ingredients commonly used in the formulation of coating materials.

A preferred resin for use in this invention is an alkyd resin. One resin that has proved particularly useful is a mixed alkyd resin and phenolic resin. Once these resins have been set to an irreversible state by heating, they are not attacked by the coating material flowing over them, and because of the presence of the finely divided electrically conducting solid, such as a carbon black, the resistivity can be controlled to a desired value.

In one embodiment of the invention, the bell-shaped head 14 was made of machined nylon. To the inner surface of this nylon bell-shaped head was applied a liquid prepared as follows:

| Base formula:                                       | Parts by weight |
|-----------------------------------------------------|-----------------|
| Glyptal alkyd resins 2480 or 2462 (50% in xylol)--- | 80              |
| n-Butanol -----                                     | 8               |
| Xylol -----                                         | 40              |
| Methyl ethyl ketone-----                            | 4               |
| Isophorone -----                                    | 4               |
|                                                     | 136             |

The following mixture added with stirring to 100 parts of the above base:

|                           | Parts by weight |
|---------------------------|-----------------|
| Phenolic resin R-108----- | 40              |
| Ethyl acetate-----        | 22              |

To 600 cubic centimeters of the above formula were then added 150 cubic centimeters of Lilly solvent 2079 (96.2 parts by weight of isopropyl acetate and 3.8 parts by weight of 85% syrupy phosphoric acid) and enough finely divided carbon to give the desired resistivity. In one embodiment, this amount was 16 grams of Monsanto B-5 carbon black which is ground to pass through a 325 mesh screen and contains by analysis over 98% pure carbon. The entire mixture was thoroughly agitated in a ball mill for eight hours.

The glyptal alkyd resins 2480 and 2462 are made by General Electric Company. The Glyptal Alkyd Resin 2480 is supplied in a 50% solution of xylol plus 5% butyl alcohol. It has an acid value of 4-5 and a phthalic content of 40% and an oil acids content of 35%. The oil acids are from dehydrated castor oil. Resin 2462 is supplied in a 50% solution of 3-1 xylol plus petroleum spirits. It has an acid value of 3-5 and a phthalic content of 40% and an oil acids content of 37%. The oil acids are from soya oil. Resin R-108 is a low molecular weight phenolic resin made by General Electric Company which has an average of two  $\text{CH}_2\text{OH}$  groups for each phenyl group, and is further characterized in that the phenyl OH is blocked with an allyl group.

In producing the atomizing device, the above composition was applied to the interior surface of a 4 inch diameter nylon bell. Excess composition was permitted to drip off while the bell was held in a vertical position and the bell then electrostatically deaired in order to further remove any excess composition and obtain a thin, reproducible uniform film on the interior of the bell. The bell was then baked at a temperature of 350-400° F. for about 60 minutes. At the end of this time when the resins in the inner film had set to irreversible thermoset conditions, this coating was found to be chemically inert and to have a surface resistivity of 300 megohms per square.

With the above formula, the electrical values were quite stable and easily predetermined by the amount and/or type of carbon. Carbon blacks vary widely in their electrical properties. For a higher resistivity the amount of the carbon black may be reduced, while for a

lesser resistivity the amount of the carbon black may be increased. The electrical values are less dependent on baking time, temperature, and other variables and are much easier to reproduce and predetermine with my invention than with other materials tested.

With the formula given above, the electrically conducting layer 18 provides a member having a surface resistivity of 300 megohms per square. I have found that changes in the amount of carbon of only a few grams in the above formula will change the surface resistivity to values which may be too high or too low for use in an electrostatic coating system as herein described. For example, by decreasing the amount of carbon in the above formula to about 12 parts by weight, the surface resistivity would be raised to about 50,000 megohms per square, a value considerably too high for an atomizing device of the type described herein.

It is to be understood that my invention is not limited to carbon as the electrically conducting material nor to resins as the solid binder. I have shown a coating applied to the inner surface of an insulating rotatable, bell-shaped atomizing member. In the aforesaid Juvinali and Marsh application the highly resistive layer is also shown applied to the outer surface of an atomizing member. The invention may be used in any type of electrostatic coating system as an electrode element of any desired configuration and is not necessarily restricted to an atomizer in an electrostatic coating system. Changes, therefore, in the construction and arrangement of my invention as illustrated above may be made without departing from the spirit and scope of my invention.

I claim:

1. In apparatus for electrostatically spray-coating a surface with discrete particles of liquid coating material, an atomizing device, comprising: a rotatable atomizing member substantially concentric about its axis of rotation terminating in a peripheral edge, including an electrically conducting inner surface layer having a predetermined high electrical resistivity and a substantially electrically insulating layer outwardly of and in contact with the inner surface layer; means operatively associated with said inner surface layer for supplying an electric current to said inner surface layer at a point remote from said peripheral edge; and means operatively associated with said inner surface layer for supplying liquid coating material to said inner surface layer for flow thereover to said peripheral edge for atomization therefrom.

2. In apparatus for electrostatically spray-coating a surface with discrete particles of liquid coating material, an atomizing device, comprising: a rotatable outwardly flaring atomizing member substantially concentric about its axis terminating in a peripheral edge, including an electrically conducting inner surface layer having a predetermined high electrical resistivity and a substantially electrically insulating layer outwardly of and in contact with the inner surface layer; means operatively associated with said inner surface layer for supplying an electric current to said inner surface layer; and means operatively associated with said inner surface layer for supplying liquid coating material to said inner surface layer for flow thereover to said peripheral edge.

3. In apparatus for electrostatically spray-coating a surface with discrete particles of liquid coating material, an atomizing device, comprising: a rotatable atomizing member substantially concentric about its axis of rotation terminating in a peripheral edge, including an electrically conducting surface layer having a predetermined high electrical resistivity comprising a solid material substantially impervious to said coating material containing a finely divided electrically conducting solid of predetermined resistivity; a substantially electrically insulating layer in contact with and carrying said surface layer; means operatively associated with said surface layer for supplying an electric current to said surface layer; and means operatively associated with said atomizing member

for supplying liquid coating material to said atomizing member for flow thereover to said peripheral edge.

4. In apparatus for electrostatically spray-coating a surface with discrete particles of liquid coating material, an atomizing device, comprising: a rotatable atomizing member substantially concentric about its axis of rotation terminating in a peripheral edge, including an electrically conducting surface layer having a predetermined high electrical resistivity comprising a synthetic resin substantially impervious to said coating material containing a finely divided electrically conducting solid of predetermined resistivity, and a substantially electrically insulating layer in contact with and carrying said surface layer; means operatively associated with said surface layer for supplying an electric current to said surface layer; and means operatively associated with said atomizing member for supplying liquid coating material to said rotatable atomizing member for flow thereover to said peripheral edge.

5. Apparatus of the character claimed in claim 4 wherein said resin is a thermoset resin and the electrically conducting material contained therein is finely divided carbon.

6. Apparatus of the character claimed in claim 4 wherein said resin is an alkyd resin.

7. In apparatus for electrostatically spray-coating a surface with discrete particles of liquid coating material, an atomizing device, comprising: a rotatable atomizing member substantially concentric about its axis of rotation terminating in a peripheral edge, including an electrically conducting surface layer having a predetermined high electrical resistivity comprising a mixed alkyd resin and phenolic resin containing a finely divided electrically conducting solid of predetermined resistivity and a substantially electrically insulating layer in contact with and carrying said surface layer; means operatively associated with said surface layer for supplying an electric current to said surface layer; and means operatively associated with said atomizing member for supplying liquid coating material to said rotatable atomizing member for flow thereover to said peripheral edge.

8. Apparatus of the character claimed in claim 7 wherein the electrically conducting material is finely divided carbon.

9. Apparatus of the character claimed in claim 7 wherein said alkyd resin is a glyptal alkyd resin.

10. In apparatus for electrostatically spray-coating a surface with discrete particles of liquid coating material, an atomizing device, comprising: an atomizing member terminating in a peripheral edge, including an electrically conducting layer having a predetermined multi-megohm per square electrical resistivity and a substantially electrically insulating layer in contact with the electrically conducting layer; means operatively associated with said electrically conducting layer for supplying an electric current to said electrically conducting layer at a point remote from said peripheral edge sufficient to establish between said peripheral edge and the surface being coated an electrostatic field having an average potential gradient of at least several thousand volts per inch; and means operatively associated with one of said layers for supplying liquid coating material thereto for flow thereover to said peripheral edge for atomization therefrom.

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