United States Patent

Walberg

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[54] METHOD OF ELECTROSTATICALLY COATING WITH HIGHLY CONDUCTIVE MATERIALS

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Related U.S. Application Data

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[52] **U.S. Cl.** **117/93.42,** 117/129

[51] **Int. Cl.** **B05b 5/02**

[58] **Field of Search** 117/93.4–93.44, 117/129

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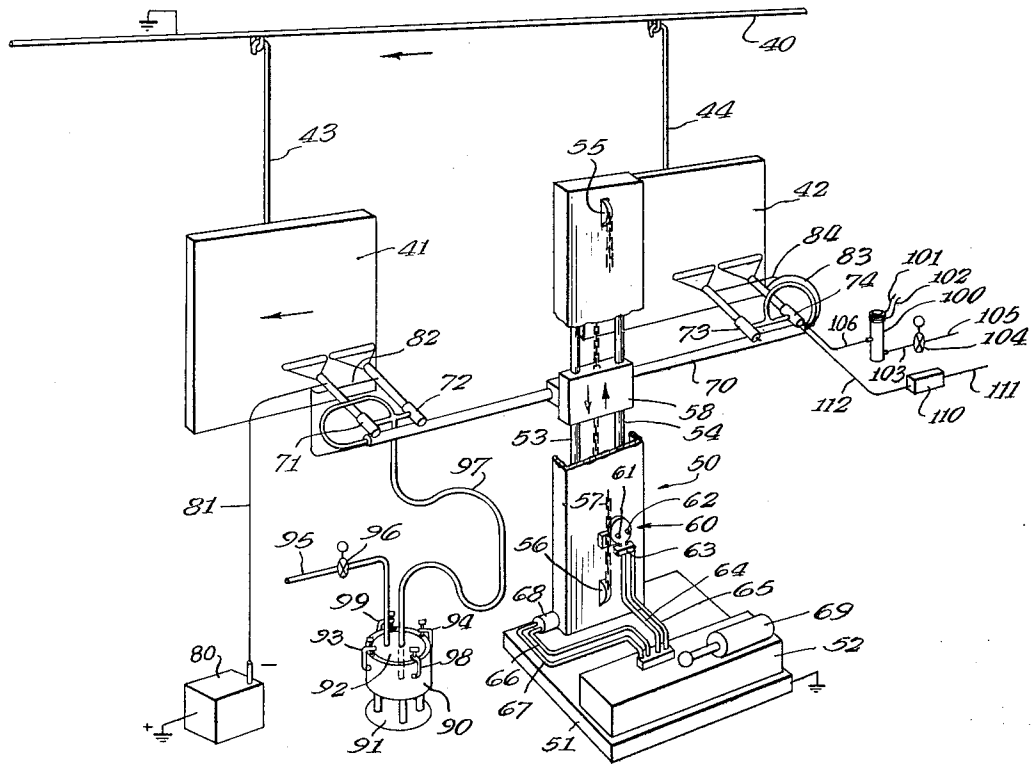
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[57] **ABSTRACT**

Work is electrostatically coated with highly conductive materials by air or hydrostatic atomizing spray guns. The rate of material application to work for water base material such as porcelain enamel is high being in excess of 3 mils of film thickness in less than 60 seconds to prevent "dry spray." The problem of "dry spray" is further controlled by placing the spray guns very close to the work (less than 12 inches).

4 Claims, 3 Drawing Figures



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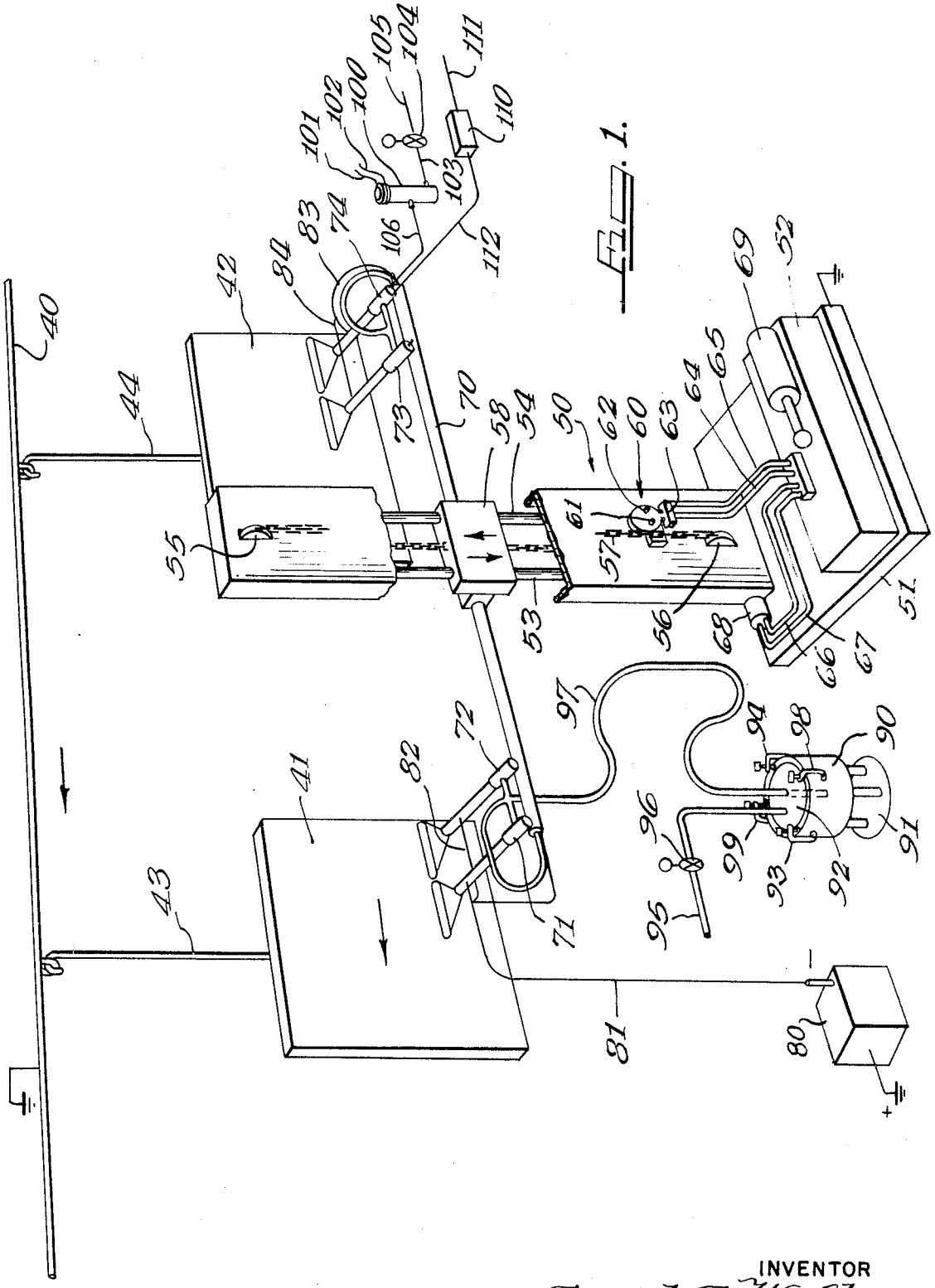


FIG. 1.

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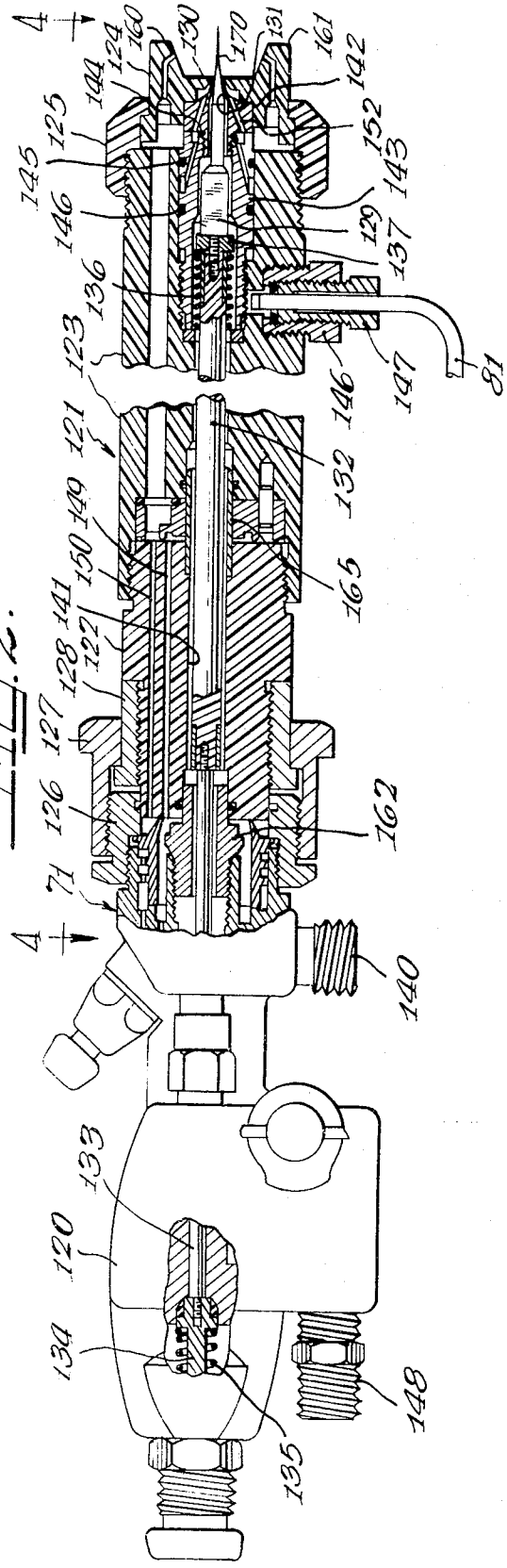


FIG. 2.

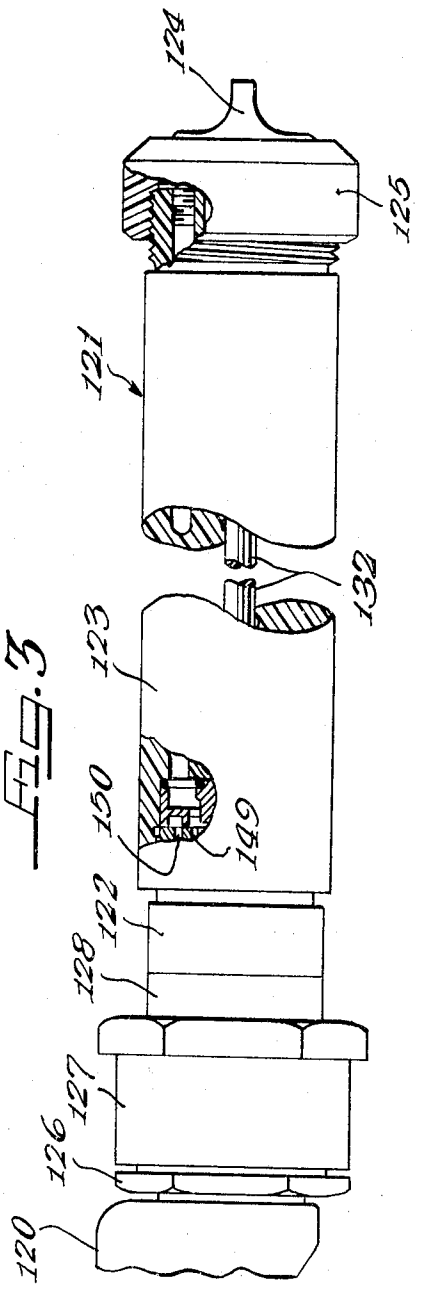


FIG. 3

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METHOD OF ELECTROSTATICALLY COATING WITH HIGHLY CONDUCTIVE MATERIALS

The present invention relates to spraying systems for applying coating material and more particularly to systems which are capable of electrostatically depositing coating materials having water as a carrier.

Attempts to spray porcelain enamel electrostatically using water as a carrier have met with failure during the past 15 years. The quality of finish has been unsatisfactory. The various electrostatic systems utilized causes defects such as (1) dry spray, (2) insufficient film thickness, (3) poor atomization, (4) nonuniform film thickness, (5) incomplete coverage and (6) poor electrostatic "wrap-around."

Dry spray was caused by building the film thickness too slowly or by having the atomized spray travel excessively long distances before it is deposited on the surface of the ware. The basic design of the systems used prevented the correction of the above problem. Since the liquid used in the porcelain enamel solution is water, the "wetness" or "dryness" cannot be adjusted in the same manner that solvent adjustments are made in electrostatic painting systems. When "dry spray" is encountered in painting, a slower "wetter" solvent can be added to the paint mixture. A paint that is too "wet" can be corrected by adding a faster solvent. This adjustable feature is missing when water solutions are sprayed electrostatically and this factor prevented prior art electrostatic systems from properly applying water base materials.

Insufficient film thickness was applied in previous attempts to master the spraying of porcelain enamel electrostatically. A heavy paint film falls in the 1.0 to 1.5 mils range of film thickness. Equipment that was designed to apply films of this thickness was not adequate to meet the 3.0 to 6.0 mils of thickness specified for porcelain enamel. Poor atomization of the porcelain enamel occurred when attempting to atomize the larger volumes of material needed to apply the heavy film thickness indicated above.

Nonuniform film thickness was caused by stacking several electrostatic spray guns in a vertical plane to spray ware that was wider than the 12-inch maximum that could be handled by one gun. It was difficult if not impossible to mate the adjacent spray patterns together to avoid an improper boundary effect. If the adjacent spray patterns overlapped, there was a heavy buildup of enamel in the overlapped area. If the spray patterns fell short of meeting, a light streak could occur. The resulting quality was not acceptable.

Some attempts were made to overcome the above problem by oscillating the spray guns in a vertical plane. This moved the heavy and light streaks around somewhat, but it did not correct the basic problem.

Incomplete coverage encountered with previous electrostatic systems was due to the excessive amount of waste caused by the poor operating efficiency of these systems. Some systems had better charging characteristics and wasted less porcelain enamel but could not penetrate into recessed areas, corners, or other hard-to-reach areas. The net result was incomplete coverage and excessive amounts of manual touchup to complete the job. The actual savings received, if any, was slight.

Poor electrostatic "wrap-around" caused by previous attempts in the spraying of porcelain enamel electrostatically resulted in poor coverage of the ware. The air spray guns used required excessively high-atomizing air pressures to atomize the high volumes of porcelain enamel that had to be sprayed. This caused excessive spray velocity and reduced electrostatic "wrap-around."Disc-type atomizers, on the other hand, can not atomize electrically conductive materials by electrostatic forces alone and had to be operated at exceptionally high-rotational speed to atomize the porcelain enamel centrifugally. This again resulted in high velocity that caused poor electrostatic "wrap-around." For the above reasons, electrostatic systems that have proved successful in applying paints and similar coatings have proved unsuccessful when used to apply porcelain enamel.

One system used consisted of a standard air-atomizing spray gun spraying through an ionizing electrode charged to 100,000 volts at the grounded ware passing on a conveyor at right-angles to the direction of the spray. The ionizing electrode consisted of two vertical tubes mounted 12 inches from the surface being sprayed and on 20-inch centers. A row of needlepoint ionizers were attached on 2-inch centers to the tubes on the side facing the ware. The needles pointed toward the ware. A spray gun or a station of several spray guns mounted on a vertical plane were arranged to spray between the two vertical electrodes. The guns were at ground potential and were positioned 12 inches behind the ionizing electrodes or about 24 inches from the grounded surface being sprayed. This 24-inch distance of travel of the atomized spray particles caused excessive drying of the spray particles resulting in a dry coat being applied to the product. There was insufficient flow-out. The quality of finish was not acceptable. In addition, all of the aforementioned faults were encountered in this system.

A variation of the above system called for mounting the guns to spray substantially parallel to the ware moving along on the conveyor. The spray passed between an ionizing electrode and grounded ware and was deposited on the ware by the electrostatic field. The distance traveled by the spray was again excessive and the resulting finish was unsatisfactory due to dry spray. All of the other faults indicated above were also encountered.

Both of the above systems were also unsuccessful because of low-operating efficiency. Too much enamel was wasted.

A newer electrostatic system consisted of a horizontal spinning disc reciprocating in a vertical plane with a conveyor carrying the ware in a loop around the disc. The disc was charged to 100,000 volts DC and the porcelain enamel was distributed over the disc by centrifugal force to be atomized at the edge of the disc. The disc normally atomizes paint electrostatically but it will not atomize electrically conductive material electrostatically. Since porcelain enamel is electrically conductive, it was necessary to drive the disc at high speed to atomize the porcelain enamel by centrifugal force. This system was more efficient since it atomized the material at the zone of ionization but the material was applied slowly as the ware passed around a 20-foot conveyor loop. This caused dry spray and required complete respraying of the surface with conventional air-atomizing spray guns to obtain an acceptable quality.

The disc-type atomizer also has severe limitations on the volume of porcelain enamel that could be atomized per unit of time. This greatly limit material delivery and caused insufficient film thickness and required excessive manual touchup to complete the job.

A disc-type atomizer had an additional disadvantage since it sprayed at all empty spaces between the products on the conveyor and caused excessive waste and uncontrolled buildup of coating on edges of a product that happened to be adjacent an open space.

The present invention overcomes a major share of the problems encountered in previous systems. Dry spray is not a problem. It was overcome by placing specially designed electrostatic spray guns at a much closer distance to the surface being sprayed. A spacing of 8 to 10 inches was found satisfactory. This spacing would be unsafe if a solvent-based paint was used in the system. The entire film of several mils is applied in a relatively short distance of conveyor travel. The actual coating operation is complete in 6 feet of conveyor travel or less. The velocity range of conventional conveyors is from 10 feet per minute to 24 feet per minute. Thus, the present invention applies the required film thickness in less than 60 seconds. This assures the desired wetness and the desired quality of finish.

Therefore, it is a principal object to provide a new and improved electrostatic spraying system for spraying abrasive material.

Another object of the present invention is to provide an electrostatic spraying system which is capable of effectively

spraying porcelain enamel or other highly abrasive material that requires control of the temperature of the atomizing air so as to counteract the effect of humidity in the atmosphere and thereby control "wetness" or "dryness" of the applied film.

Further objects and advantages will become apparent from the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is a perspective view of an automatic electrostatic spraying system embodying the present invention;

FIG. 2 is a partial sectional drawing of the electrostatic spray gun illustrated in FIG. 1; and

FIG. 3 is a partial broken-away elevational drawing of the electrostatic spray gun illustrated in FIG. 2 taken along the line 4—4.

While this invention is susceptible of embodiment in many different forms, there will be described herein in detail an embodiment of the invention with the understanding that the present disclosures are to be considered as exemplifications of the principles of the invention and are not intended to limit the invention to the embodiment illustrated. The scope of the invention will be pointed out in the appended claims.

Referring now specifically to FIG. 1, a conveyor 40 of any conventional design well known to those skilled in the art propels work to be coated, such as panels 41 and 42, when they are connected to the conveyor 40 by means of conductive hangers 43 and 44, respectively. The conveyor 40 is electrically connected to an electrical ground and therefore the work carried by the conveyor, such as panels 41 and 42, are also connected to ground through the respective electrically conducting hangers, such as 43 and 44, and the conveyor 40. A hydraulic reciprocator generally indicated at 50 has a base 51 upon which is mounted a hydraulic unit 52 and vertical guide rails 53 and 54. A pair of pulleys 55 and 56 are rotatably mounted to the guide rails 53 and 54 near the top and bottom of the rails. The pulleys 55 and 56 have grooves shaped to receive a drive chain 57 which has its ends connected to a spray gun carriage 58. The carriage 58 has ball bearings mounted internally (not shown) which contact the respective rails 53 and 54 in order that the carriage 58 may be smoothly guided in vertical movement by the guiderails. An analog control generally indicated at 60 is operatively connected to the chain 57 and has a pair of cams 61 and 62 for engaging a "rabbit ear" hydraulic four-way valve 63. The analog control 60 and the four-way valve 63 reverse the direction of travel of the spray gun carriage at the top and bottom of its stroke. By moving the cams closer together the unit will take a short strike. The shortest stroke will be in the neighborhood of 12 inches. By moving the cams on the analog control further apart, the length of the stroke is increased up to the maximum possible for the size of the reciprocator. The maximum stroke is approximately 3 feet less than the height of the reciprocator 50. The four-way valve 63 is connected to the hydraulic unit 52 by hydraulic lines 64 and 65. Another pair of hydraulic lines 66 and 67 are connected between the hydraulic unit and a hydraulic drive motor 68 which is connected to the pulley 56 to drive it, and thereby drive the chain 57 and the spray gun carriage 58. Since the hydraulic unit 52 may be any conventional source of hydraulic pressure well known to those skilled in the art, and since the valve 63 and drive motor 68 are connected and operated as is well known to those skilled in the art, this structure will not be described in detail.

A hollow crossarm 70 in the form of a tube of electrically insulating material is rigidly secured in the spray gun carriage 58. The movement of the crossarm 70 is therefore controlled by the analog control 60. The speed of reciprocation is adjusted by a manual control 69 which is mounted on and connected to the hydraulic unit 52. A set of four spray guns 71–74 are clamped to the crossarm 70.

A high-voltage power supply capable of supplying voltages generally in he range of 60,000 to 150,000 volts 80 has its positive output terminal connected to electrical ground and its negative output terminal connected to the spray guns 71–74 by high-voltage electrical lines 81, 82 83, and 84. The high-voltage line 83 passes through the hollow crossarm 70 in order to reach gun 74 and the gun 73 via line 84.

A porcelain enamel pressure tank 90 is mounted on a three-legged insulator stand 91. The tank 90 has a cover 92 which makes an airtight seal for the tank 90 when screw clamps 93, 94, 98 and 99 are utilized to secure it. A source of air pressure (not shown) is connected to an air line 95 of electrical insulating material (such as nylon) which has a manually or remotely operated air regulator 96 placed therein. The air line 95 is connected to the tank cover 92 to supply air at controlled pressure to the interior of the tank. A fluid hose 97 of electrical insulating material (such as nylon) extends through the cover 92 downward into the tank 90 and is connected to each of the guns 71–74 to supply coating material thereto. It will be noted that the hose 97, after is supplies coating material to the guns 71 and 72 through short connecting branches, passes through the hollow crossarm 70 to reach guns 73 and 74.

An air heater 100, which contains electrical heating elements (not shown), has these elements electrically connected to a source of electrical potential (not shown) by electrical leads 101 and 102. The air heater 100 has its air passages connected to a source of high-pressure air (not shown) through an air line 103, a manual air pressure regulator 104, and an air line 105 and connected to the gun 74 by an air line 106. A similar atomizing air heater (not shown) is provided for each of the other spray guns. A solenoid air valve 110 is also connected to a source of high-pressure air (not shown) by an air line 111, and it is connected to the trigger mechanism of gun 74, as will presently be described in greater detail, through the airhose 112. Similar controls (not shown) are provided for spray guns 71, 72 and 73 as well.

Since each of the spray guns 71–74 is identical in construction, only gun 71 will be described in detail. Referring now to FIGS. 2 and 3, the spray gun 71 comprises a metallic rear housing 120 and a barrel portion of nylon insulating material, generally indicated at 121, which comprises a first barrel section 122 threaded to a second barrel section 123 and an air cap 124 secured to the second barrel section 123 by a threaded annular retainer 125. The barrel section 122 is secured to section 120 by an annular fitting 126 to which an annular retainer 127 is secured by threads, and an annular cylinder 128 which is threaded onto section 122 and has an annular edge which contacts an annular edge of the retainer 127. A stainless steel valve 130 closes a passage 141 through the barrel portion 121 and the rear housing 120 when it engages an annular tapering valve seat 131 in a fluid tip 142. The valve 130 is connected to a stainless steel square shaft 129 which is connected to a stainless steel operating shaft 132 which is in turn connected to a stainless steel shaft 133. Shaft 133 is connected to an adjustable needle plunger 134 which has a spring 135 urging it towards the forward portion of the spray gun. A second spring 136 bears against a spring retainer 137 which is rigidly mounted on the shaft 132 to urge the shaft 132 and the valve 130 forwardly, closing the valve against the valve seat. Water carried porcelain enamel coating material from hose 97 enters an aperture 140 that connects with the passage 141 containing the shafts 129, 132 and 133 in order that coating material may flow around the shafts to the fluid tip 142. Thus, the coating material is conducted directly around the shafts which operate the valve in the front of the gun to the valve 130 within the fluid tip 142. Preferably, all parts with which abrasive coating material contacts such as water based porcelain enamel are constructed of abrasive resistant material such as tungsten carbide and stainless steel. The fluid tip 142 is secured between the air cap 124 and a fluid tip housing 143. Sealing rings 144, 145 and 146 prevent fluid from the passage 141 from leaking past the fluid tip housing 143. The fluid tip 142 and the fluid tip housing 143 are constructed of tungsten carbide and stainless steel, respectively, so that abrasive coating material such as porcelain enamel will have a minimum erosion effect upon these parts. The high-voltage electric lead 81 is connected through an electrical lead bushing 146 and an electrical truss screw 147. The

airhose **106** is connected to the threaded fitting **148** to supply air to the passages generally indicated at **149** and **150**. The passage **150** supplies air to two air horns **160** and **161** which form part of the air cap **124**, and the passage **149** supplies air to an annular air passage **152** in the fluid tip **142**.

The forward edge of the fluid tip **142** and a needle **170** mounted on the valve **130** and extending through the orifice of the fluid tip **142** form an electrode.

The length of the overall barrel **121** is normally of the order of 18 inches which prevents any substantial electrostatic field from existing between the charged rear housing **120** and grounded product **41**. The strongest electrostatic field exists between fluid tip **142** and needle **170** toward grounded product **41**.

A pilot bushing **165** aids in completing the passage **141** across the junction barrel section **122** and **123**, and a cylinder adapter **162** aids in completing this passage across the junction of the rear housing **120** and the barrel section **122**.

The guns **71–74** are similar in construction and design to the hand gun shown in my U.S. Pat. NO. 3,251,551, issued May 17, 1966, with the primary differences being that harder metals are used for such parts as the fluid tip **142** to resist abrasion, and that electrical connection is made directly to the fluid tip through an aperture in the side of the barrel rather than having an electrical lead run from one end of the insulated portion of the gun to the other end. While the gun illustrated in my U.S. Pat. No. 3,251,551, issued May 17, 1966, can be utilized for coating material having a resistivity of 10 megohms or greater per inch cube, the guns illustrated in FIGS. **11–3** can spray electrostatically conductive materials such as water based materials and such as Teflon. When a coating material such as Teflon is sprayed, it is not necessary to utilize the air heater **100** in the system.

However, in spraying porcelain enamel, the air heater **100** is an important element of the system. Since porcelain enamel coatings require the use of water as a vehicle in the slip being sprayed, the relative humidity in the ambient air in the spray booth or spray area creates special problems in control of the operation. These problems are especially noticeable during the summer months when the variations in relative humidity are the greatest. The heater **100** increases the atomizing air temperature as the humidity of the ambient air increases. This evaporates moisture in the sprayed film of coating on the work at an increased rate to permit control of the "wetness" or "dryness" of the applied film. The operating temperature of the heater may be as high as the order of 210° F. The heater **100** can be either controlled by a manually operated control or by a humidistat. If a humidistat is utilized, a completely automatic system is achieved since the relative humidity in the spray area or booth can vary substantially and repeatedly without a resulting deterioration of the quality of the applied porcelain enamel.

Porcelain enamel is very abrasive and creates problems in regulators used to control its pressure. Standard pressure regulators presently used in the spray painting art will not stand up under porcelain enamel service. Therefore, the system illustrated in FIGS. **1–3** does not have a regulator between the tank and the spray gun, but instead utilizes a pressurized tank to eliminate the requirement of a regulator. By utilizing a stationary pressure source, there is a variation in the static head at the various gun elevations as the reciprocator raises and lowers the guns as the work passes through their spray patterns as illustrated in FIG. **1**. This problem is overcome by the utilization of an orifice that creates sufficient back pressure at the desired delivery rate to cause a relatively high pressure to be maintained at the pressure tank **90** containing the porcelain enamel. Thus, the static head becomes a small percentage of the total fluid pressure at the spray gun. The static pressure of porcelain enamel varies approximately 0.65 to 0.75 p.s.i. for every foot of variation in elevation. When reciprocating the gun vertically, the gun will deliver more material at the bottom of the stroke and less at the top of the stroke. The film thickness on the product will vary in the same proportion. When a spray gun is positioned 36 inches above the floor, for example, a pressure at the gun of 3 p.s.i. can be established. If the pressure is controlled by a stationary pressure tank, this pressure will remain fixed. When the gun is raised 12 inches, the pressure will decrease approximately 0.75 p.s.i. leaving only 2.25 p.s.i. At 60 inches above the floor, the pressure will be reduced to 1.5 p.s.i. Thus, with only a 2-foot stroke, there would be a pressure variation of 2 to 1 and the applied film thickness would vary in a ration of approximately 2 to 1. By using a fluid orifice sufficiently small to cause a high-tank pressure, the variation in film thickness from top to bottom of the panel will be greatly decreased. At 10 p.s.i. fluid pressure variation of 2 feet in elevation will still cause a variation in static head of approximately 1.5 p.s.i. This is only 15 percent of the total and is therefore more acceptable. At 15 p.s.i. tank pressure, the variation drops to 10 percent and is considered highly satisfactory. Therefore, a tank pressure of 15 p.s.i. or higher is utilized to maintain a substantially consistent film thickness.

Spray guns **71–74** have the ability to atomize much larger volumes of material than anything encountered in the past. This permits the applying of heavy film thicknesses at high-operating speed (3.0 mils or greater in less than 60 seconds) with a minimum amount of equipment. The fast buildup of film thickness also helps to provide the necessary wet coat and eliminates the problem of dry spray. With the gums mounted horizontally and reciprocated vertically for the full height rather than being stacked vertically as in previous systems, each gun can apply a minimum of two light coats of porcelain enamel. Therefore, the four guns can apply eight light coats in rapid succession. Thus, the system illustrated in FIGS. **1–3** can provide higher quality than was possible prior to the present invention.

While the spraying of porcelain enamel and Teflon in a water base carrier has been specifically referred to, those skilled in the art will recognize that other coatings composed of particles such as various glass materials can be handles in the same manner as porcelain enamel, and that other particle coatings such as a plastic may be handles without humidity control in the same manner as Teflon. While abrasive material such as porcelain enamel can only practically be handles by air-atomizing spray guns as previously described herein, less abrasive materials such as Teflon and similar material can be sprayed as herein described both by air and hydrostatic spray guns. The scope of the appended claims is intended to include all such variations and modifications.

If it is desirable in a particular installation to have an electrode which will be highly erosion resistant beyond the structure illustrated in FIG. **2**, the fluid tip **142** may be made of tungsten carbide or other similar erosion-resistant material, and the needle **170** may be laterally offset from the nozzle of the fluid tip sufficiently so that material being ejected from the nozzle of the fluid tip does not impinge upon the needle. Such lateral offsetting of the needle **170** is accomplished by securing the needle to the fluid tip **142** rather than to the valve **130**. Such modifications are intended to be within the scope of the appended claims.

I claim:

1. The method of applying highly conductive fluid materials to work to be coated comprising:

air-atomizing conductive fluid material at a location within 12 inches of work to be coated,

directing the atomized material towards said work,

assisting the deposition of the atomized material on the work by applying an electrostatic field to the atomized material to charge it to a high potential with respect to the work, and

adjusting the rate of atomization of said material and the movement of said atomization location with respect to the work such that for any given position on the work the total elapsed time from he beginning of the first spraying of that position to the end of the last spraying of that position is less than 60 seconds and a film thickness of at least 3.0 mils is deposited.

2. The method of applying highly conductive fluid materials to work to be coated comprising:

hydrostatically atomizing conductive fluid material at a location within 12 inches of work to be coated,

directing the atomized material towards said work,

assisting the deposition of the atomized material on the work by applying an electrostatic field to the atomized material to charge it to a high potential with respect to the work, and

adjusting the rate of atomization of said material and the movement of said atomization location with respect to the work such that for any given position on the work the total elapsed time from the beginning of the first spraying of that position to the end of the last spraying of that position is less than 60 seconds and a film thickness of at least 3.0 mils is deposited.

3. A method of applying highly conductive materials to work to be coated as specified in claim 1 wherein said conductive material is porcelain enamel frit in water as a carrier.

4. A method of spraying highly conductive fluid materials to work to be coated as specified in claim 2 wherein said conductive fluid material is porcelain enamel frit in a water carrier.

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