United States Patent [19]

Walberg

[11] **3,795,839**

[45] **Mar. 5, 1974**

[54] **METHOD FOR PREVENTING ARCING IN AN ELECTROSTATIC COATING SYSTEM**

[75] Inventor: **Arvid C. Walberg,** Lombard, Ill.

[73] Assignee: **Graco Inc.,** Minneapolis, Minn.

[22] Filed: **Nov. 3, 1971**

[21] Appl. No.: **195,430**

Related U.S. Application Data

[62] Division of Ser. No. 665,104, Sept. 1, 1967, Pat. No. 3,641,971.

[52] **U.S. Cl.** **317/3,** 118/7, 239/15

[51] **Int. Cl.** **B05c 1/00**

[58] **Field of Search** 317/3; 118/4, 7, 8; 239/15

[56] **References Cited**

UNITED STATES PATENTS

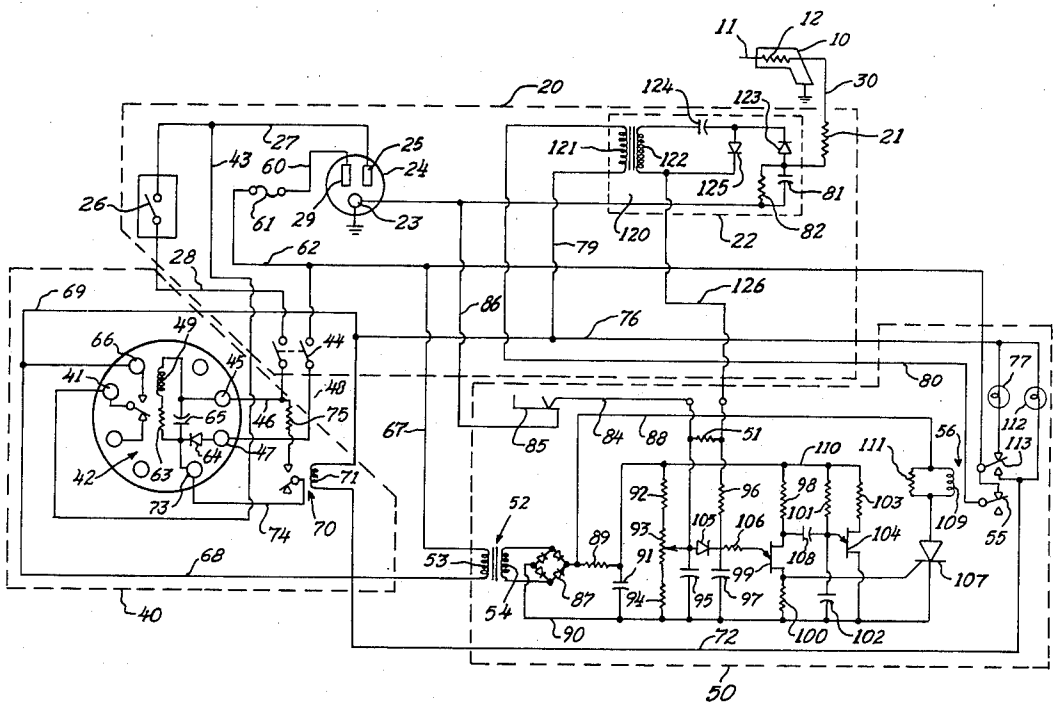
2,650,329	8/1953	Orndoff	317/3 X
3,273,015	9/1966	Fischer	317/3

Primary Examiner—James D. Trammell

[57] **ABSTRACT**

A method for setting up and using a safety circuit for an electrostatic coating system. A sensing circuit is connected to a source of potential to sense the current flow between the gun electrode and work to be coated. A delay circuit normally delays de-energization of the current to the electrode unless the sensing circuit senses a predetermined value in which case de-energization occurs without delay. A resistance may be connected to the electrode to aid in reducing disruptive arch and also to the sensing circuit. The sensing circuit may be set to sense the current through the electrode at different predetermined values after determining the maximum length of disruptive arc between the electrode and work to be coated and also the amount of current that would cause such an arc. Before the predetermined value in the sensing circuit is exceeded, the source of high potential is de-energized. The potential source may be prevented from being energized until control means are recycled.

9 Claims, 8 Drawing Figures



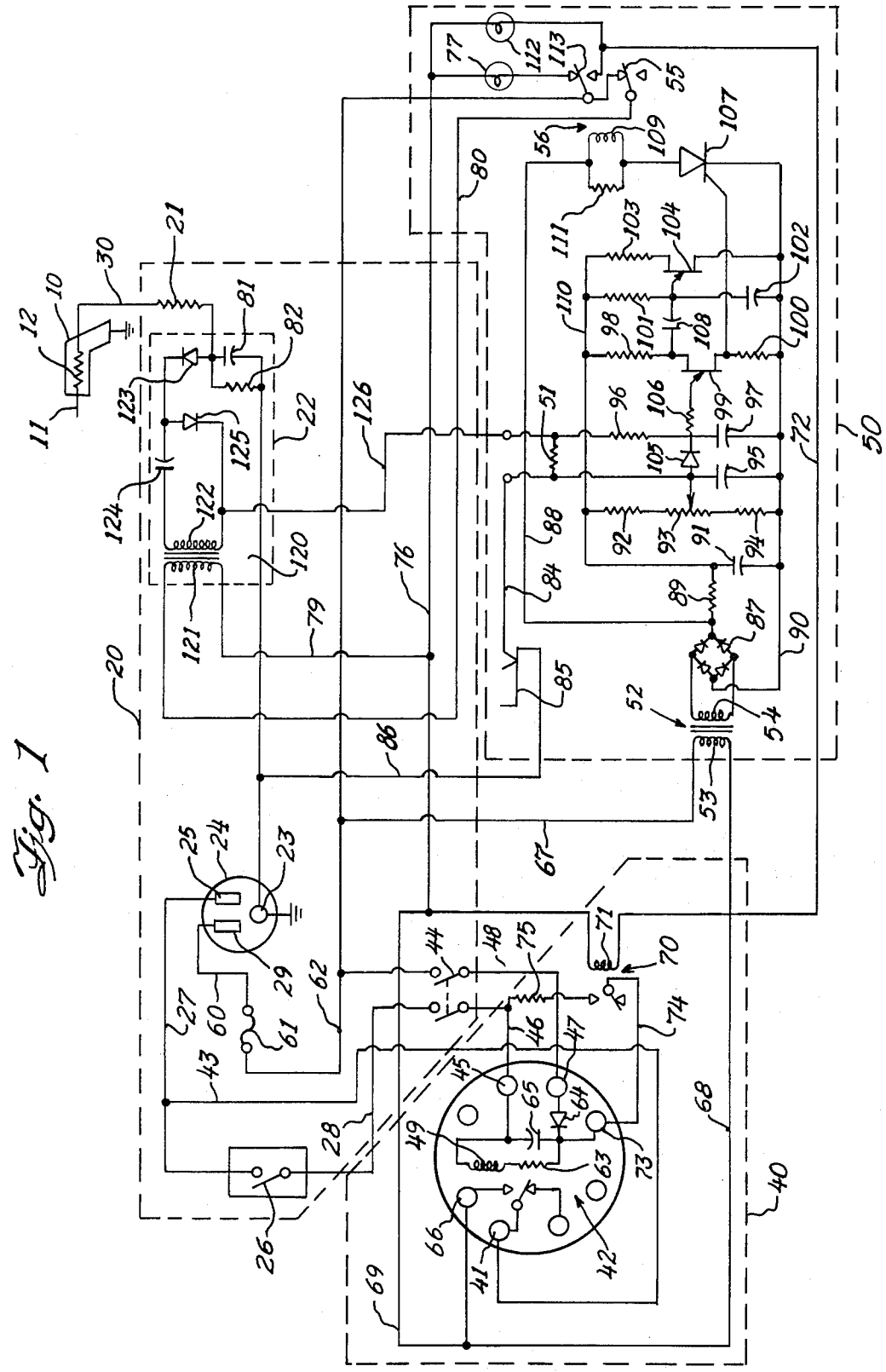


Fig. 1

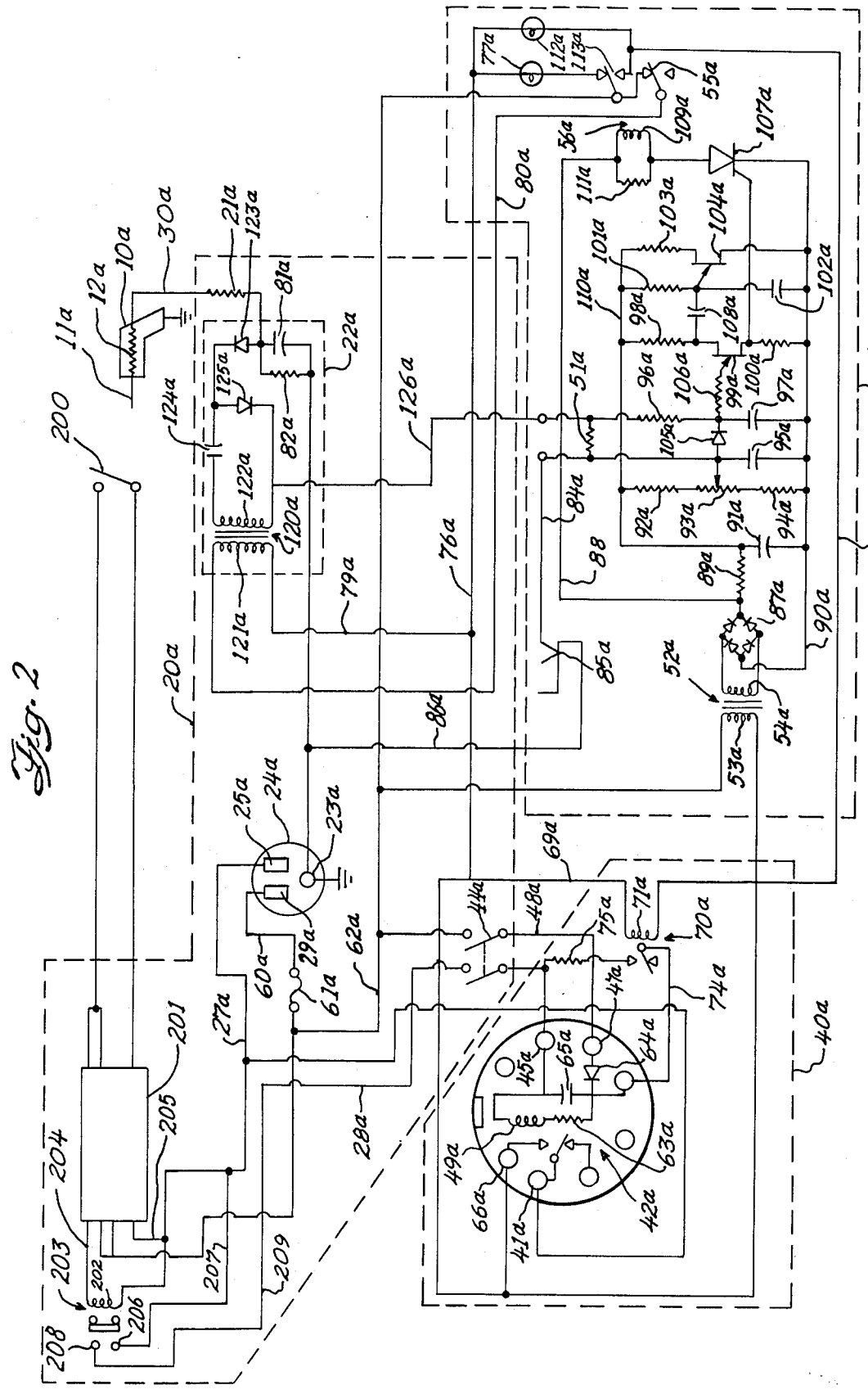
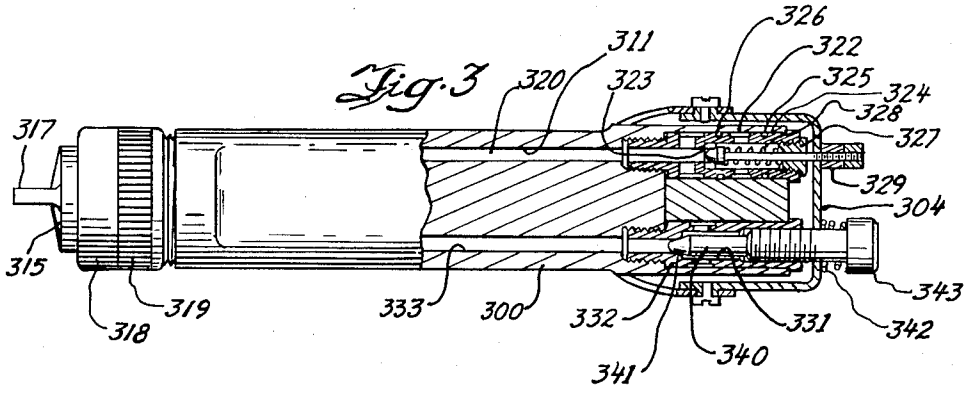


Fig. 2

Fig. 3


326
322
311
325
320
323
324
328
327
317
329
304
315
343
319
333
300
332
331
342
318
340
341

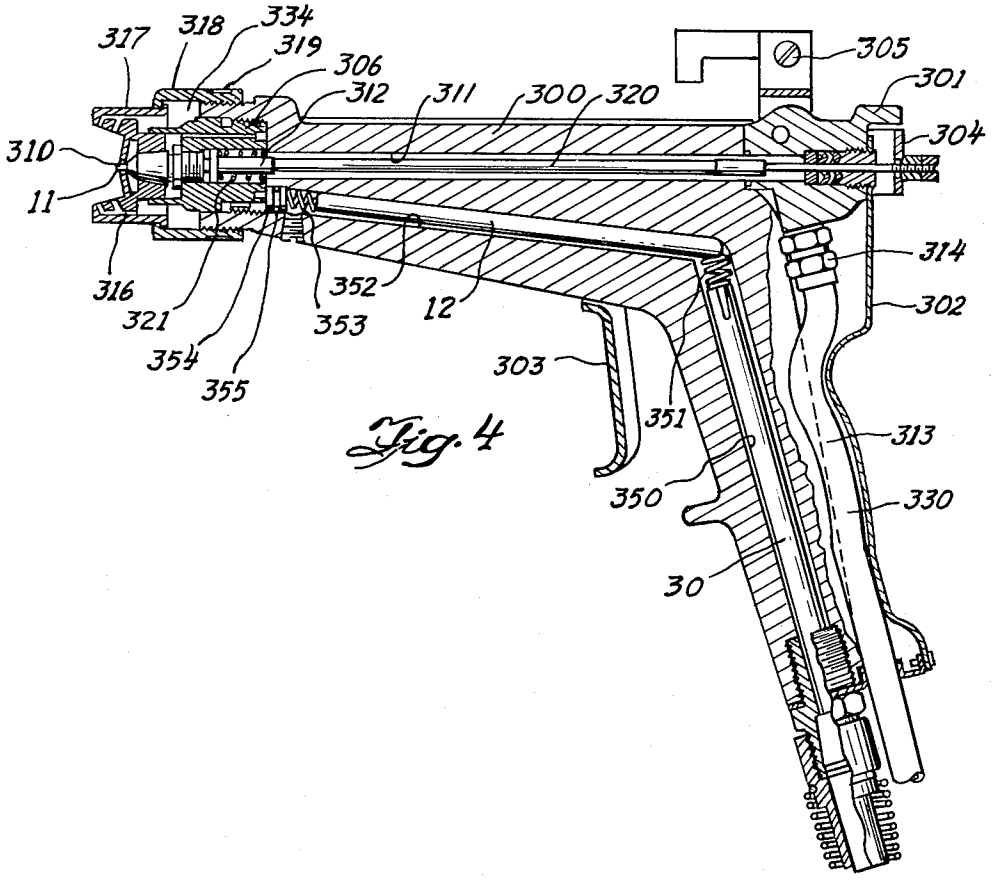

317
318
334
319
306
312
311
300
320
305
301
304
310
11
314
302
316
321
352
12
353
354
355
303
351
313
350
330
30

Fig. 4

Fig. 6

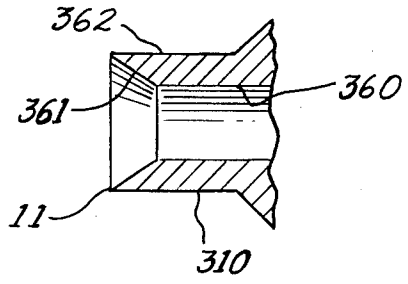


Fig. 5

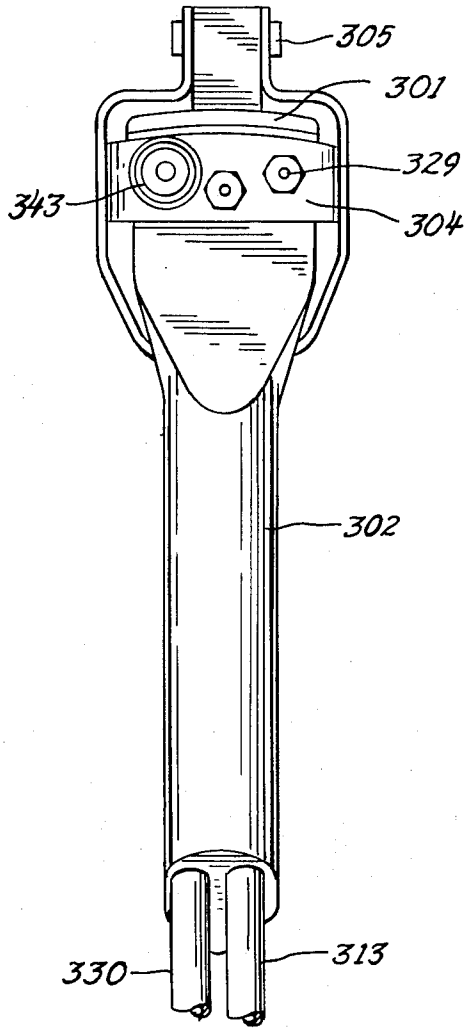


Fig. 7

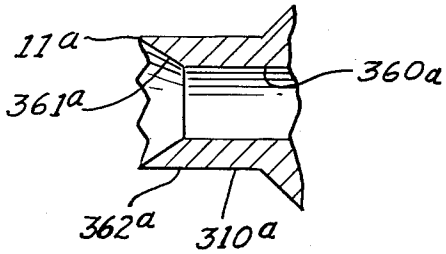
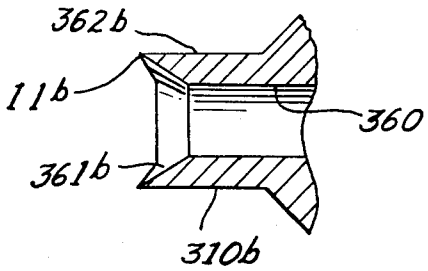


Fig. 8



METHOD FOR PREVENTING ARCING IN AN ELECTROSTATIC COATING SYSTEM

This is a divisional of application Ser. No. 665,104 filed Sept. 1, 1967, now U.S. Pat. No. 3,641,971.

This invention relates to electrostatic coating systems and more particularly to method and apparatus for the safe operation of electrostatic coating systems while maintaining the maximum efficiency of such systems.

Electrostatic coating systems are divided into two major categories of automatic systems and manual systems. The spray guns in automatic systems are mounted on supports and work to be coated is moved past the spray guns. The spray guns themselves may be stationary or given a reciprocating movement by an automatic drive. In the manual systems the spray guns are hand held and hand manipulated. Since the spray guns in the automatic systems may be placed at a reasonably fixed distance from the closest approach of the work to be coated when such work is carried by a conveyor, this distance is generally fixed to be greater than the maximum length possible for a disruptive arc between the electrode associated with the spray gun and the work to be coated. It is common to utilize electrical potentials of 100,000 volts between the electrode and the work to be coated in automatic systems. In order to prevent a disruptive arc occurring between the electrode and the work to be coated, the electrodes must be at least 6 inches from the work to be coated as it passes on the conveyor. Thus, at the present time, spacing of the electrode from the closest approach of the work is the primary method of achieving safety from hazardous arcing in automatic electrostatic systems.

However, in manual electrostatic coating systems, the operator often brings the forward part of the spray gun close to the work being coated and to other objects which are grounded relative to the potential placed on the electrode by the system's power supply. Thus, some other method of achieving safety in manual systems was required. The present inventor, Arvid C. Walberg, in his U.S. Pat. No. 3,251,551, issued May 17, 1966, teaches the use of a dropping resistance to reduce the maximum length of a disruptive arc to less than 2 or 3 inches and the use of a shield of electrical nonconductive material surrounding all conductive portions on the forward end of the spray gun body. James W. Juvinall and James G. Marsh in their U.S. Pat. No. 3,048,493, issued Aug. 7, 1962 taught the use of an electrode having a very small capacity to the work to be grounded with a very large resister connected in series between the electrode and the high voltage lead from the power supply. In the Walberg system the safety control action is obtained by the combination of a suitable dropping resister and metal at high potential insulated from atmosphere except for a very sharp tie or edge from which continuous electrostatic charge escapes into the atmosphere. This results in the electric charge from the exposed metal being drained off so fast as the distance from the exposed tip to ground is reduced that no substantial charge can be built up on the surface of the metal in the gun where sheltered from the atmosphere by insulation. Thus, the Walberg patent teaches the use of a moderate amount of resistance to reduce the maximum length of disruptive discharge to less than 2 or 3 inches and reduces the destructive effect (electrical energy expended) by convering all exposed metal in the forward end of a spray gun with insulation so that only the tip of the electrode is exposed.

Juvinall and March utilize generally larger resistances and employ them in a different manner. They teach the use of resistance to limit the amount of current that can flow into their small electrode after it has been discharged. The initial discharge from an electrode will be followed by a series of repetitive disruptive discharges as long as the electrode is manually held sufficiently close to the work to be coated or other grounded objects. After the currents of each arc, the electrical potential on their small electrodes will be charged through the associated resister. Thus, the resister and the electrode become a resistance-capacitance circuit having the traditional exponential charging curve. As soon as the electrode charges to a voltage which sill cause an arc, the arc will again dissipate the charge on the electrode. Thus, a series of pulses in the form of disruptive arcs will occur between the electrode and a grounded object when the electrode is held sufficiently close to allow such arcs to occur. During such arcing, the voltage between the electrode and ground will have essentially a saw-toothed wave form. The slope of this saw-toothed wave form, which is a graph of voltage plotted against time, will depend upon the time constant of the resistance-capacitance circuit. Increasing the voltage applied to the resistance-capacitance circuit will increase the amount of electrical energy dissipated per unit time by the arcing. Increasing resistance decreases the amount of energy dissipated per unit time by disruptive arcing. The quantity of energy expended by such arcing is equal to the energy stored in the electrode at the time of each discharge multiplied by the number of discharges per unit time. Thus, if the time between discharges should be equal to one time constant, the quantity of charge dissipated in the arcing would be equal to the quantity of charge on the electrode divided by the time constant. Thus, the amount of energy dissipated in the arcs per unit time would be an effective arcing current, I_{ae}. Then,

$$I_{ae} = Q/T$$

but

$$Q = CV$$

where c is the capacitance of the electrode and V is the voltage on the electrode as compared to ground at the time of each discharge and T is equal to RC. Thus,

$$I_{ae} = EC/RC = E/R$$

Whenever the time between discharges or arcs is less than one time constant, the voltage to which the electrode would charge will be approximately proportionately less, since the curve of a resistance-capacitance circuit is approximately linear during the first time constant. Therefore, as the frequency of disrcharges increases, the voltage and therefore the energy is each discharge will proportionately decrease, and I_{ae} will remain essentially constant. The capacitance of electrodes increases gradually as the electrode is brought towards a grounded object but this effect is negligible. When the frequency of discharge is greater than one time constant of the resistance-capacitance circuit, the proportional amount of voltage and, therefore, energy will be less and I_{ae} will decrease. Therefore, by taking a time period of one time constant and computing I_{ae}, we are in effect computing I_{ae} maximum and I_{ae}

maximum occurs throughout arcs occurring less than one time constant apart.

In pointing out the relationship between the value of the resistance and the amount of capacitance of the electrode to ground that can be tolerated, Juvinall and March taught that in a system having an order of 1,000 megohm resistance with 100 kilovolts applied from the negative terminal of a power pack having its positive terminal grounded, the energy level of a disruptive discharge to a grounded polished metal sphere of about one centimeter radius from an electrode ahead of the control resistance should preferably not exceed that of a polished metal sphere having a radius of about one centimeter and in any event should not exceed that of a sphere having a radius of about three centimeters. Such a combination would have an effective arcing current of 100 microamperes. They further taught that for an electrode having a capacity of a sphere having a radius of three centimeters without objectionable shock and without danger of ignition and the most combustible vapor air mixture possible a higher resister value is 4,000 megohms and a lower applied voltage of 500 kilovolts should be utilized. This combination would have an effective arcing current of 12.5 microamperes.

In the Walberg device the use of about 25 megohms for 10,000 volts is taught to provide a normal operating current drain of about 0.1 milliampere. Thus, if 100,000 volts is to be applied in a Walberg type system, the resistance in the spray gun should be 250 megohms. In such an arrangement the effective arcing current would be 400 microamperes. Since the suggested resistance is related to the applied voltage, the Walberg system should always have approximately 400 microamperes for its value of effecting arcing current.

Thus, at the present time, the two methods recognized in the art required the use of resistance in a manual electrostatic coating system for different purposes. In the Juvinall and Marsh system, the resistance must be great enough if an electrode has a capacity equal or less than a sphere of 1 centimeter radius to limit I_{ae} to 100 microamperes. In the Walberg system, the resistance is utilized to limit the length of the maximum disruptive discharge and to limit the steady state current of a grounded electrode. The steady state current of a grounded electrode, I_g, is equal to the I_{ae} of a system when there are no other resistances placed elsewhere in the system. Thus, in the Walberg system

$$I_g = I_{ae} = 400 \text{ milliamperes}$$

The utilization of the Walberg system utilizing a shield with only a small tip of electrode protruding allows for approximately four times the amount of normal current flow than that which can be tolerated under the resistance-capacitance circuit safety device taught by Juvinall and Marsh. It has been found that while the Juvinall and Marsh safety device is operable to prevent hazardous ignitions of volatile fluids and to prevent uncomfortable shocks to personnel, it is at a sacrifice of the maximum efficiency inherent in any electrostatic coating system. It has been found that the employment of the Walberg system creates far less loss of maximum efficiency inherent in an electrostatic coating system because it provides approximately four times the normal current flow for charging the atomized particles of coating material ejected from a spray gun. Although both the aforementioned Walberg and Juvinall et al systems provide safety for manual electrostatic spray guns, nevertheless an arc may be produced by either system which is disturbing to some potential uses of manual electrostatic spray guns. The present invention provides a completely non-arcing system regardless of the electrode to ground spacing while maintaining high efficiency and the ability to spray at very close ranges to the grounded work to be coated.

Thus, it is an object of the present invention to provide a method of operating a manual electrostatic coating system without the reduction of efficiency and without the occurrence of any type of disruptive arc.

A principal object of the present invention is to provide a new and improved method of preventing hazardous disruptive arcs in an electrostatic coating system together with apparatus to implement such a method.

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 schematic diagram of a preferred embodiment of the present invention particularly applicable to an air atomizing electrostatic coating system;

FIG. **2** is a schematic diagram of a modified form of the present invention which is particularly applicable to a hydrostatic atomizing electrostatic coating system;

FIG. **3** is a sectional elevational view of an air atomizing spray gun utilized in the schematic drawing of FIG. **1**;

FIG. **4** is a top partial sectional view of the air atomizing spray gun shown in FIG. **3**;

FIG. **5** is a rear elevational view of the air atomizing electrostatic spray gun shown in FIG. **3**;

FIG. **6** is an enlarged sectional view of the nozzle portion of the air atomizing electrostatic spray gun shown in FIG. **3**;

FIG. **7** is an enlarged view of a modified form of the nozzle portion of the air atomizing electrostatic spray gun shown in FIG. **3**; and

FIG. **8** is an enlarged sectional view of another modified form of the nozzle portion of the air atomizing electrostatic spray gun shown in FIG. **3**.

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

Referring to FIG. **1**, an air atomizing electrostatic spray gun **10** is connected to a power supply generally indicated within the dashed lines **20** by a high voltage cable **30**. The high voltage shut-off delay circuit generally indicated within the dashed lines **40** is connected to the high voltage power supply **20**. A current sensing circuit generally indicated within the dashed lines **50** is connected to the high voltage power supply **20** and to the high voltage shut-off delay circuit **40**. The high voltage power supply **20** provides at least 60,000 volts D.C. between ground and cable **30**. The principal elements in the high voltage circuit of the coating system are an electrode **11** mounted on the spray gun **10**, a **150** megohm resister **12** mounted in the spray gun **10** and connected to the electrode **11**, the high voltage cable **30** which is connected to the other end of the resistor **12**, a **25** megohm resister **21** mounted in the power supply **20** and connected to the other end of the high voltage

cable 30, a high voltage doubler supply circuit generally indicated within the dotted lines 22 which provides a source of 60,000 volts or more in the power supply 20, a 10,000 ohm resister 51 forming a part of the current sensing circuit 50 and a connection to ground made by the grounding pin 23 of a 117 volt A.C. grounded plug 24 which forms a part of the high voltage power supply 20. Work to be coated by the spray gun 10 is grounded and, therefore, connected in series with the aforementioned resistances, source of high potential 22 and the electrode 11.

Power for the coating system shown in FIG. 1 is supplied by connecting the plug 24 into a suitable 117 volt A.C. socket. Plug 24 has a prong 25 which is connected to one terminal of an air flow switch 26 by a lead 27 and to a terminal 41 of a relay 42 by a lead 42. The other terminal of the air flow switch 26 is connected to a terminal of single-throw double-pole switch 44 by a lead 28. The switch 44 electrically connects the air flow switch 26 to a terminal 45 through lead 46 when the switch 44 is closed. Another prong 29 of the plug 24 is connected through a lead 60 and fuse 61, a lead 62 to another terminal of switch 44. Switch 44 electrically connects the prong 29 of the plug 24 to a terminal 47 through a lead 48 when switch 44 is closed. Thus, when switch 44 is manually closed and air flow switch 26 is closed by the application of air flow thereto, 117 volts of alternating current are available between the terminals 45 and 47 in the high voltage delay circuit 40. A solenoid coil 49 of the relay 42 is connected in series with a resister 63 between the terminals 45 and 47 to be energized when the air flow switch 26 and the switch 44 are both closed. The air flow switch 26 is of conventional design and has its high pressure pneumatic leads connected between a source of high air pressure and an air valve in the spray gun 10 in order that it will close when the air valve in the gun 10 is operated to supply atomizing air to coating material being ejected by the spray gun. Therefore, after the manual switch 44 is placed in a closed position, the relay 42 may be energized by operating the air control valve in the spray gun 10. Energization of the relay 42 connects terminal 41 to a terminal 66. A diode 64 is connected in series with resister 63 and solenoid 49 across terminals 45 and 47. A condenser 65 is connected across the terminals 45 and 47.

A pwoer supply transformer 52 is provided in the sensing circuit 50 having a primary coil 53 and a secondary coil 54. The primary coil 53 is connected between prong 29 of plug 24 and terminal 66 by the lead 60, the fuse 61, the lead 62, a lead 67 and a lead 68. Thus, power is supplied to the sensing circuit whenever relay 42 is closed by the actuation of switches 44 and 26. A relay 70 has one end of a solenoid coil 71 connected to terminal 66 by a lead 69. The other end of the solenoid coil 71 is connected to contacts 113 of a relay 56 by a lead 72. The condenser 65 has one side connected to a terminal of the relay 70 through a terminal 73 and a lead 74. Another terminal of the relay 70 is connected to the other side of the condenser 65 through the terminal 45 through the lead 46 and a resister 75. When the solenoid coil 71 is energized the relay is closed and the condenser 65 becomes discharged through resister 75. The function of the condenser 65 and the resister 63 is to provide the solenoid 49 with a D.C. voltage after the air flow switch 26 is open so that the relay 42 will remain closed and keep the power supply energized for a period of 2½ seconds after the air flow switch 26 opens. Thus, the closing of the relay 70 will cause condenser 65 to discharge within a half second, thereby disabling the high voltage delay shut-off of 2½ seconds.

The terminal 66 is connected by the leads 69 and a lead 76 to an indicator lamp 77 which is also connected to the other side of contact 113. Thus, as long as the relay 42 is closed and relay 56 is open, the red "on" lamp 77 will be illuminated.

The terminal 66 is also connected by the lead 60, the lead 76 and a lead 79 to one end of a primary coil 121 of a high voltage transformer 120. The other end of the primary coil 121 is connected through a set of switching contacts 55 of the relay 56 by a lead 80 to the lead 62, which, as aforementioned, is connected to the prong 29 by the lead 60 and the fuse 61. Therefore, whenever the high voltage transformer 120 is energized by the closure of the switch 44 and the air flow switch 26 which closes the relay 42, relay 70 is open to prevent the discharge of condenser 65 and the red indicator light 77 is illuminated.

When the high voltage transformer 120 is energized, it provides 30,000 volts A.C. or more across its secondary coil 122. One side of the secondary coil 122 is connected to a diode 123 through a condenser 124; the other side is connected through four series diodes 125 to the same side of diode 123, and a condenser 81 is connected between four series diodes 123 and ground pin 23 to form a voltage doubler circuit which will provide 60,000 volts D.C. or more. The resistor 21 is connected through the series of four diodes 123 and the series of four diodes 125 to one side of the resister 51 by a lead 126. A 250 megohm resister 82 is connected in parallel with condenser 81 to bleed off the high voltage from the cable 30 through resister 21 when the transformer 120 is de-energized. The other end of the resistor 51 is connected to the ground prong 23 by a lead 84, a milliameter jack 85, a lead 86 and the lead 83.

The secondary coil 54 of the power transformer 52 is connected to a four diode bridge 87 which has one side of its out-put connected to a bus bar 88 and a resistor 89, and the other side of its out-put connected to a bus bar 90. Connected between the bus leads 88 and 90 in series are the condenser 91; the resister 92, potentiometer 93 and the resister 94; a condenser 95, the resister 96 and the condenser 97, a resister 98, a type 2N2647 transister 99 and a resister 100; a resister 101 and a condenser 102; and a resister 103 and a type 2N2646 transistor 104. These elements will be recognized by those well skilled in the art to form a microampere sensing circuit utilizing the voltage appearing across the resister 51 as the in-put voltage to be detected. The variable resistance tap of the potentiometer 93 is connected through a diode 105, a resistor 106, to the 2N2647 transistor 99. The potentiometer 93 is set so that its out-put voltage is one-half to three-fourths volts below the level that triggers transistor 99. A small in-put current of only about 40 milliamperes will charge the condenser 97 and raise the voltage at the emitter to the triggering level. When the transistor 99 is triggered, both capacitors 95 and 97 are discharged through the resistor 100 which generates a positive pulse to trigger a silicon controlled rectifier 107 which is connected to transistor 99. The capacitor 97 is kept small for faster triggering response time and condenser 95 is used to provide the pulse out-put energy. Rapid recovery is obtained after the transistor 99 triggers,

since both capacitors are charged through potentiometer **93.** The function of the remaining elements of the microampere sensing circuit, including a condenser **103** will be recognized by those skilled in the art since this microampere sensing circuit is of common design and is more fully described in General Electric Company's Transistor Manual, 7th Ed., at pages **325** and **326** thereof, and in its SCR Manual, 3rd Ed., at pages 119 thereof. The silicon controlled rectifier **107** is connected in series with a solenoid **109** of relay **56** across the out-put diode bridge **87** by the bus bar **90** and a lead **110.** A resister **111** is connected in parallel with the solenoid coil **109.** Thus, by adjusting potentiometer **93,** the amount of current flowing in the high voltage circuit of electrode **11** can be made to trigger silicon controlled rectifier **107** at any desired value of high voltage current flow. Triggering of silicon controlled rectifier **107** energizes the relay **56** opening contact **55** to de-energize high voltage transformer **120.**

In order to place the system shown in FIG. **1** in operation, the operator plugs the 117 V.A.C. grounded plug **24** into a 110–120 volt power recepticle. The operator turns on manual switch **44** after grounding the work to be coated and after air pressure and coating fluid under pressure is supplied to the gun. He then turns on the high pressure air at the gun as will be more fully described presently. This action, as aforementioned, will close the air flow switch **26,** thereby energizing relay **42.** The closing of relay **42** places 117 volts across the primary coil **121** of the high voltage transformer **120.** Thus, the source of high voltage **22** produces 60,000 volts which is applied across resister **12,** resister **21,** resister **51,** the electrode **11,** the work to be coated and the space between the electrode **11** and the nearest grounded object, which will normally be the work to be coated. Most operators spray work with a swinging action of their arm, turning the air and paint supply off at the end of each stroke across the work. If the transfromer were to be de-energized each time the operator turned off the coating material at the end of a stroke, and turned it on again as his arm swung back across the work for another painting stroke, the frequent initial surge of voltage would shorten the life of the transformer, the power supply **20** in general, and the cable **30.** Therefore, when the operator turns off the air at the end of each painting stroke, the delay shut-off circuit **40** causes the transformer **120** to remain energized for a period of 2½ seconds after the air flow switch **26** is open. The relay **42** is maintained closed by the resistance-capacitance circuit consisting of the relay coil **49,** resistance **63** and the capacitor **65.** As soon as the air flow switch **26** is open, the capacitor **65** will commence to discharge through the resister **63** and the relay coil **49.** Relay coil **49,** resistance **63** and the capacitor **65** determine the time constant for the delayed de-energization of the relay coil **49.** Thus, the high voltage supplied to the electrode **11** will not normally be turned off until 2½ seconds after the air and coating fluid being ejected by the air spray gun **10** are turned off.

However, should the operator bring the electrode **11** suddenly towards a grounded object such as the work to be coated, it is desirable to turn off the high voltage power supply essentially immediately without delay. This is accomplished by the sensing circuit **50.** As the electrode **11** approaches a grounded object, the flow of current between the electrode and the grounded object will increase rapidly. The greater amount of the voltage provided by the power supply **20** will appear across the resistances **12, 21** and **51.** When the electrode **11** approaches the grounded object sufficiently closely to provide enough voltage across resister **51** to trigger the sensing circuit, relay points **55** of the relay **56** will open, de-energizing primary coil **121** of the high voltage transformer **120** thereby de-energizing the high voltage out-put of the power supply **20.** The transformer **120** will remain de-energized until either the air flow switch **26** or the manual switch **44** is opened to de-energize the power supply to the sensing circuit **50** through the transformer **52** because the silicon controlled rectifier **107** will continue to conduct until the voltage across it is turned off. Thus, the relay points **55** must remain open until the operator causes air flow switch **26** to be opened. In some cases this action might be accomplished by manual opening switch **44.** Therefore, when the current in the high voltage circuit of the system exceeds a predetermined value as set by potentiometer **93,** the high voltage is turned off even through relay **42** remains energized. The potentiometer **93** is set so that the silicon controlled rectifier **107** will be triggered before the electrode **11** can come close enough to a grounded object to cause an arc. A white indicator light **112** is connected between the lead **76** and the lead **72** through contacts **113** of the relay **56** so that when the silicon controlled rectifier **107** is energized, thereby energizing relay **56** to shut off the high voltage, the white indicator light **112** will be energized and the red light **77** de-energized to indicate to the operator that the high voltage has turned off by the sensing circuit **50** and that he must re-cycle his control means by shutting off the high pressure air and coating material supplies. Thus, after the sensing circuit has de-energized the high voltage power supply, the high voltage cannot again be turned on until the system is re-cycled by the operator.

Contacts **113** of relay **56** connect lead **72** to lead **62** to energize relay **70** to sufficiently discharge condenser **65** in less than a half second that relay **42** is de-energized. Thus, when the silicon controlled rectifier **107** is triggered not only is the high voltage transformer turned off, but the energizing relay is also de-energized in less than a half-second.

Referring now to FIG. **2,** a modified form of the present invention for a hydrostatic atomized manual spray gun system is shown. The system is similar to the system shown in FIG. **1** except that it does not contain an air flow switch. Corresponding elements to those shown in FIG. **1** have corresponding numbers with the suffix "a". Since the function of these elements is the same as that of the elements in FIG. **1,** the description of their structure and their operation will not be repeated. The air flow switch **26** shown in FIG. **1** is replaced in FIG. **2** by a microswitch **200** which is connected across an intrinsically safe relay coil **202** of the relay **203.** The other end of the relay coil is connected by a lead **204** to the intrinsically safe switch assembly **201.** The lead **27a** is also connected to the intrinsically safe switch **201** by a lead **205.** One contact **206** of a pair of contacts of the relay **203** is connected to the lead **27***a* by a lead **207** and the other contact **208** is connected by a lead **209** to the lead **28***a*. The microswitch **200** is physically mounted in the spray gun **10***a* so that it is closed when the operator turns on the high pressure coating material. The intrinsically safe switch assembly **201** is of conventional design well known to those skilled in the art and is provided to allow switch **200** to be a low en-

ergy switching device as a safety measure to avoid an explosion in a spray booth filled with explosive vapor. Closure of the switch **200** causes the intrinsically safe switch assembly to connect the lead **204** to the lead **62***a* so that the relay coil **202** is energized closing the relay **203**, which causes the lead **27***a* to be joined to lead **28***a* in a manner similar to that in which the air flow switch **26** joined the lead **27** to the lead **28** in FIG. **1.** Thus, in the hydrostatic intrinsically safe switch assembly **201** and the relay **203** perform the same function as does the air flow switch **26** in FIG. **1.**

Referring now to FIGS. **3, 4** and **5,** the air spray gun **10 300** of insulating material has a valve body **301** and a handle portion **302** mounted thereon. The trigger **303** is pivotally mounted on the body **300** and connected to the actuator **304.** Rearward movement of the trigger **303** causes the actuator arm **304** to move rearwardly since the trigger of **303** is pivoted about a pin **305.** A nose bushing **306** of conducting material is threaded into the forward end of the body **300.** A nozzle **310** which provides a valve seat closes off the forward end of a passage **311** through the body **300** and a passage **312** through the nose bushing **306** through which coating material is supplied. The passage **301** is connected through a ⅜ O.D. nylon tube **313** which is connected to a passage in the valve body **301** to the passage **311** by a connector **314.** An air cap **315** having air passages **316, 317** and **318** to provide atomizing air, as is well known to those skilled in the art, is secured against the body **300** by a nose cap **319** composed of insulating material. A valve rod **320** is slidably mounted in the passage **311** and has a valve formed on its forward end which seats against the valve seat of the nozzle **310.** A spring **321** forces the valve at the forward end of the rod **320** to a closed position. The valve rod **320** has formed thereon a second valve **322** which seats against a valve seat **323** which is mounted in an insert **324.** The insert **324** is mounted in the valve body **301** and sealed thereto by the O rings **325** and **326.** A packing nut **327** is threaded into the rear portion of the insert **324** securing a spring **328** in tension against the valve head **322.** A nut **329** is threaded on the rear portion of the rod **320** so that when the trigger **303** is pulled the actuator **304** will bear against the nut **329** to carry the rod **320** rearwardly, opening both valves. Another nylon tube **330** is connected through the valve body **301,** a chamber **331** is an insert **332** threaded into the valve body **301,** a passage **333** in the body **300** and a chamber **334** to the air passage **316, 317** and **318** to supply high pressure atomizing air to atomize coating material ejected by the nozzle **310,** as is well known to those skilled in the art. The air pressure control valve is rotatably threaded in the insert **332.** The valve **340** bears against the valve seat **341** in the insert **332.** The spring **342** is interposed between a head **343** of the valve **340** and the actuator **304** to urge the actuator **304** and the trigger **303** forwardly when manual pressure is not being applied to the trigger **303.** The position of the valve **340** controls the quantity of atomizing air flow. The high voltage cable **30** is inserted through a passage **350** to connect to the **150** megohm resister **12** through a conductive spring **351.** The resister **12** is located in a passage **352.** Another conductive spring **353** connects the resistor **12** of conductive plug **354** which is sealed to the walls of the passage **352** by an O ring **355.** The plug **354** bears against the nose bushing **306,** which in turn is threadably connected to the nozzle **310.**

Referring now to FIG. **6,** the nozzle **310** has an internal orifice surface **360** which forms an orifice through which coating material is ejected into the atmosphere. The nozzle **310** also has a forward facing surface **361** joining the internal orifice surface **360** to form an obtuse angle therebetween and an outer surface **362** joining the forward facing surface **361** to form a sharp edge which is the electrode **11** schematically shown in FIG. **1.**

It has been found that by removing a sharp edge, such as the sharp-edged electrode shown in FIG. **4,** from direct contact with the coating material being ejected, that higher painting efficiencies can be obtained. In addition, the wrap-around qualities have been found to be improved over a sharp-edged electrode where the sharp edge is in contact with the coating material being ejected. By use of the nozzle shown in FIG. **6,** an electrode which cannot be easily broken off, such as a "handle" electrode, is provided. Modified forms of the electrode shown in FIG. **6** are shown in FIGS. **7** and **8.** In FIG. **7** the sharp edge is serrated in order to form a multiplicity of sharp points. In FIG. **8** the edge has been formed into a single point. It will be understood by those skilled in the art that while three preferred embodiments are illustrative of the invention, other modifications may be made which are intended to be within the scope of the appended claims.

In FIGS. **7** and **8** the portions of the nozzle which correspond to the portions of the nozzle shown in FIG. **2** have been labeled with respective numbers having the respective suffixes *a* and *b.* By spacing the sharp-edged electrode away from direct contact with the ejected coating material as shown in FIGS. **6–8,** an improved "point source" is provided. The operation of the point source electrode is more fully described in my U.S. Pat. No. 3,251,551, issued May 17, 1966.

Thus, the present invention not only makes it possible the first non-arcing mechanically atomized electrostatic spray gun systems, but it also provides such systems with improved sharp-edged orifices that are not damaged by being brought into contact with other objects.

I claim:

1. A method of preventing disruptive arcs in an electrostatic coating system having a source of high potential connected across an electrode associated with a spray gun and work to be coated comprising:

providing first means to terminate the spraying operation normally for short periods of time and control means operable in response to operation of said first means to deenergize said source of high potential after a time period which normally exceeds the short periods of time during which said spraying operation is terminated,

determining the amount of current flowing between the gun electrode and the work to be coated, and

deenergizing said source of high potential without the delay of said time period whenever such current exceeds a predetermined value.

2. A method of operating an electrostatic coating system in accordance with claim **1,** which includes reducing the maximum length of a disruptive arc between said electrode and said work to be coated by increasing the series resistance of said source of high potential, said electrode and said work to be coated.

3. The method of claim **1** in which the reenergization of said source of high potential is prevented until said

control means is recycled when such source of high potential has been deenergized as a result of said current exceeding said predetermined value.

4. The method of claim **1** in which said gun has an air supply for supplying air to the paint in the gun and propelling the same towards the work to be coated and in which said first means is a means for interrupting said air supply.

5. A method of reducing disruptive arcs in an electrostatic coating system having a source of high potential connected across an electrode associated with a spray gun and work to be coated comprising:

reducing the maximum length of a disruptive arc between the electrode and the work to be coated to a predetermined value,

determining the amount of electrical current flowing between said electrode and said work to be coated, and

promptly deenergizing said source of high potential whenever said electrical current exceeds a predetermined value resulting from the electrode approaching a distance from the work to be coated that is less than said predetermined value of maximum disruptive arc length.

6. A method of reducing disruptive arcs in an electrostatic coating system having a source of high potential connected across an electrode associated with a spray gun and work to be coated in accordance with claim **5**, wherein the predetermined value of the maximum length of a disruptive arc is less than one inch.

7. A method of reducing disruptive arcs is an electrostatic coating system have a source of high potential connected across an electrode associated with a spray gun and work to be coated in accordance with claim **5**, wherein the predetermined value of the maximum length of a disruptive arc is less than 2 inches.

8. A method of reducing disruptive arcs in an electrostatic coating system having a source of high potential connected across an electrode associated with a spray gun and work to be coated in accordance with claim **5**, including normally delaying the de-energizing of said source of high potential after control are operated to de-energize it and de-energizing it whenever said current exceeds a predetermined value without delaying such de-energization.

9. A method of reducing disruptive arcs in an electrostatic coating system having a source of high potential connected across an electrode associated with a spray gun and work to be coated in accordance with claim **8**, which includes a step of preventing the reenergization of said source of high potential unit said controls are recycled to energize said source of high potential.

* * * * *