

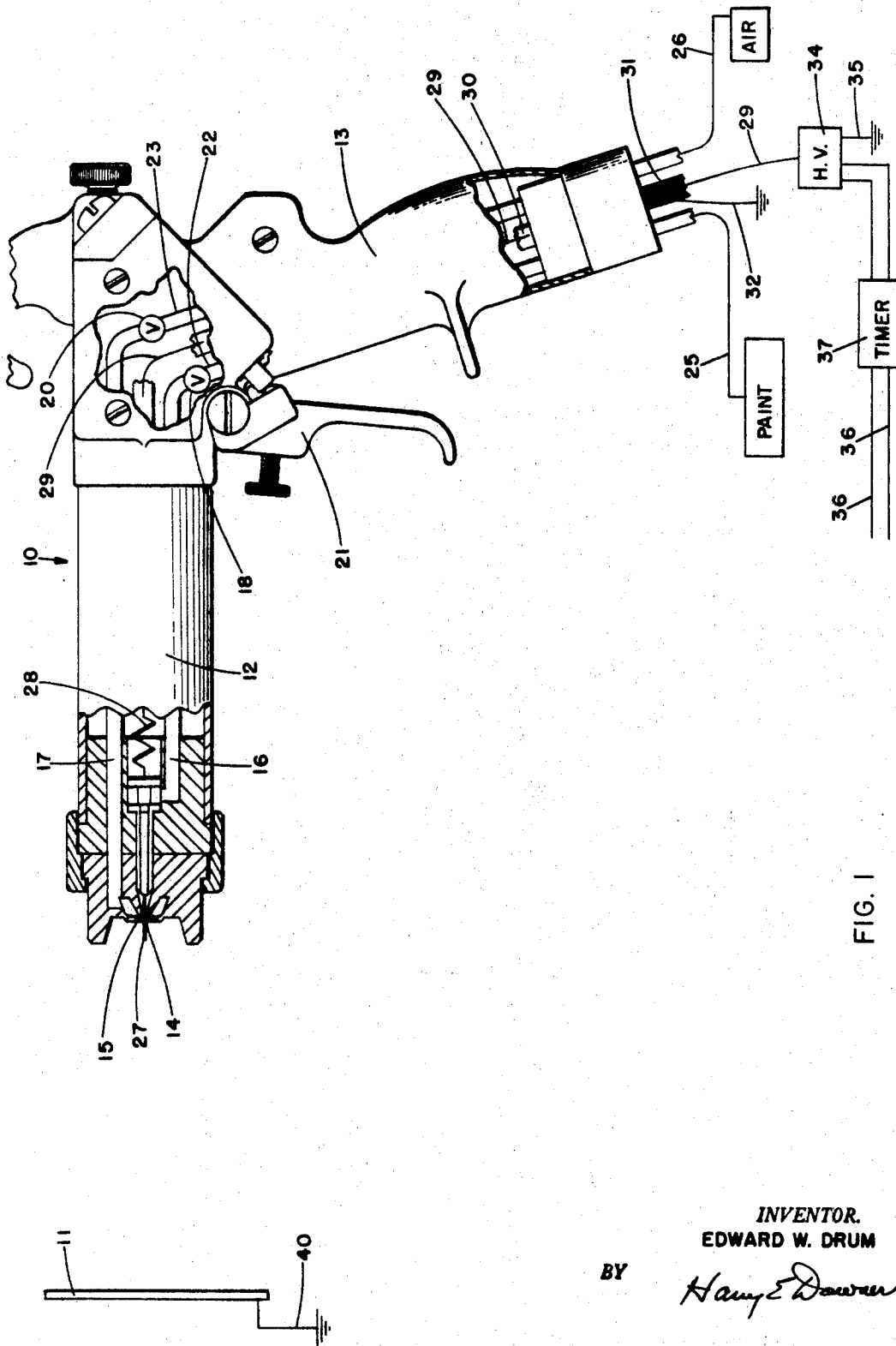
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ELECTROSTATIC COATING METHODS AND APPARATUS FOR
CONDUCTIVE COATING MATERIALS

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2 Sheets-Sheet 1



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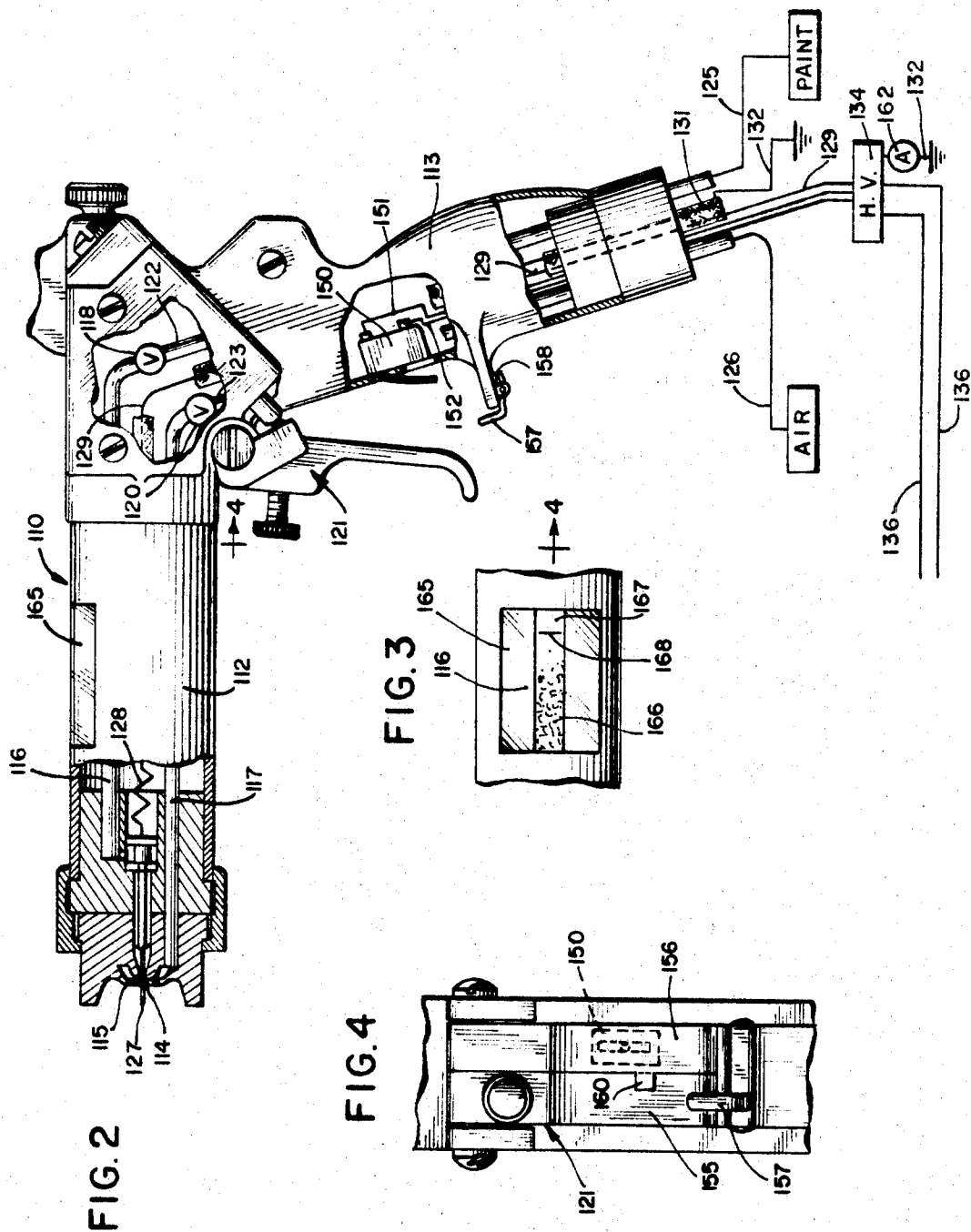
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ELECTROSTATIC COATING METHODS AND APPARATUS FOR CONDUCTIVE COATING MATERIALS

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Continuation-in-part of application Ser. No. 448,556, Apr. 5, 1965. This application Jan. 7, 1966, Ser. No. 530,753

15 Claims. (Cl. 117—93.4)

This application is a continuation-in-part of my application Ser. No. 448,556, filed Apr. 5, 1965, which is a continuation of my application Ser. 122,858, filed July 10, 1961 (both now abandoned), and both assigned to the assignee of this application.

This invention relates to methods and apparatus for electrostatic spray coating and more particularly to methods and apparatus wherein the use of electroconductive paints presents problems of design and/or operation.

Types of electrostatic spray coating systems in which conductivity of the coating material may present problems include those in which the paint or other coating material, at or adjacent the atomizing site, is in contact with an electrode maintained at high voltage. If the paint is electroconductive, the electrode will be grounded through the paint-supply column unless the entire paint supply apparatus is insulated from ground; and a system in which the entire paint supply apparatus is insulated from ground may frequently be undesirable because of the large amount of electrical energy it stores. Certain forms of electrostatic spray guns designed to be held in the hand while in use embody a grounded handle at the rear of the gun, a charged electrode in contact with the coating material at the front end of the gun, a current-limiting resistance through which the electrode is connected to high voltage, and a paint-supply system so arranged that the paint column is electrically connected to the grounded gun handle at the rear of the gun. In such a gun, any increase in the conductivity of the paint increases the current flowing through the current-limiting resistor and thereby decreases the voltage of the electrode; and some paints, otherwise usable in such a gun, are so conductive that the electrode potential would be lowered to a point where the paint particles are so poorly charged that the efficiency of paint utilization is seriously impaired.

The present invention springs from the discovery that the electrical conductivity of a column of paint containing electroconductive pigment particles dispersed in a liquid continuum of relatively low conductivity is a joint function of the voltage impressed on the paint column and time. Specifically, a paint of the type indicated may exhibit relatively low conductivity when a voltage is first impressed upon it and the conductivity will increase with the passage of time. However, if the voltage on such a column of paint is reduced while the paint is flowing, the conductivity of the paint column will drop. One way of taking advantage of this characteristic of paints of the type indicated is by cyclically varying the voltage impressed on the electrode through which high potential is imposed on the paint at or adjacent the atomizing site. By appropriate choices of the frequency and of the values between which the voltage is varied, it is possible to maintain the column of flowing paint effectively non-conductive while still retaining effective charging of the paint particles and relatively high paint utilization efficiency.

In the accompanying drawings:

FIGURE 1 illustrates one system with which the invention may be used, somewhat diagrammatically, employing an electrostatic spray gun adapted to be held in the hand while in operation;

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FIGURE 2 illustrates a hand gun with which the method of the invention can be practiced manually;

FIGURE 3 is a fragmentary plan view of the top of the gun barrel; and

FIGURE 4 is a fragmentary section taken along line 4—4 of FIGURE 2.

In the system shown in the drawing, a spray gun, designated in its entirety by the reference numeral 10, is shown as being used to spray a coating of paint or other liquid coating material on an article 11. The gun 10 comprises a hollow body or barrel 12 of insulating material projecting forwardly from a grounded, electroconductive handle 13. At the front of the insulating body 12 are means providing a central paint orifice 14 surrounded by an annular orifice 15 for the emission of atomizing air. Paint is supplied to the paint orifice 14 through a supply tube 16, while air is supplied to the orifice 15 through a tube 17. The tubes 16 and 17, which are of insulating material, extend rearwardly through the body 12 to the handle 13, where they are connected respectively to a paint valve 18 and an air valve 20, both adapted to be controlled, through means not shown, by a trigger 21. Tubes 22 and 23, connected respectively to the valves 18 and 20, extend downwardly through the grip portion of the handle 13 and are connected at the lower end thereof to flexible paint-supply and air-supply lines 25 and 26.

Supported within the paint orifice 14 at the front of the gun is a charging electrode 27, the rear end of which is connected through a resistor 28 in the body 12 to a lead 29 extending through the handle 13 to the lower end of the grip portion of the latter. Within the gun, the lead 29 is protected by a covering 30 of insulating material. Extending from the lower end of the handle 13, the lead 29 and its surrounding insulating cover are enclosed within a flexible conductive sheath 31, conveniently formed of braided wire. Such sheath is in electrical contact with the gun handle 13 and is grounded in any convenient manner, as indicated at 32. The lead 29 extends to the "hot" or ungrounded terminal of a high voltage source 34, the other terminal of which is grounded as at 35.

At the rear end of the gun, the column of paint flowing forwardly is grounded, either by electrical connection of the valve 18 to the grounded handle or by making the tube 22 of metal and electrically connecting it to the grounded handle.

The gun as so far described is not new. When the gun is in operation a high voltage is applied to the spray charging electrode 27 through the resistor 28, and the atomized spray particles formed by the interaction of paint emerging from the orifice 14 and atomizing air emitted from the orifice 15 are effectively charged and attracted to the article 11, which is grounded as indicated at 40. The resistor 28, which preferably has a multi-megohm value, serves the purpose of preventing or reducing the intensity of the electrical discharge which would occur from the electrode 27 upon its unduly close approach to any grounded article.

The system illustrated in the drawing and above described works satisfactorily so long as the paint or other coating material supplied to it possesses adequate electrical resistivity. However, if the paint should possess a relatively low resistivity, it would provide a conductive path from the electrode 27 to the grounded gun-handle 13, and current flowing over such conductive path, by increasing the voltage drop across the resistor 28, could lower the voltage of the spray charging electrode to a point such that the spray particles would be ineffectively charged and many of them would escape deposition on the article 11. Certain types of paint, not infrequently used in industry, cannot be used efficiently in such a gun because of their effect in reducing the potential of the

electrode 27. Such paints are those, such as aluminum paints, containing particles of electroconductive material suspended in a liquid continuum of relatively high electrical resistance.

As previously indicated, it has been found that when a high voltage is impressed upon a column of paint of the type just mentioned, the electrical conductivity of the paint increases with the passage of time. The time interval required for the paint to acquire a conductivity capable of seriously affecting operation of the gun depends on several factors including the nature of the paint and the voltage applied. Under operating conditions such as are most likely to be encountered in practice, that time interval may vary from about one second, or even less, to about several seconds. Upon reduction or removal of the applied voltage to the column of paint, when it is flowing, the conductivity of the paint column falls off, usually at a rate more rapid than that at which it increases when voltage is applied. By incorporating in the supply line 36 to the high-voltage source a timer 37 which will produce properly chosen variations in the output voltage in the high-voltage source 34, it has been found that aluminum paints and other paints of similar character can be prevented from causing reduction of the voltage at the electrode 27 to a point such that paint utilization efficiency is undesirably impaired. Likewise, the variations in output voltage produced by the timer 37, if properly chosen, will not reduce the voltage at the electrode 27 to a point such that paint utilization efficiency is undesirably impaired. The voltage at the electrode 27 is of course dependent upon the output voltage of the high voltage source. However, variations in the output voltage of the high voltage source do not instantaneously result in equal variations of the voltage at the electrode.

The nature of the effect produced by the timer 37 upon the output voltage of the source 34 may vary depending upon the character of paint being sprayed, upon the dimensions of the insulated paint supply tube 16, and perhaps other factors. One of the factors determining the character of the cyclical variation in output voltage of the source 34 is the viscosity of the paint. It has been found that in general the more viscous the paint, and the lower its content of conductive pigment, the longer is the time interval required for the column of paint between the electrode 27 and the grounded handle 13 to become objectionably conductive. This observation tends toward a conclusion that conductivity of the paint depends upon movement of the electroconductive pigment particles into some particular relative arrangement. However, while dependence of conductivity upon arrangement of pigment particles would explain the phenomenon which has been observed, that explanation is not meant to be binding.

As a specific example of the practice of this invention, citation may be made to conditions employed in the spraying of a typical aluminum paint containing 4.4 ounces of aluminum pigment per gallon of a vehicle consisting of approximately 28% alkyd resin (100% solid), 14.5% ureaformaldehyde resin (100% solid) in xylol, 57% solvents and 0.5% amine additive, and sprayed from a gun of the type illustrated in which most of the paint column was contained in a glass tube, and between its point of contact with the electrode 27 and its point of grounding, had a diameter of about 0.190 inch and a length of about 7 inches. With the paint having a viscosity of 25 seconds in a Zahn No. 2 cup at 82° F., and with the voltage source 34 arranged to provide an output voltage of 45 kilovolts, satisfactory results may be obtained by adjusting the timer 37 to provide repetitions of a cycle in which the source 34 is energized for intervals of one to three seconds and de-energized for intervals of one-half to one second.

It is to be noted that with air spray guns of the type illustrated, wherein the high voltage is applied to the charging electrode only when the trigger is engaged, engaging and disengaging the trigger in a cyclical manner

may, under certain conditions and with some types of coating materials, achieve the results of this invention. However, in many situations triggering alone is not sufficient to overcome the problems solved by this invention, although in many of such situations, cyclical variation of the output voltage of the high voltage source, as hereinbefore described, will produce the desired results.

In FIGURE 2, a modified hand gun 110 is shown, in part diagrammatically. With the hand gun of FIGURE 2, the high voltage may be cycled manually while the coating material continues to flow. The basic structure of the spray gun 110 is the same as that of the spray gun 10 shown in FIGURE 1. A barrel 112 extends forwardly from grounded conductive handle 113. The nozzle structure at the front of barrel 112 has a coating material discharge orifice 114 surrounded by an orifice 115 for the emission of air which atomizes the coating material. Charging electrode 127 extends outwardly through coating material discharge orifice 114 and is connected through resistor 128 and lead 129 with high voltage source 134. The conductive sheath 131 on the high voltage cable is connected with conductive handle 113 and is returned to a suitable ground 132.

Coating material is delivered to the discharge orifice through tube 116 and the control valve 118 which in turn is connected through tube 122 and supply line 125 with a source of paint or other coating material. Atomizing air is delivered through tube 117 and control valve 120, which is connected through tube 123 and supply line 126 with a compressed air source.

The high voltage supply 134 is energized from a suitable source, as 110 volts AC, connected with terminals 136, and its operation is controlled by a switch 150 mounted in the handle of the gun. When switch 150 is actuated, high voltage supply 134 is rendered operative and high voltage is present on electrode 127. When switch 150 is released, the high voltage is removed from the charging electrode circuit. Switch 150 is connected through leads 151, 152, which may be a part of the high voltage cable, with the high voltage supply.

Trigger assembly 121 is pivotally mounted on the gun body and has two independently actuable sections 155 and 156. Trigger section 155 operates the coating material and air valves 118 and 120 and, when it is moved toward handle 113, the valves are opened. Trigger section 156 operates switch 150 and when moved toward handle 113 actuates the switch turning on the high voltage to charging electrode 127. Trigger section 155 may be secured in the actuated position by a latch 157 pivoted on handle 113 and urged to the position shown in FIGURES 2 and 4 by spring 158. Trigger section 155 can be released by depressing catch 157.

A tab 160 extends from trigger section 156 across a portion of the surface of trigger section 155, insuring that coating material and air valves 118 and 120 are open whenever high voltage switch 150 is actuated.

When utilizing hand gun 110 to spray conductive coating materials which after a period of use provide a low resistance path to ground for the high voltage, the operator may release trigger 156 at appropriate intervals, removing the high voltage until the resistance of the column of coating material in tube 116 returns to a high value such that excessive current is not diverted to ground. The operator may determine when to release trigger portion 156 by observing an indication of the resistance condition in the column of coating material between electrode 127 and valve 118. One measure of the conductivity of the coating material is the current drawn from high voltage power supply 134. This current may be measured by a micro-ammeter 162 connected in the ground return for the high voltage circuit. In practice, the ammeter 162 is placed in a location where it is visible to the operator and the dial provided with an appropriate marking to indicate the flow of excessive current. When this occurs, the operator releases the trigger section 156, removing the high

voltage. After an appropriate period of time, trigger section 156 can again be actuated turning on the high voltage.

The operator might also observe the condition of the coating material between high voltage charging electrode 127 and valve 118. The physical appearance of the coating material in tube 116 provides an indication of the resistance of the coating material column. As the gun is operated and the column of paint between the charging electrode and the grounded valve is subjected to high voltage, the coating material develops a turbulent appearance which begins at the charging electrode and moves rearwardly through the tube to the valve. The closer the turbulent appearing zone of the coating material comes to the grounded valve, the less the resistance of the column and the greater the current flow. This effect can be utilized to provide an indication to the operator to operate trigger portion 156. In the embodiment of the invention illustrated in FIGURES 2 and 3, barrel 112 has a transparent window 165 in the upper surface thereof. Paint tube 116 is of a transparent material, as glass, so that the condition of the coating material moving therethrough is readily apparent to the operator. This condition is illustrated in FIGURE 3 where the coating material in tube 116 has a turbulent appearing area 166 and a non-turbulent appearing area 167 rearwardly thereof. When the turbulent appearing area reaches index mark 168 on window 165, the operator releases trigger section 166 removing high voltage from the system.

In addition to the factors of viscosity and conductive particle content mentioned above, the rate at which the resistance of the coating material column decreases is also affected by the rate of flow of the coating material through tube 116. If the tube is large in diameter and the coating material slow moving, the resistance will tend to fall rather rapidly as the coating material has a laminar flow and the particles tend to retain the same relative positions while they flow through the tube. With a tube of smaller diameter, friction between the coating material and the tube wall causes a shearing effect, disorienting the coating material particles. This reduces the tendency of the coating material to form a low resistance shunt path to the grounded valve. Conversely, after the high voltage is removed, the coating material which has been acted on by the electric field is disoriented rapidly, if the tube 116 is small, permitting re-establishment of the high voltage.

In referring above to voltage variations as occurring cyclically, it is not to be implied that the variations need involve repetitions of a uniform pattern at uniform time intervals, as such uniformity is not at all necessary. Neither need the variations be produced strictly in accordance with time; since a current-responsive device could be employed to reduce the voltage whenever the current, as affected by conductivity of the paint, reached an undesirably high value.

While this invention has been illustrated and described in conjunction with particular electrostatic spray coating systems, it is not limited thereto, but may be employed in electrostatic coating systems having a spraying device to which coating material is fed and in which there exists a voltage difference between any two points along the coating material feed path.

I claim:

1. In a method of electrostatically coating an article with a coating composition having conductive particles suspended within a liquid continuum of relatively low conductivity, the steps of flowing said coating composition in the form of a column between first and second points, maintaining said points at different electrical potentials, and promoting electrical impedance between said two points in the paint column by cyclically varying the potential maintained between said two points while continuing the flow of coating composition between said points.

2. The method of claim 1 in which said coating composition is maintained at a high voltage at a first point

adjacent a site at which the composition is atomized and the composition flows towards said site in the form of a column grounded at said second point.

3. The method of claim 1 wherein said potential gradient is cyclically varied between higher and lower values and, in each cycle, the potential is maintained at the higher value for more than one-half the duration of the cycle.

4. A method as set forth in claim 1 wherein the variation is cyclical at a frequency of about 15 to 40 cycles per minute.

5. A method as set forth in claim 1 wherein the conductive particles of the coating composition are metallic flakes.

6. The method of claim 2 wherein a spray charging electrode is provided adjacent the site of atomization, there being a first conducting path between said electrode and the high voltage source to energize said electrode, said method including the steps of providing a second conducting path through the atmosphere between said spray charging electrode and the grounded article establishing an electrostatic field therebetween, said second conducting path and said column of coating composition providing parallel electroconductive paths from said charging electrode to ground, the cyclical variation of the voltage from said high voltage source maintaining said paint column effectively nonconducting.

7. An electrostatic coating apparatus for coating an article with a coating composition having conductive particles suspended within a liquid continuum of relatively low conductivity comprising, an atomizer having an atomizing zone, means for feeding said coating composition to said atomizing zone in the form of a column, means for maintaining a high voltage on said coating composition at a first point adjacent said atomizing zone, means for maintaining a second point of said column, spaced from said first point, at a potential different from said first point, and means for cyclically varying the potential between said first and second points.

8. The electrostatic spray coating apparatus of claim 7 wherein said coating material feed means includes a passage extending to said atomizing zone, said passage being electrically connected to ground at a point remote from said atomizing zone, a charging electrode adjacent said atomizing zone and contacted by said coating material, means connecting said electrode to a source of high voltage for maintaining a highly ionized zone surrounding said electrode, the voltage from said high voltage source being cyclically varied to prevent the formation of highly conducting paths through the coating material, thereby substantially to sustain the highly ionized zone surrounding said electrode.

9. The method of controlling the conductivity of a composition having conductive particles suspended in a liquid medium of relatively low conductivity, comprising the steps of flowing said composition in the form of a column between first and second points, applying an electric potential to said column between said points and cyclically varying the electric potential between a high value and a low value while continuing the flow of said composition.

10. The method of claim 9 wherein the high value of electric potential is of the order of several kilovolts and the low value of electric potential is zero.

11. The method of claim 9 wherein the cyclic variation is such that the high value of electric potential is maintained for a time at least as great as the time the low potential is maintained.

12. The method of claim 1 wherein the cyclic variation of potential is between a high value of the order of at least several kilovolts and a low value, substantially zero.

13. The method of claim 1 wherein the cyclic variation of the potential is between a high value and a low value and the high value is maintained for a period of

time at least as great as the time the low value is maintained.

14. The apparatus of claim 7 wherein said potential varying means includes a timer.

15. The apparatus of claim 14 wherein said means for maintaining a high voltage includes a high voltage source having a supply line and said timer is connected in said supply line and is operative to interrupt the supply line at intervals.

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