

[54] **ELECTROSTATIC DEPOSITION COATING SYSTEM**

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[51] Int. Cl. **B05b 1/02**
[58] Field of Search **239/3, 15, 124, 125, 239/304, 307; 117/93.4**

References Cited

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[57] **ABSTRACT**

Electrostatic disposition spray coating systems in which water base paints, teflon coatings and other highly conductive materials are sprayed utilize the conductive fluid in a paint conduit of insulating material for connecting an ionizing electrode to the high voltage power supply of the system. Higher operator safety is accomplished by mixing the conductive coating material fluid and air internally prior to rejecting it through an air cap and by limiting the exposed portion of the ionizing electrode to a short needle point or knife edge.

59 Claims, 14 Drawing Figures

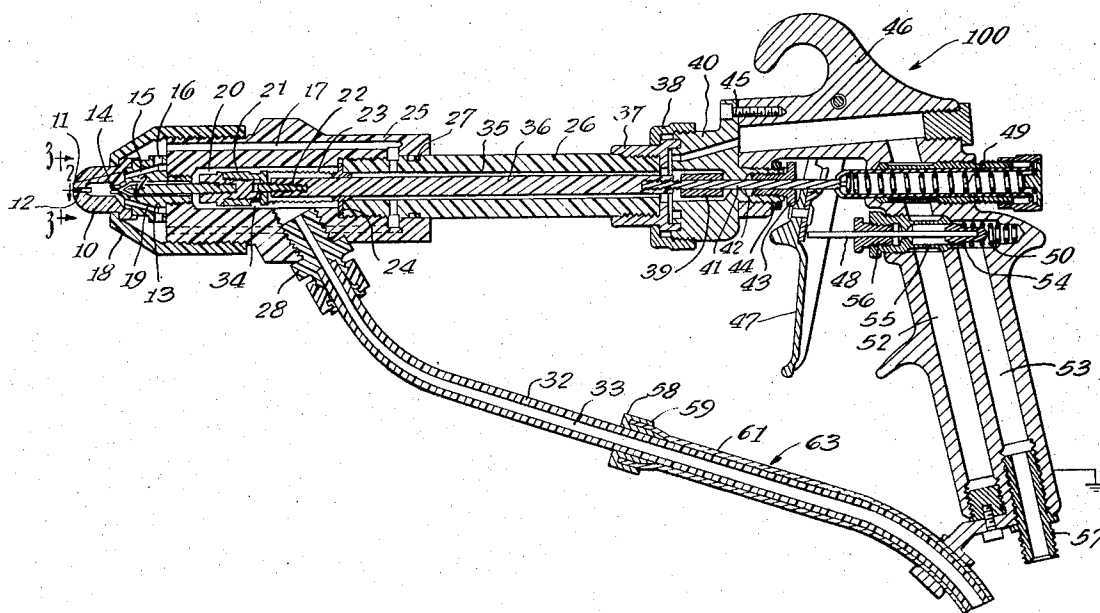


Fig. 1

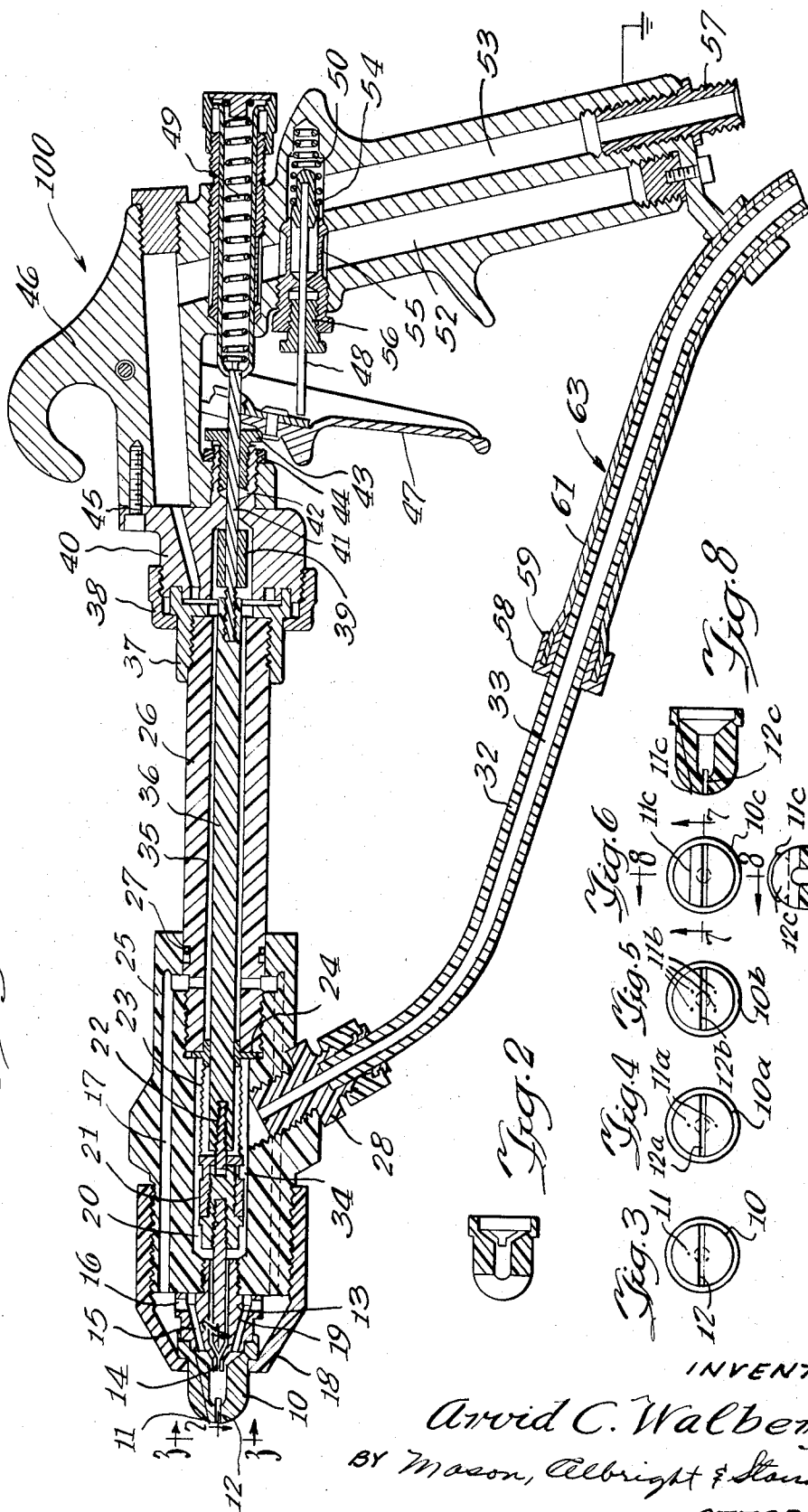


Fig. 2

Fig. 3

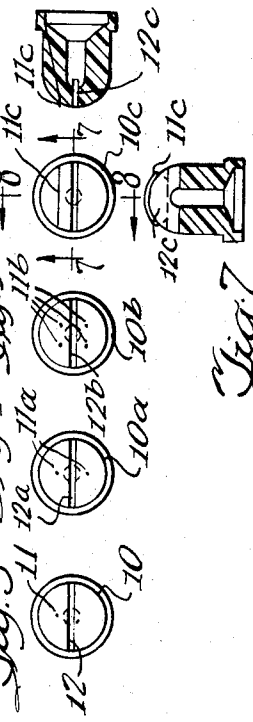
Fig. 4

Fig. 5

Fig. 6

Fig. 7

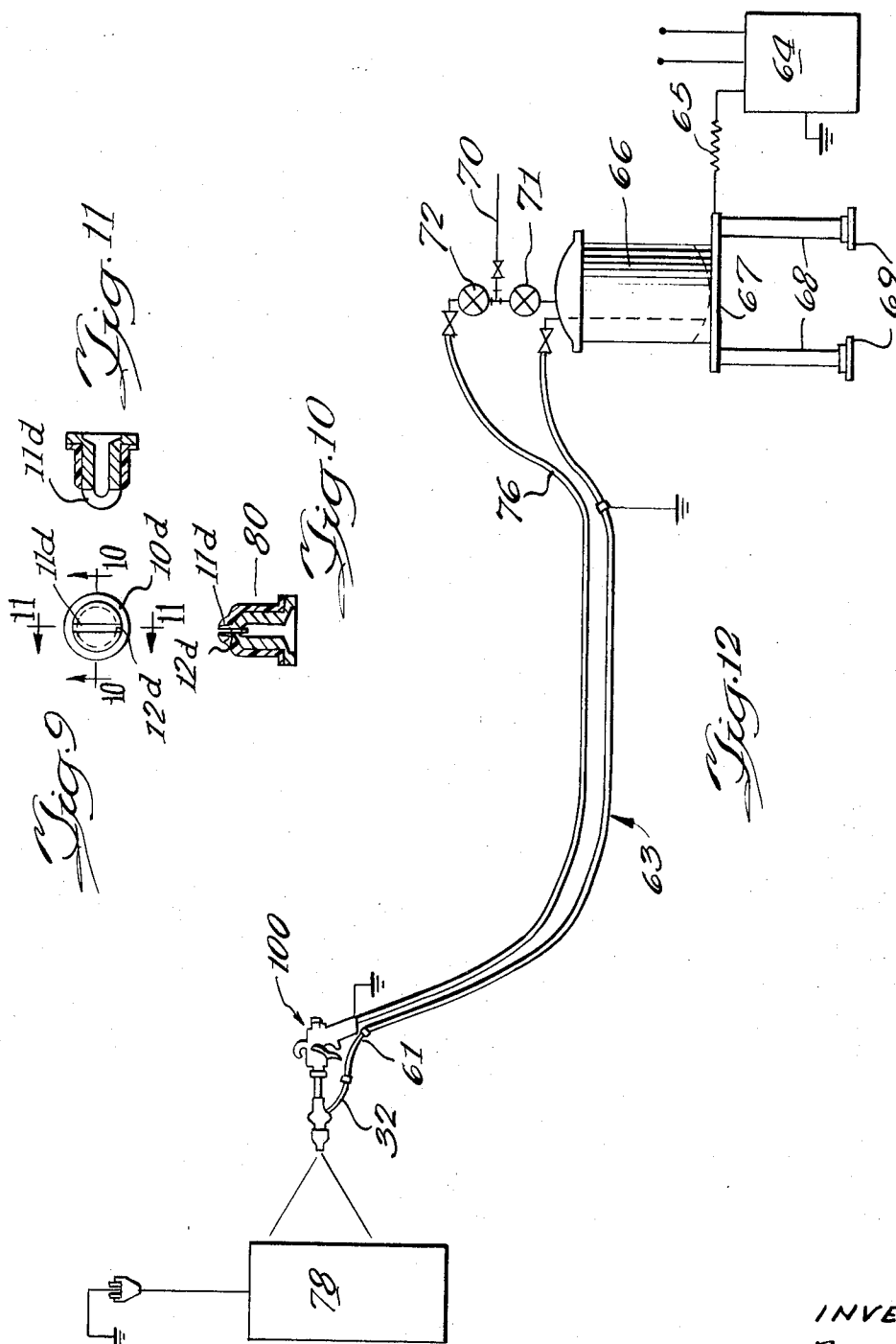
Fig. 8



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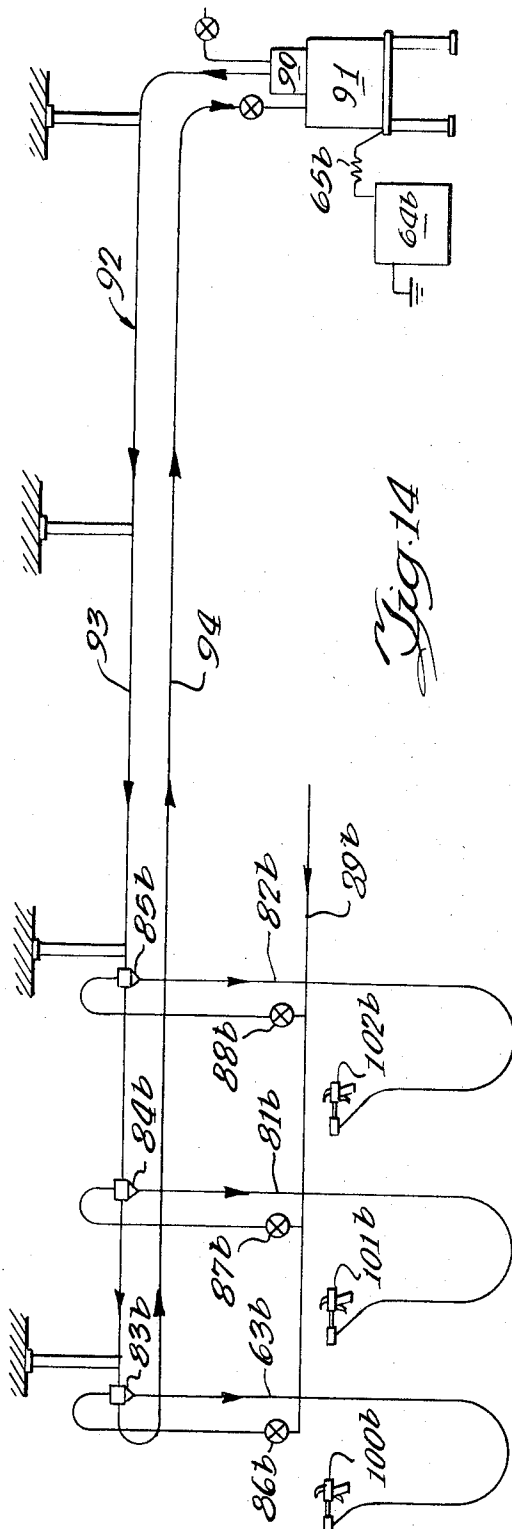
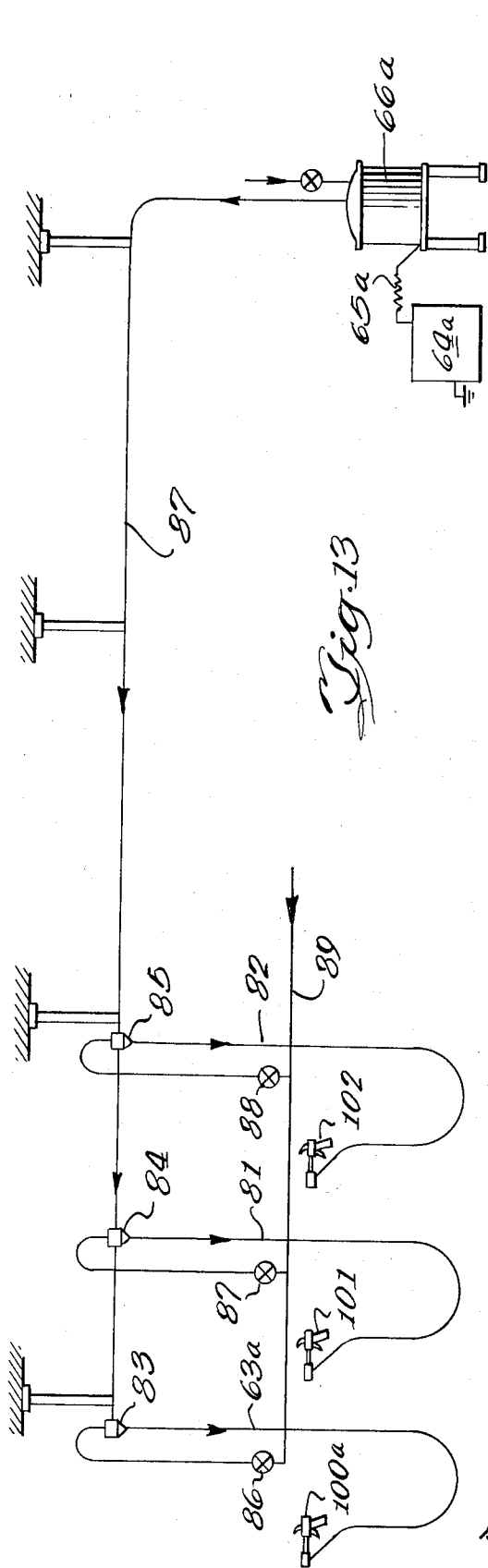
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ELECTROSTATIC DEPOSITION COATING SYSTEM

This is a continuation, of application Ser. No. 24,104, filed Mar. 31, 1970, now abandoned.

The present invention relates to electrostatic coating systems and more particularly to methods and apparatus for safe operation of electrostatic coating systems which spray highly conductive coating material.

Air pollution due to conventional paint solvents is a problem that must be solved. By substituting water-base paints for solvent-base paints, the air pollution problem is virtually eliminated. Water vapor discharged into the atmosphere is not harmful and is fully acceptable to all air pollution regulation agencies.

Paint manufacturers have spent millions of dollars in the development of water-base paint. These paints are used primarily in electrophoretic coating systems which are similar in operation to a plating system. There are several limitations of electrophoretic coating systems however such as high coat of equipment, single coat application, limited color change possibilities, limited film thickness, precision control requirements, expensive ware precleaning equipment, spoilage of large tanks of paint and the limited flexibility of the entire system. A good electrostatic spray gun can eliminate or reduce some of these limitations and expand the use of water-base coatings very substantially. The technology of electrophoretic coating produced at great expense by the paint manufacturers can readily be converted to the field of electrostatic spraying to expand the total market for water-base coatings of this type. The spray gun disclosure herein will contribute to the expansion of this new paint technology.

Water-base coatings have also been available for several years on the domestic market for house painting and similar projects. In order to paint a wooden frame house with an electrostatic hand gun it has been helpful to make the paint as conductive as possible. A solvent-base paint with a resistance as low as 200,000 to 400,000 ohms with a Fischer meter has been used. With the gun disclosure herein, water base paint may be applied to a frame house electrostatically. The lower resistance of the water-base material (about 400 to 500 ohms with a Fischer meter) makes the electrostatic application more effective. The wooden siding becomes more conductive over the surface through the applied wet film thereby causing the electrostatic field to function more efficiently. The gun in this disclosure can be used very effectively for contract painting when water-base coatings are used. It will spray wood, brick, concrete and plaster surfaces electrostatically.

Another large potential market for electrostatic spraying of water solutions is in the agricultural industry. It can be used to spray fields and orchards and since electrostatically charged particles will coat the underside of leaves as well as top surfaces it will be far more effective in doing the intended job. Finer atomization without corresponding excessive waste due to the fine particles becoming airborne and being carried away from the product is one of the important advantages. Thinner more complete films can be applied with a very substantial reduction in material usage. By using herbicides, insecticides and other chemicals in much smaller quantities, the problems of air and water pollution can be greatly reduced.

Other nozzles such as external-mix air atomization and hydraulic atomization can use the principles of this

invention as well when water-base or highly conductive solutions are to be sprayed.

Oil-base paints and other high resistance materials can also be used in the gun by adjusting these materials with chemical additives into a more conductive range. A water-alcohol solution or other similar solution can be added. Acids will also tend to make paints more conductive. Acids are frequently added to give good bonding characteristics and would serve a dual purpose. A resistance up to several hundred megohms in a 25 feet 0 inch insulated paint hose can be tolerated. The maximum resistance permitted is in the order of 250 megohms at 60,000 volts. Higher resistances can be permitted at higher voltage. In general the paint resistance required is substantially below that permitted in prior art electrostatic hand guns.

Because water-base coatings are highly conductive, a new and different technology is required to handle these coatings electrostatically. Prior art air atomizing electrostatic automatic spray guns have been used to spray water-base materials but these guns cannot be readily adapted to manual operation. These guns have also used external-mix air-atomizing techniques that call for discharging a stream of fluid into the atmosphere forward of the gun and atomizing this fluid with jets of compressed air. Since water-base materials are rather difficult to atomize, high air pressures and large volumes of compressed air are used in the atomization process. This causes high spray velocity and lowers operating efficiency. This problem is overcome with the internal-mix air cap of this invention.

Prior art manual electrostatic spray guns grounded the paint column at or near the handle of the gun and the high voltage shorted out through the paint column if conductive water-base paint was used in the gun. These guns have also been equipped with a high voltage cable and a current limiting resistor in the gun. This added extra weight to the gun and reduced maneuverability. The prior art electrostatic hand guns also used external mix air atomization or hydraulic atomization and this means of atomization has various limitations. External-mix atomization tends to be wasteful, particularly where water-base coatings are concerned, since large volumes of air at high velocity are required as previously mentioned. Hydraulic atomization tends to be wasteful also by applying excessive film thickness on the work. The extra film thickness represents wasted paint even though the paint is on the product. This invention relates primarily to an internal-mix air nozzle made of insulating material used in connection with water base or other conductive paint and having an electrostatic field applied to a sharp ionizing electrode tip at the nozzle with the high voltage connection completed through the fluid line.

The internal-mix air cap has been used in conventional non-electrostatic spray equipment but its use has steadily diminished over the years. It was displaced by guns using external-mix air caps. The external mix gun provided a higher quality of finish, higher speed and greater flexibility. When adapting the external-mix air cap to high speed electrostatic hand guns, however, the high air pressures of 50 to 100 psi and the high air volume consumption tended to increase spray velocity, hinder good electrostatic operation and lower operating efficiency. An internal mix air cap requires much less compressed air volume to achieve the same atomization at the same speed of operation. This results in

higher operating efficiency when this basic construction is used in a high speed electrostatic spray gun.

Since water-base paint is highly conductive, it has substantial capacitance and tends to provide an uncomfortable electrical discharge. Since water-base paint is non-flammable, this is not a serious objection, however. The sprayer can also learn to refrain from touching the charged front end of the gun. This problem is equivalent to working with a hot soldering iron. A worker can handle this problem without difficulty and will not burn himself.

The disclosed invention overcomes this disruptive discharge problem to some degree. Prior art guns used a concept known as "low effective capacitance" are disclosed in U.S. Pat. Nos. 3,048,498; 3,169,882, and 3,168,883, but this concept cannot apply to water base paints since the entire paint supply becomes charged to high voltage and the resultant capacitance is substantially greater than several micro-micro-farads and greater than a 3-centimeter sphere as discussed in U.S. Pat. No. 3,048,498.

The guns disclosed in U.S. Pat. No. 3,048,498 cannot handle water base paints. The spinning bell hand gun cannot electrostatically atomize water base paints since the material is too conductive. The hydraulically atomizing gun has a short column of paint serving as a resistor and when water base paint is used in the gun this short paint column is highly conductive and the disruptive discharge from the front of the gun would be extremely uncomfortable if approached too closely by a spray operator. The patent teaches that the paint column in the gun must have high resistance.

The spray guns of U.S. Pat. No. 3,169,882 also suffer from similar limitations. The FIG. 1 gun is an automatic gun and if supplied with water-base paint from a paint source insulated from ground will provide a very uncomfortable arc because of a high capacitance discharge if approached too closely by a spray operator. The gun has an excessive amount of exposed charged metal. Disruptive discharges can occur from the exposed metal surfaces. The excessive exposure of charged metal also lowers operating efficiency. The gun utilizes an external-mix air cap and requires an excessive volume of compressed air to function properly when operating at high speed. The gun cannot be used as a hand gun. The FIG. 4 and FIG. 6 hand guns ground the paint column at the handle and would provide a short circuit for the high voltage if conductive paint was used in the gun. These guns also utilize a high voltage cable and a current limiting resistor in the gun. This increases weight and reduces maneuverability.

The spray guns of U.S. Pat. No. 3,169,883 have the same limitations as the guns shown in U.S. Pat. No. 3,169,882. All guns would either arc excessively because of large exposed charged metal surfaces or a conductive paint would short out to grounded portions of the gun.

My previous U.S. Pat. No. 3,251,552 contemplates the use of water base paints in an automatic gun but does not permit use of water base paints in the hand gun. The automatic gun would produce an uncomfortable arc if used with water base paint since an electrical connection is made directly to the metal in the head of the gun without use of an intervening resistance. The hand gun would short circuit the high voltage to the grounded handle of the gun if water base or highly conductive paint is used.

My U.S. Pat. No. 3,251,551 also discloses an external mix air cap but does not disclose an internal mix air cap. Material is atomized according to this patent after it is ejected into atmosphere at the forward end of the gun. My present invention atomizes the paint prior to ejection into the atmosphere.

My present internal-mix electrostatic spray gun is not only more efficient because of the substantial reduction in amount of compressed air use, but it also can handle water-base or conductive paint with ease and at the same time it can be made relatively safe by minimizing disruptive discharges even though very high capacitance conductive material is used in the gun. This applies to high capacitance metal structures within the gun as well as conductive coating materials being sprayed. My previous concept calling for an insulating shield over all charged metal with minimum exposure of a sharp tip or edge in the zone of atomization should be as fully employed as possible to provide non-arcing or minimal-arcing operation with conductive coatings. The nature of the exposed metal must be far more carefully taken into consideration when high capacitance conductive coating materials are used.

An all-metal or highly conductive electrode can be made non-arcing and safe from an ignition or comfort standpoint if its true capacitance is below specified limits at given operating voltage and its current supply is limited by specified values of resistance as taught in U.S. Pat. No. 3,048,498. A one centimeter radius metal sphere is safe when charged to 100,000 volts d.c. through a 1000 megohm resistor for example. A three centimeter radius sphere charged to 50,000 volts d.c. through a 4000 megohm resistor is also safe but not quite as safe as the first example. The above examples are less safe when the capacitance is increased, the voltage increased or the resistance is decreased. The opposite is true if the capacitance and voltage are decreased while the resistance is increased.

The gun of the present invention provides for the safe use of conductive coatings and charged metal electrodes that, in combination, provide a capacitance that is well in excess of the three centimeter radius sphere contemplated as the maximum permissible under the theory taught in the U.S. Pat. No. 3,048,498 patent. The gun of this disclosure will also permit the use of much lower resistances than the specified 1000 megohm resistor when the total capacitance is as low as that of a one centimeter radius sphere.

When a high capacitance metal electrode equivalent to a 3 cm radius metal sphere is built into the gun it is possible to reduce the required resistance substantially below the values specified in U.S. Pat. No. 3,048,498 by adding an insulating shield over the charged metal and exposing only a sharp ionizing electrode in the zone of atomization as taught in my previous U.S. Pat. Nos. 3,056,557 and 3,251,551. The arcing from a sharp exposed tip is very low but is higher from other surfaces on the same metal electrode and an insulating shield provides the needed protection for these other surfaces.

Adding extra resistance as the capacitance increases as taught in the No. 3,048,498 patent is effective for the lower capacities only. The extra resistance causes a severe drop in operating efficiency when values of 500 megohms and above are used in air-atomizing or hydraulic atomizing electrostatic spray guns. Lower

values of resistance are preferred for maximum operating efficiency.

Making the electrode out of semi-conductive material when higher capacities are encountered is satisfactory for items like the spinning bell in the No. 3,048,498 patent but the patent does not teach how to handle conductive coating materials such as water-base paints with the inherent high capacities.

Higher capacitance metals or conductive coating materials can be made non-arcng or the arcing minimized in my present gun by fully employing the teaching of my 3,056,557 and 3,251,551 patents. This calls for an insulating shield over all conducting surfaces except the extreme sharp tip of the needle point. Even the shank of the needle must be insulated since an uncomfortable arc can be drawn from any smooth surface. A sharp-edged electrode must have an insulating shield bonded to all surfaces with only the edge itself exposed. The sharp edge or point will drain off the electrical energy stored in the high capacitance of the charged metal or conductive coating material thus lowering the voltage to safe non-arcng levels. While the small radius of curvature of a fine wire of about 0.020 inch in diameter is considered "sharp" in prior art devices, for the purposes of my present disclosures, I desire to have the exposed sharp points or edges to have a radius of curvature in the order of 0.001 inch or less. This permits a much higher capacity such as a large volume of conductive coating material to be discharged safely.

Prior art patents a number of which issued subsequent to my U.S. Pat. Nos. 3,056,557 and 3,251,551 disclosed exposed charged surfaces that have a relatively large radius of curvature and this causes disruptive discharges that are unsafe and uncomfortable when high capacitance material is directly connected electrically to these exposed surfaces. This occurs even though a resistor is used in the high voltage circuit. It applies to the entire gun body of FIG. 1 of U.S. Pat. No. 3,169,882, the length of exposed fine wire electrode of FIG. 4 and FIG. 6 of U.S. Pat. No. 3,169,882, and the exposed fine wire of FIG. 7 of U.S. Pat. No. 3,169,883. All exposed needle electrodes should have a bonded insulating material applied to the surfaces so that only the tip of the needle is exposed. All fine wire electrodes should preferably be sharpened to a needle point and the shank of the wire coated with high grade insulating material. All sharp-edged orifices or fluid tips should be fully coated with insulating material right up to the sharp edge itself. Tungsten carbide orifices should have a tiny needle tip or tips affixed to the orifice and the entire exposed surface coated with insulating material except for the needle tip or tips. This latter item will also eliminate the need for an offset needle point since the tungsten carbide orifice with its protruding electrode points will serve as its own electrode.

It is, therefore, an object of the present invention to provide a new and improved electrostatic deposition coating system.

Another object of the present invention is to provide an electrostatic spray coating system which is capable of spraying highly conductive materials.

An additional object is to provide an electrostatic deposition coating system wherein high voltage is applied to an ionizing electrode projecting forwardly from the head of a spray gun through a column of conductive coating material which is to be sprayed by the gun.

Still another object is to provide an electrostatic deposition spray coating system wherein an electrode extending forwardly from the head of an insulation covered spray gun is charged to high voltage through conducting fluid material and the conductive fluid material is atomized by internal mixing with air so that only atomized spray is ejected from the spray gun.

A still further object is to provide a system in accordance with the aforementioned objective, wherein the charging electrode protruding from the head has only the tip of a sharp point or knife edge exposed to the atmosphere.

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

FIG. 1 is a sectional view of an electrostatic deposition hand gun which forms a portion of a preferred embodiment of the present invention;

FIG. 2 is a sectional view of the air cap portion of the hand gun illustrated in FIG. 1 taken along the line 2—2;

FIG. 3 is a front elevational view of the air cap shown in FIGS. 1 and 2 taken along the line 3—3 in FIG. 1;

FIG. 4 shows a front elevational view of a modified air cap which may be utilized in the hand gun illustrated in FIG. 1;

FIG. 5 is a front elevational view of another modified form of air cap which may be utilized in the hand gun illustrated in FIG. 1;

FIG. 6 is a front elevational view of still another air cap which may be utilized in the hand gun illustrated in FIG. 1;

FIG. 7 is a sectional view of the air cap illustrated in FIG. 6 taken along the line 7—7;

FIG. 8 is a sectional view of the air cap illustrated in FIG. 6 taken along the line 8—8;

FIG. 9 is a front elevational view of yet another modified form of air cap which may be utilized in the hand gun illustrated in FIG. 1;

FIG. 10 is a sectional view of the air cap illustrated in FIG. 9 taken along the line 10—10;

FIG. 11 is a sectional view of the air cap illustrated in FIG. 9 taken along the line 11—11;

FIG. 12 view of the preferred embodiment of the present invention of which the hand gun illustrated in FIG. 1 forms a part;

FIG. 13 is a schematic diagram of a modification of the preferred embodiment illustrated in FIGS. 1 and 12; and

FIG. 14 is another modification of the preferred embodiment of the present invention illustrated in FIGS. 1 and 12.

While 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 disclosures 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.

FIG. 1 shows an internal mix air atomizing electrostatic hand gun 100 designed to handle water-base paints and other conductive materials. The gun consists of a grounded handle portion 46 of conventional construction. It consists of a manual trigger 47 that operates an air valve 54. Trigger 47 is pivotably mounted on the handle by a shaft 51. Air valve 54 seats against in-

sert 55 which is threaded into handle portion 46. A plug 56 is threaded in insert 55 to receive rod 48 and seal it against air leakage. The valve is opened by compressing a spring 50 when valve rod 48 is pushed by the trigger 47. This turns on the atomizing air to the gun. When the trigger of the gun is depressed further the upper portion of the trigger contacts the rear of a valve rod 41 forcing it back against a spring 49 thus causing fluid to flow through a fluid orifice 14 by pulling back a needle valve 19 and thus opening fluid orifice 14. The valve rod 41 and needle valve 19 are connected together by an insulating valve rod 36, a No. 5-20 cap screw 22, a bellows swivel connection 21, and a swivel cap 20.

Compressed air is supplied to the gun by means of an air hose connected to a hose connection 57 at the base of the handle of the gun. The compressed air enters a passageway 53, flows through air valve 54 and insert 55 into a passageway 52, flows through the metal handle portion of the gun into an insulating barrel 26 and through a passageway 35 formed between barrel 26 and insulating valve rod 36. Insulating barrel 26 has an insert 37 threaded onto its rear end. A retaining ring 38 is threaded onto a block 40 to secure barrel 26 thereto. Block 40 is secured to the handle portion 46 by a nut 44 and a bolt 45. A sleeve 39 surrounds valve rod 41. Air leakage around rod 41 is prevented by seal 42 secured by plug 43 threaded into block 40.

At the front of insulating barrel 26, lateral passageways allow the compressed air to enter an insulating head 25 near the back. Insulating head 25 is threaded onto the forward end of barrel 26, and air leakage between them is prevented by an O-ring 27 mounted in an annular slot in barrel 26. The air moves forward through the head 25 by way of passageways 17 into side ports 16 and connecting passages 15 of a metal fluid tip 13 to atomize the paint internally in the chamber ahead of fluid orifice 14 formed by an air cap 10 secured against fluid tip 13 by a retaining ring 18. The atomized spray is discharged through a slot 12 in the form of an atomized fan shaped spray. The slot 12 measures 0.032 inch wide in this one specific embodiment of the invention.

The fluid passes through a shielded fluid hose 63 which is composed of a conduit 32 and a braided metal shield 61, which surrounds conduit 32. Shield 61 is maintained at ground potential. The braided metal shield 61 is terminated in an end fitting 58 and held in place by a clamp 59. The insulated fluid conduit 32 is made of polyethylene, nylon or other suitable insulating material to insulate against electrical breakdown from the charged conductive fluid in passageway 33 formed by conduit 32 and the grounded metal shield 61. The conductive fluid moves through passageway 33 and enters the insulated gun head 25 through a threaded fitting 28 flowing into chamber 34 and passing out through metal fluid orifice 14 when the needle valve 19 is opened.

Fluid is sealed in chamber 34 to prevent leakage into air passageway 35 by a metal bellows 23 having end connections. A bellows flange 24 provides the rear bellows connection. This fitting is soldered to the metal bellows 23 and clamped between barrel 26 and head 25 to prevent fluid leakage. The bellows swivel connection 21 is soldered to the forward end of the bellows 23. Swivel cap 20 seals against fluid leakage into air chamber 35. Atomizing air pressure is applied to the interior

surfaces of bellows 23 while fluid pressure is applied to exterior surfaces of bellows 23. The bellows 23 is used to permit axial movement of needle valve 19, insulating valve rod 36 and valve rod 41 to open the fluid valve and allow conductive fluid to flow through orifice 14 where it is atomized in the chamber just ahead of orifice 14 and discharged through slot 12.

Referring to FIGS. 1 through 3, the internal mix air cap 10 is made of a suitable electrical insulating material such as polyvinylchloride, nylon, celcon, delrin or polyethylene and is removably mounted on metal fluid tip 13 by the mounting ring 18 which is threaded onto insulating head 25. Mounting ring 18 is also made of a suitable electrical insulating material.

Air cap 10 has a sharp protruding needle point ionizing electrode tip 11. Only the sharp tip is exposed. It protrudes about 1/32 of an inch or less from the surface of the air cap 10 to prevent arcing from exposed smooth surfaces. It electrically contacts the metal fluid tip 13 at its rear end.

If the needle point is allowed to project any distance ahead of plastic air cap 10 it is necessary to place an insulating coating over the shank of the needle and allow only the sharp tip to be exposed. If the gun is operated as an automatic gun and a disruptive discharge can be avoided by maintaining adequate clearance between the electrode tip and the grounded ware it is permissible to make the air cap 10 of metal and project the electrode tip 11 ahead of the air cap 10 by a distance in the order of 1/4 inch.

FIGS. 4 through 11 illustrate four modifications of the air cap 10 which may be utilized on the hand gun illustrated in FIG. 1 in place of air cap 10. Corresponding numbers with different suffixes indicate corresponding elements of the various modifications of the air caps.

FIG. 4 shows an alternate air cap 10a with two electrode tips 11a. FIG. 5 shows an alternate air cap 10b with four electrode tips 11b. FIG. 6 shows three views of an air cap 10c with a knife-edge electrode 11c. The knife-edge electrode is coated with insulating material except for the sharp edge itself. A metal conductor in air cap 10c of FIG. 6 connects the knife edge 11c with the metal fluid tip 13. With just the sharp edge exposed the current leakage on close approach to ground is at a maximum and this helps drain the energy stored in the high capacitance of the charged metal mass and in the charged conductive coating material. This eliminates a disruptive discharge when the output from the transformer is limited to safe levels. The transformer output can be controlled with a high value resistor, internal resistance, poor regulation or controlled limited input. These methods of limiting transformer output are well known to those skilled in the art.

FIGS. 9 through 11 show an alternate metal air cap 10d with a sharp ionizing edge 11a on either side of a slot 12d. The air cap 10d is shielded by an insulating coating 80 bonded to the metal except at the tip of the ionizing edge 11d. This construction concentrates the electro-static field at the tip of the ionizing edge 11d and applies a maximum charge on the atomized spray particles. Numerous alternate arrangements of air caps and electrodes are feasible without departing from the basic scope of this invention.

The process for spraying of water-base or other highly conductive coatings is more fully shown in FIG. 12. In this drawing the spray gun 100 is connected to

a pressure tank 66 filled with conductive fluid. The insulated fluid hose 32 of polyethylene, nylon or other good insulating material protects the spray operator from receiving a shock from the charged material within the hose, and a portion of the insulating hose 32 is covered with a braided ground shield 61 to further protect the operator from accidental shock. This shielded fluid hose extends from a point about eight inches behind the nozzle to a point within about 18 inches of the charged pressure tank.

The fluid in hose 63 will have a small inherent electrical resistance. With a 10 feet 0 inch long by 1/4 inch inside diameter insulating fluid hose filled with ordinary tap water the resistance from one end of the hose to the other is 1.5 megohms. This resistance will vary directly with the length of hose and inversely with the cross sectional area of the fluid passageway through the hose. This means that the hose length and inside diameter can be varied to produce improved results by controlling the total resistance in the circuit. The length and diameter is limited only by the convenience of the spray operator and the desired flow rate. A hose with a very small inside diameter would produce a low flow rate.

An outside white, latex, water-base paint was found to be much more conductive than tap water. Reducing this paint with water in the ratio of 2:1 lowered the viscosity to sprayable range of 22 seconds in a Sears viscosity cup. This compares with a viscosity of water of 17.5 seconds. When placed in the spray gun of this disclosure the resistance through a ten foot length of 1/4 inch i.d. nylon fluid hose was only 250,000 ohms compared with the 1,500,000 ohms of tap water. The fluid hose length should be increased to 25 feet 0 inch or more and the inside diameter reduced to help minimize arcing at the electrode of the gun with this paint.

The paint tested was as follows:

Pittsburgh Plate Glass Co. Sun-proof Latex house paint (White)			
Pigment			34.5%
1. Titanium Dioxide	65.8%		
2. Silica and Silicates	34.2%		
Vehicle			65.5%
1. Non-volatile	33.2%		
a. Alkyd modified vinyl resin	96.8%		
b. Fungicide	3.2%		
2. Volatile (water)	66.8%		
			100%

The above material was reduced in a ratio of 2 paint to 1 water to a spray viscosity of 22 seconds in a Sears cup.

The pressure tank 66 sets on a metal platform 67 that is insulated from ground by insulators 68. The lower end of insulators 68 are attached to floor flanges 69 which may be bolted to the floor. The pressure tank 66 may be made of metal or insulating material. It is normally of substantial size to hold a production quantity of coating material. The size may normally vary from 1 to 60 gallons but other sizes are permissible. Because of its size the pressure tank and its conductive contents have very substantial capacitance. Even when the pressure tank is made of insulating material its conductive contents has very substantial capacitance.

A high voltage electrical connection is completed from a transformer 64 to platform 67 through a high valve of resistance 65. An example of resistance used was 250 megohms with 60,000 volts negative D.C. transformer output. The resistor may be built into the transformer so that it oil-immersed for cooling. A

length of cable can be used between the resistor 65 and platform 67 for convenience. For example, a 25 feet 0 inch long cable, amphenol RG/11U is satisfactory. This cable has a ground shield that can be stripped back about 13 inches from both ends. The cable added substantial capacitance to the pressure tank 66 and its contents. If the pressure tank 66 is made of insulating material to protect the operator from a disruptive discharge, the high voltage connection must be completed directly to the conductive fluid within the tank. The platform 67 may also be made of insulating material and all exposed charged metal should be covered with an insulating shield.

The second terminal of the high voltage transformer 64 is grounded and a product 78 being sprayed is also grounded to complete the circuit. The charging current passes from the transformer 64 through the resistor 65 into metal platform 67, pressure tank 66, and through the column of conductive paint in the insulated paint hose 32 and into head 25 of spray gun 100. The current flows to electrode 11 and flows off of the ionizing tip of the electrode 11 across the intervening space to the grounded ware 78 and back through a ground connection to transformer 64 to complete the circuit.

The primary of the transformer 64 is supplied with 110 volt single phase power. An airflow switch (not shown) operated by the atomizing air fed to the spray gun may trigger the 110 volt line so that the high voltage is "on" only when the gun is spraying.

Compressed air is fed to the system through an insulated supply line 70. It passes through an air regulator 71 where the air pressure fed to the space above the paint in pressure tank 66 is controlled. This causes the paint to flow at a constant pressure from the pressure tank 66 to spray gun 100.

Compressed air is also fed to an air regulator 72 where the atomizing air pressure to gun 100 is controlled. Atomizing air at controlled pressure is delivered through an insulating air hose 76 to gun 100. The hose 76 may be made of nylon, polyethylene or the like. If an air flow switch is used to trigger the high voltage transformer it would be placed in air line 76 to turn on the 110 volt supply to the transformer when atomizing air flows through the line.

The atomizing air pressure, the fluid pressure, fluid orifice size and air orifice size determine the fluid delivery and operating speed of the spray gun. Below is a chart showing various operating conditions for the spray gun. The fluid orifice 14 is 0.040 inch in diameter while the annular air orifice around the outside of fluid orifice 14 is 0.125 inch O.D. by 0.100 inch I.D. for the specific air cap and fluid tip combination shown in the chart.

Fluid pressure (water)	10	10	20	20	30	30
Atomizing air pressure	16	22	28	34	38	44
Fluid flow (GPH)	2.95	1.32	4.45	2.78	5.94	4.32
Air consumption (SCFM)	1.92	2.50	2.66	3.22	3.22	3.74
						Spray fan width
(15" in front of gun)	7"	9"	12"	14"	17"	19"

The fan width increases as the air pressure is increased. The fluid delivery decreases as the atomizing air pressure increases. The degree of atomization improves as the air pressure is increased or the fluid pressure is decreased. For this reason a high degree of pre-

cision is required in controlling atomizing air and fluid pressure.

If the paint cannot be made conductive, a small diameter core of semi-conductive polyethylene or the like can be placed in the fluid hose to complete the electrical connection to the head of the gun. The paint would flow around the semi-conductive core through the fluid hose. The maximum resistance of the core would be about 250 megohms at 60,000 volts to keep the operating efficiency high. Higher resistances tend to reduce operating efficiency somewhat.

Referring to FIG. 13, a form of multiple gun system in accordance with the invention is illustrated. Similar elements to the elements showing in FIG. 12 are similarly numbered with distinguishing suffixes.

A paint container or pressure tank 66a can be kept in a central paint mixing room. The central paint mixing room can be as much as several hundred feet from the spray booth. A high voltage unit die will also be in the paint mixing room and the electrical connection is made directly through a suitable resistor 65a to the paint tank. The tank is insulated from ground so that it can be charged to high voltage.

The paint and electrical distribution systems are combined into a single system for delivering paint to each of the electrostatic guns and charging the spray particles electrostatically. An insulated pipe 87 such as polyvinylchloride, nylon or the like is connected to the paint source and is piped where necessary throughout the painting area. Several spray guns 100a, 101 and 102 may be connected to the paint line and operated independently. A remote control fluid regulator can be used to control the coating fluid pressure to each gun. The fluid line 63a, 81, 82 to each gun also serves as a high voltage connection to the gun since as aforementioned water base coatings have very low resistance and function quite readily as a conductor of electrical current.

This is similar to the single gun hook-up but the paint tank is in a more remote location. While the fluid pressure to each gun is controlled by an air-loaded fluid pressure regulator, 83, 84 or 85, each sprayer can control his fluid pressure by adjusting an air regulator 86, 87 or 88 respectively that supplies air pressure to the control dome of the respective fluid regulator. Air is supplied to the air regulators from air line 89.

The second multiple gun system in FIG. 14 utilizes an air-operated reciprocating pump 90 that is isolated from ground to supply paint under pressure to the spray guns. The paint is recirculated continuously to prevent settling out of solids of the coating material in a connected piping system 92. The piping system 92 consists of a delivery conduit 93 connected to the fluid regulators 83b, 84b and 85b, and the air supply connection to both a pressure tank 91 and the pump 90 is made of insulating material so that the high voltage charge will not short out through the air line.

The arrangements shown provide a convenient means of energizing several guns to high voltage simultaneously and require only one high voltage source per system. This substantially reduces the cost of equipment and simplifies the installation. From a safety standpoint it provides somewhat less of a shock than a system operating with a single gun. All guns draw some current thereby reducing the maximum current available at a single gun.

With the system shown each spray gun is energized continuously. If a gun is not being used it is supported from a hook in such a manner that the charged head of the gun has a clearance space to grounded items of 6 inches to 12 inches. When all guns are turned off at the termination of painting operations the high voltage transformer will also be turned off. A switch and pilot light in the spray booth can be used to remotely control the high voltage transformer.

I claim:

1. An electrostatic deposition coating system comprising:

a spray gun body having a forward end provided with an internal chamber and a passage therein having an intake for connection to a source of coating material and an outlet through which coating material is ejected into said internal chamber,

means comprising air inlets to said chamber for atomizing said coating material in said chamber prior to ejection,

means comprising an aperture in said chamber for ejecting the atomized coating material into the atmosphere,

a container for holding conductive coating,

a fluid conduit having at least an inner layer of electrical non-conducting material connecting said container and said intake to transport conductive coating material from said container to said spray gun body passage,

a high voltage supply connected between conductive coating material in said container and work to be coated, and

means applying an electrostatic field to the atomized coating material ejected through said aperture of said chamber including an electrical conducting element extending forwardly of said body and connected to said conducting coating material prior to atomization in said chamber, the coating material in said fluid conduit being the sole electrical conductor of high voltage between the coating material in the container and the electrical conducting element extending forwardly.

2. The electrostatic deposition coating system according to claim 1 wherein said spray gun body comprises a rear end having a shield of electrical conductive material exposed to the atmosphere and a center section having all parts therein composed of electrical non-conductive material and connecting said forward end and said rear end.

3. The electrostatic deposition coating system according to claim 1 wherein said fluid conduit for transporting coating material is composed of electrical non-conducting material and the coating material in said container is electrically insulated from ground.

4. The electrostatic deposition coating system according to claim 2 wherein said fluid conduit for transporting coating material is composed of electrical non-conducting material and the coating material in said container is electrically insulated from ground.

5. The electrical deposition coating system according to claim 4 wherein said fluid conduit of electrical non-conducting material is covered by a shield of electrical conducting material, said conduit shield being connected to said shield on said spray gun body rear portion and to ground.

6. The electrostatic deposition coating system according to claim 3 wherein a multiplicity of said spray

gun bodies are connected through respective said conduits to a single container.

7. The electrostatic deposition coating system according to claim 6, wherein each said non-conducting conduit is connected to a fluid regulator, said fluid regulators being connected by conduit means electrically insulated from ground to said container.

8. The electrostatic deposition coating system according to claim 7, wherein said conduit means comprises a delivery conduit, a return conduit, a pumping means forcing coating material from said container through said delivery conduit to said regulators and through said return conduit to said container.

8. An electrostatic deposition coating system comprising:

a spray gun body having a forward end provided with an internal chamber and a passage therein having an intake for connection to a source of coating material and an outlet through which coating material is ejected into said internal chamber,

means comprising air inlets to said chamber for atomizing said coating material in said chamber prior to ejection,

means comprising an aperture in said chamber for ejecting the atomized coating material into the atmosphere,

a shield of electrical non-conducting material surrounding all conducting portions on the forward end of said body,

a fluid conduit connecting said container and said intake to transport conductive coating material from said container to said spray gun body passage,

a high voltage supply connected between conductive coating material in said container and work to be coated, and

means applying an electrostatic field to the atomized coating material ejected through said aperture of said chamber including an electrical conducting element extending through said shield at said aperture and connected to said conducting coating material prior to atomization in said chamber.

10. The electrostatic deposition coating system according to claim 9 wherein said spray gun body comprises a rear end having a shield of electrical conductive material exposed to the atmosphere and a center section having all parts therein composed of electrical non-conductive material and connecting said forward end and said rear end.

11. The electrostatic deposition coating system according to claim 9 wherein said fluid conduit for transporting coating material is composed of electrical non-conducting material and the coating material in said container is electrically insulated from ground.

12. The electrostatic deposition coating system according to claim 10 wherein said fluid conduit for transporting coating material is composed of electrical non-conducting material and the coating material in said container is electrically insulated from ground.

13. The electrical deposition coating system according to claim 12 wherein said fluid conduit of electrical non-conducting material is covered by a shield of electrical conducting material, said conduit shield being connected to said shield on said spray gun body rear portion and to ground.

14. The electrostatic deposition coating system according to claim 11, wherein a multiplicity of said spray

gun bodies are connected through respective said conduits to a single container.

15. The electrostatic deposition coating system according to claim 14, wherein each said non-conducting conduit is connected to a fluid regulator, said fluid regulators being connected by conduit means electrically insulated from ground to said container.

16. The electrostatic deposition coating system according to claim 15, wherein said conduit means comprises a delivery conduit, a return conduit, and a pumping means forcing coating material from said container through said delivery conduit to said regulators and through said return conduit to said container.

17. The electrostatic deposition coating system according to claim 9, wherein said electrical conducting element comprises a needle point having only its sharp tip protruding from said shield of electrical non-conducting material.

18. The electrostatic deposition coating system according to claim 9, wherein said electrical conducting element comprises a knife edge having only its sharp tip protruding from said shield of electrical non-conducting material.

19. The electrostatic deposition coating system according to claim 9, wherein said electrical conducting element comprises side surfaces of said aperture through which coating material is ejected into the atmosphere terminating in a forwardly facing knife edge having only its sharp tip protruding forwardly of said shield of electrical non-conducting material.

20. An electrostatic deposition coating system comprising:

a spray gun body having a forward end provided with a passage therein having an intake for connection to a source of coating material and an aperture through which coating material is ejected into the atmosphere from the forward end of the body, means for atomizing said coating material on or prior to ejection,

a container for holding conductive coating, a fluid conduit having at least an inner layer of electrical non-conducting material connecting said container and said intake to transport conductive coating material from said container to said spray gun body passage,

a high voltage supply connected between conductive coating material in said container and work to be coated, and

means applying an electrostatic field to the atomized coating material ejected through said aperture of said spray gun body including an electrical conducting element extending forwardly of said body and connected to said conducting coating material prior to atomization, the coating material in said fluid conduit being the sole electrical conductor of high voltage between the coating material in the container and the electrical conducting element extending forwardly.

21. The electrostatic deposition coating system according to claim 20 wherein said spray gun body comprises a rear end having a shield of electrical conductive material exposed to the atmosphere and a center section having all parts therein composed of electrical non-conductive material and connecting said forward end and said rear end.

22. The electrostatic deposition coating system according to claim 20 wherein said fluid conduit for

transporting coating material is composed of electrical non-conducting material and the coating material in said container is electrically insulated from ground.

23. The electrostatic deposition coating system according to claim 21 wherein said fluid conduit for transporting coating material is composed of electrical non-conducting material and the coating material in said container is electrically insulated from ground.

24. The electrostatic deposition coating system according to claim 23 wherein said fluid conduit of electrical non-conducting material is covered by a shield of electrical conducting material, said conduit shield being connected to said shield on said spray gun body rear portion and to ground.

25. The electrostatic deposition coating system according to claim 22, wherein a multiplicity of said spray gun bodies are connected through respective said conduits to a single container.

26. The electrostatic deposition coating system according to claim 25, wherein each said non-conducting conduit is connected to a fluid regulator, said fluid regulators being connected by conduit means electrically insulated from ground to said container.

27. The electrostatic deposition coating system according to claim 26, wherein said conduit means comprises a delivery conduit, a return conduit, and a pumping means forcing coating material from said container through said delivery conduit to said regulators and through said return conduit to said container.

28. The coating system according to claim 20, wherein said container is constructed of electrically nonconductive material.

29. An electrostatic deposition coating system comprising:

a spray gun body having a forward end provided with an internal chamber and a passage therein having an intake for connection to a source of coating material and an outlet through which coating material is ejected into said internal chamber,

means comprising air inlet to said chamber for atomizing said coating material in said chamber prior to ejection,

means comprising an aperture in said chamber for ejecting the atomized coating material into the atmosphere,

a shield of electrical non-conducting material surrounding all conducting portions on the forward end of said body,

means applying an electrostatic field to the atomized coating material ejected through said aperture of said chamber including an electrical conducting element extending through said shield at said aperture and connected to said conducting coating material prior to atomization in said chamber, and means for charging said electrical conducting element to a high potential with respect to work to be coated.

30. The electrostatic deposition coating system according to claim 28, wherein said electrical conducting element comprises a needle point having only its sharp tip protruding from said shield of electrical non-conducting material.

31. The electrostatic deposition coating system according to claim 28, wherein said electrical conducting element comprises a knife edge having only its sharp tip protruding from said shield of electrical non-conducting material.

32. The electrostatic deposition coating system according to claim 28, wherein said electrical conducting

element comprises side surfaces of said aperture through which coating material is ejected into the atmosphere terminating in a forwardly facing knife edge having only its sharp tip protruding forwardly of said shield of electrical non-conducting material.

33. An electrostatic deposition coating system comprising:

a spray gun body having a forward end provided with a passage therein having an intake for connection to a source of coating material and an aperture through which coating material is ejected into the atmosphere from the forward end of the body, means for atomizing said coating material on or prior to ejection,

a container for holding conductive coating,

a shield of electrical non-conducting material surrounding all conducting portions on the forward end of said body,

a fluid conduit connecting said container and said intake to transport conductive coating material from said container to said spray gun body passage,

a high voltage supply connected between conductive coating material in said container and work to be coated, and

means applying an electrostatic field to the atomized coating material ejected through said aperture of said spray gun body including an electrical conducting element extending through said shield at said aperture and connected to said conducting coating material prior to atomization in said chamber.

34. The electrostatic deposition coating system according to claim 32 wherein said spray gun body comprises a rear end having a shield of electrical conductive material exposed to the atmosphere and a center section having all parts therein composed of electrical non-conductive material and connecting said forward end and said rear end.

35. The electrostatic deposition coating system according to claim 32 wherein said fluid conduit for transporting coating material is composed of electrical non-conducting material and the coating material in said container is electrically insulated from ground.

36. The electrostatic deposition coating system according to claim 33 wherein said fluid conduit for transporting coating material is composed of electrical non-conducting material and the coating material in said container is electrically insulated from ground.

37. The electrostatic deposition coating system according to claim 35 wherein said fluid conduit of electrical non-conducting material is covered by a shield of electrical conducting material, said conduit shield being connected to said shield on said spray gun body rear portion and to ground.

38. The electrostatic deposition coating system according to claim 34, wherein a multiplicity of said spray gun bodies are connected through respective said conduits to a single container.

39. The electrostatic deposition coating system according to claim 37, wherein each said non-conducting conduit is connected to a fluid regulator, said fluid regulators being connected by conduit means electrically insulated from ground to said container.

40. The electrostatic deposition coating system according to claim 38, wherein said conduit means comprises a delivery conduit, a return conduit, and a pumping means forcing coating material from said container

through said delivery conduit to said regulators and through said return conduit to said container.

41. The electrostatic deposition coating system according to claim 32, wherein said electrical conducting element comprises a needle point having only its sharp tip protruding from said shield of electrical non-conducting material.

42. The electrostatic deposition coating system according to claim 32, wherein said electrical conducting element comprises a knife edge having only its sharp tip protruding from said shield of electrical non-conducting material.

43. The electrostatic deposition coating system according to claim 32, wherein said electrical conducting element comprises side surfaces of said aperture through which coating material is ejected into the atmosphere terminating in a forwardly facing knife edge having only its sharp tip protruding forwardly of said shield of electrical non-conducting material.

44. A coating system comprising:

a spray gun for atomizing and ejecting coating material into the atmosphere having a forward end provided with a passage therein having an intake,
a container for holding conductive coating material, a high voltage supply having a maximum voltage output connected between conductive coating material in said container and work to be coated,
a fluid conduit connecting said container and said intake to transport conductive coating material from said container to said spray gun body passage, said transported conductive coating material having a high effective capacitance and said conduit having a layer of electrically nonconductive material adjacent said transported conductive coating material to electrically insulate said conductive coating material from electrical potential differences equal to said power supply maximum voltage output at said high effective capacitance, and
means applying an electrostatic field to the atomized coating material ejected from said spray gun connected to said coating material at said spray gun.

45. The coating system according to claim 44, wherein said layer of electrically nonconductive material is surrounded by a shield of electrically conductive material.

46. The coating system according to claim 44, wherein said container is constructed of electrically nonconductive material.

47. A coating system comprising:

a spray gun for atomizing and ejecting coating material into the atmosphere having a forward end provided with a passage therein having an intake,
a container for holding conductive coating material, a high voltage supply connected to apply at least 50,000 volts direct current between conductive coating material in said container and work to be coated,
a fluid conduit connecting said container and said intake to transport conductive coating material from said container to said spray gun body passage, said transported conductive coating material having a high effective capacitance and said conduit having a layer of electrically nonconductive material adjacent said transported coating material to electrically insulate said conductive coating material

from said work and other objects at an electrical potential difference of 50,000 volts at said high effective capacitance, and

means applying an electrostatic field to the atomized coating material ejected from said spray gun connected to said coating material at said spray gun.

48. The coating system according to claim 47, wherein said layer of electrically nonconductive material is surrounded by a shield of electrically conductive material connected to a circuit ground.

49. The electrostatic deposition system according to claim 29, wherein said electrical conducting element comprises a multiplicity of needle points having only their sharp tips protruding from said shield of electrical nonconductive material.

50. A coating system comprising:

a spray gun for atomizing and ejecting coating material into the atmosphere having a forward end provided with a passage therein said passage having an intake,
a shield of electrical nonconducting material surrounding all conducting portions on the forward end of said body,
means applying an electrostatic field to the atomized coating material ejected from said spray gun comprising a multiplicity of needles having sharp tips protruding from said shield of electrical nonconductive material, said needles having insulating shields bonded to all their surfaces except their extreme sharp tips, and
a high voltage supply connected between said needles and work to be coated.

51. A coating system comprising:

a spray gun for atomizing and ejecting coating material into the atmosphere having a forward end provided with a substantial mass of electrically conductive material to produce a high capacitance to a circuit ground,
means applying an electrostatic field to the atomized coating material ejected from said spray gun connected to said coating material within said spray gun,
a container for holding coating material,
a high voltage supply having a maximum voltage output connected at said container between coating material in said container and ground, and
an electrical nonconductive fluid conduit connecting said container and said intake to transport coating material and electrical current from said container to said spray gun body passage.

52. A coating system according to claim 51, wherein said material being transported in said fluid conduit provides a resistance between said container and said spray gun not greater than 5,000 ohms per volt provided by said high voltage supply.

53. A coating system according to claim 51, wherein said mass of electrically conductive material has an effective capacity greater than a metal sphere of a radius of about three centimeters.

54. A coating system according to claim 53, wherein said material being transported in said fluid conduit provides a resistance between said container and said spray gun not greater than 5,000 ohms per volt provided by said high voltage supply.

55. A coating system according to claim 51, wherein the electrically conductive material in said spray gun

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and the coating material in said conduit have an effective capacity greater than a metal sphere of a radius of three centimeters.

56. A coating system according to claim 55, wherein said material being transported in said fluid conduit provides a resistance between said container and said spray gun not greater than 5,000 ohms per volt provided by said high voltage supply.

57. A coating system according to claim 51, wherein the ratio of the resistance of the coating material in the

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conduit to the voltage provided by the high voltage supply is approximately 4 ohms per volt.

58. A coating system according to claim 51, wherein the ratio is less than 25 ohms per volt.

59. A coating system according to claim 51, wherein the resistance in the conduit is approximately 250,000 ohms.

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