

[54] **ELECTROSTATIC SPRAYING
METHODS AND APPARATUS**

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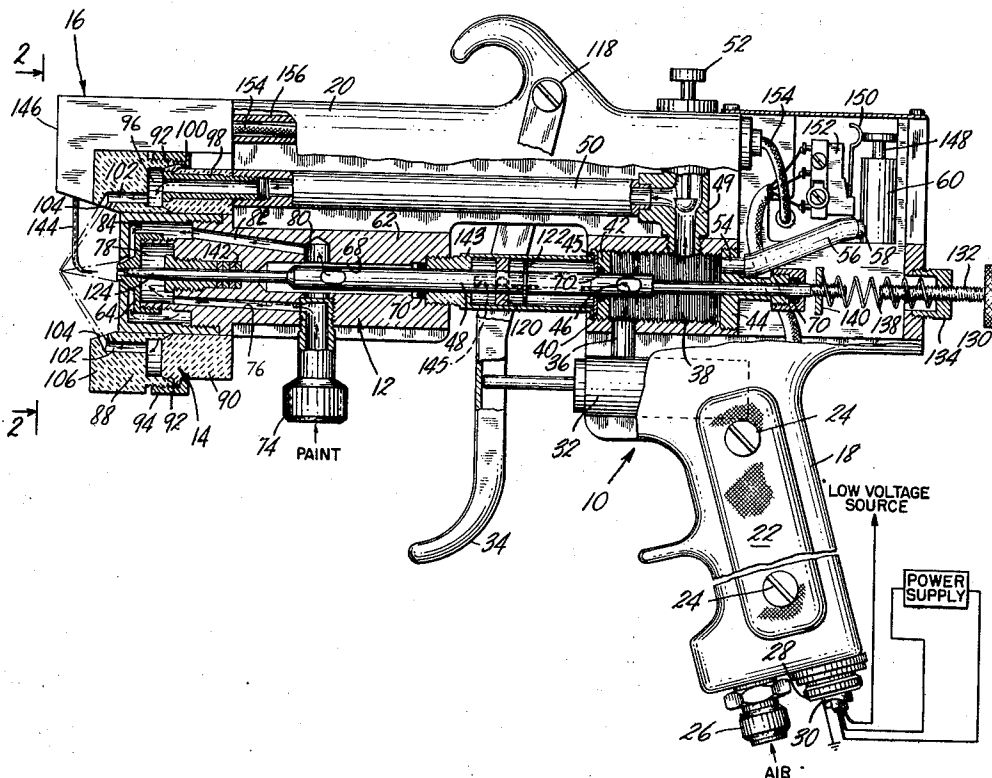
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ABSTRACT

Apparatus and methods for electrostatically coating a workpiece in which a spray of atomized coating material particles is charged electrically and thereafter confined within a surrounding shroud of moving air to control dispersal of the charged particles and to increase the charge potential carried by the particles. The shroud of air issues from the spray apparatus as a multiplicity of separate airstreams that extend toward the workpiece to be coated a distance sufficient to confine the charge particles against electrostatic attraction to objects other than the workpiece. Electrostatic charges are imparted to the coating material particles by a rearwardly directed corona discharge established between a corona electrode positioned in the spray path and the spray head. An air-operated switch energizes the corona electrode upon the flow of air to the spray head, thus preventing sparking between the corona electrode and the spray head by ensuring that the corona electrode is immersed in an airflow prior to being energized.

17 Claims, 4 Drawing Figures



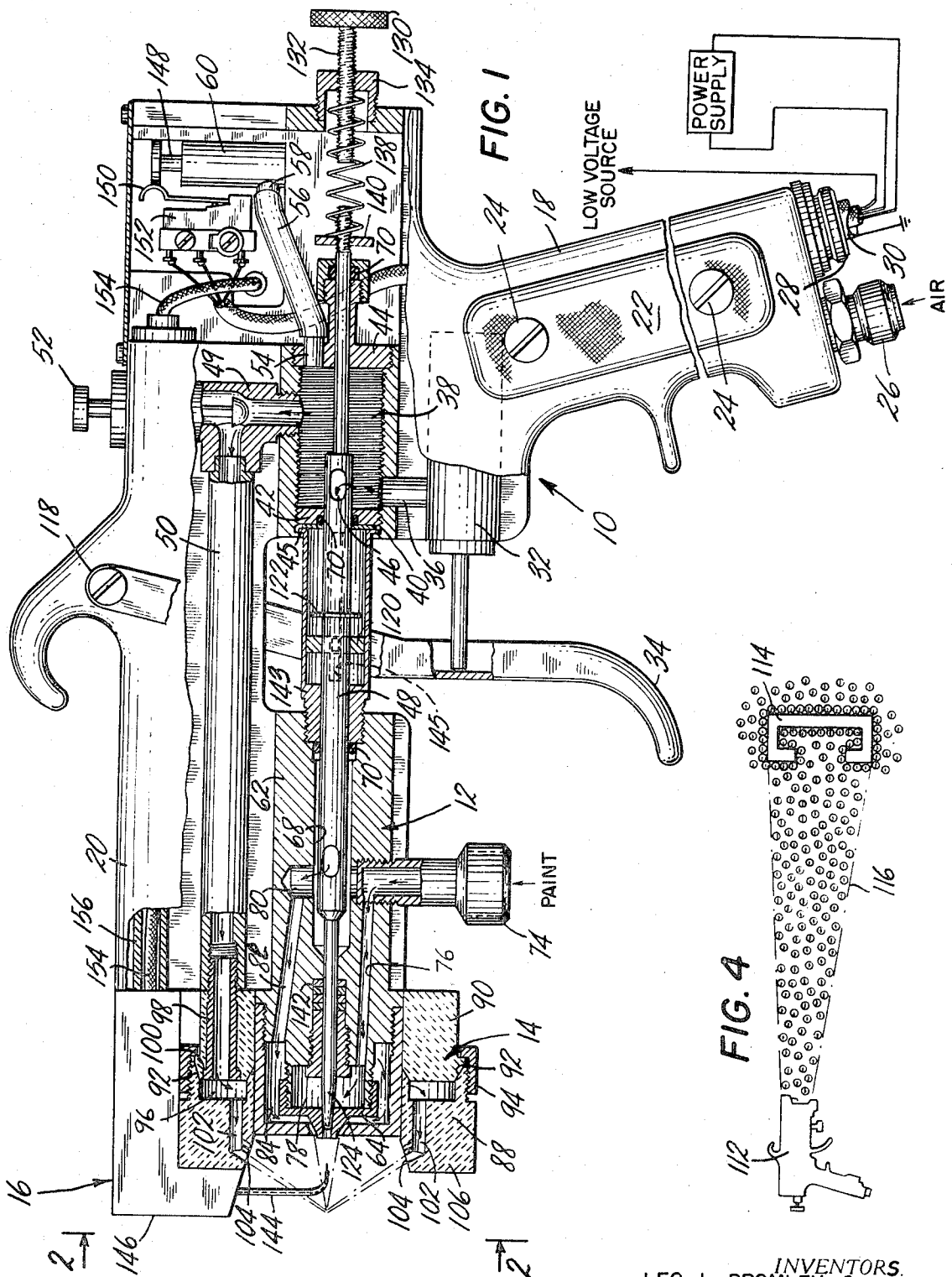
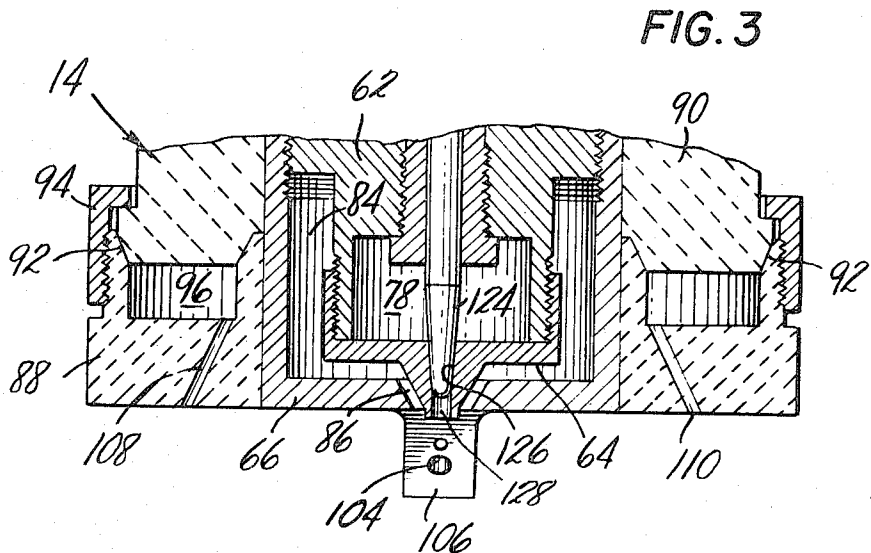
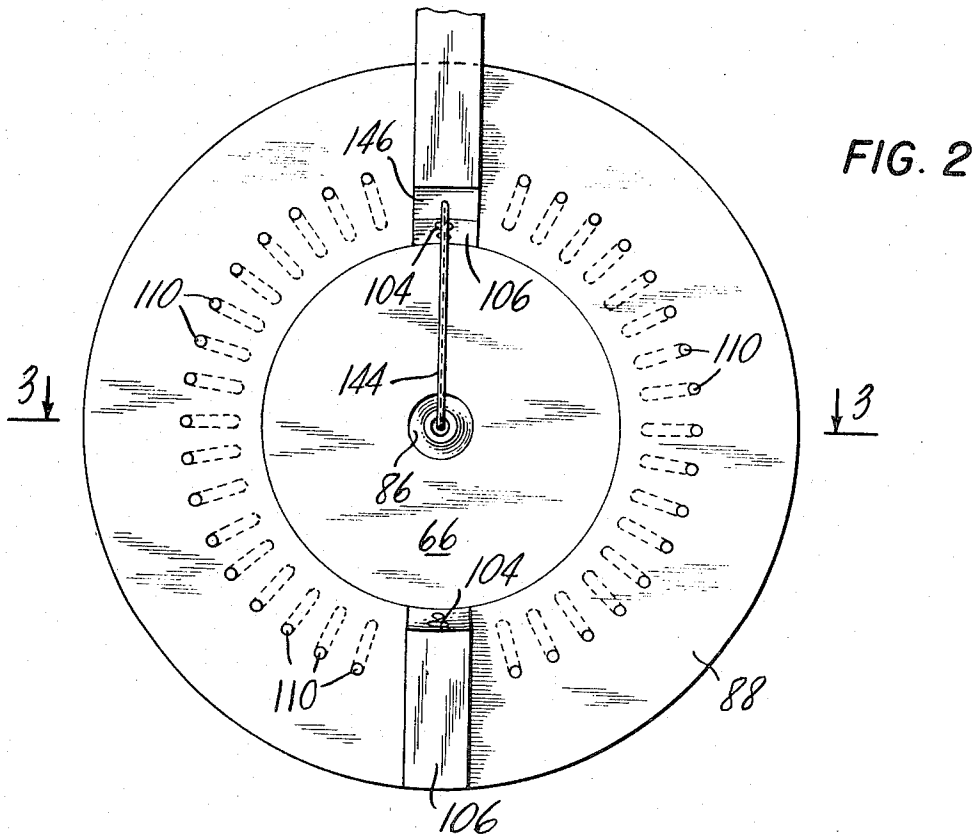


FIG. 4

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ELECTROSTATIC SPRAYING METHODS AND APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to electrostatic spray apparatus and methods and, more particularly, to improved electrostatic spray coating apparatus and methods for more efficiently and safely producing an electrified spray of coating material and for directing the charged spray to an article to be coated.

In current electrostatic spray technology, electrified sprays of coating material are normally produced by mechanically or electrostatically atomizing a supply of coating material and imparting electrostatic charges to the coating material particles concurrently with, or immediately after, their atomization. Upon issuing from the spray apparatus, the charged particles are impelled toward the workpiece to be coated by an electric field maintained between the spray apparatus and the workpiece or by the attraction of the charged particles towards opposite "image charges" on the workpiece, which typically is maintained at or near ground potential.

Nevertheless, even with present electrostatic spray coating techniques and apparatus significant quantities of coating material are wasted, that is to say, some coating material particles are not deposited on the workpiece or workpieces to be coated, but are attracted instead to other objects in the vicinity of the spray apparatus. Increased quantities of coating material must be sprayed, therefore, to allow for such losses and to obtain a coating finish on the workpiece of the desired quality.

Where the spray device is a hand-held unit, frequently the charged coating material particles are attracted to the device itself and to the operator where they present a possible health or safety hazard. In fixed spray installations, the dispersed particles collect on the walls and floor of the installation facility, as well as on the spray device and other components of the system, necessitating frequent shutdowns for cleaning and often interrupting operation by clogging working components. Moreover, the tendency of electrified sprays to disperse widely precludes the use of electrostatic spraying techniques in many applications, as for example where the workpieces to be coated cannot be removed from the presence of other articles whose finishes must be preserved.

Attempts directed toward alleviating the difficulties caused by such dispersal of the charged spray particles have included the use of dielectric shields which surround the emerging spray and mechanically confine it to a flow path of predetermined size. Others have confined the spray electrostatically by positioning one or more electrodes, generally of the same polarity as the charged spray particles, in the vicinity of the spray apparatus. Such spray controlling devices are not satisfactory in many application, however, because they interfere with the use or manageability of the apparatus and, particularly in the case of electrostatic shields, detract considerably from the versatility of the apparatus. In addition, the costs of manufacture and maintenance of the apparatus are increased.

Similarly, various types of mechanical and electrical shielding have been used to prevent inadvertent sparkover between surfaces of different electrical potentials, a constant fire and shock hazard in electrostatic spray systems. This shielding, too, is not fully satisfactory in all applications. For example, such shielding in a hand-held device often increases the weight and size of the device to an extent that the device becomes unwieldy and can be used only for short periods of time without overly tiring the operator.

The foregoing and other objectionable features of the prior art are overcome by the present invention.

SUMMARY OF THE INVENTION

In accordance with the present invention, the spray of atomized coating material particles is charged electrostatically in a high intensity, but low applied voltage, corona discharge and thereafter confined within a surrounding shroud of mov-

ing air to control dispersal of the charged spray and to direct the spray toward the workpiece to be coated.

The surrounding air shroud acts, in effect, like a mechanical dielectric shield and performs a plurality of functions. Chiefly, it retards radial dispersal of the charged coating material particles to objects in the vicinity of the workpiece and substantially prevents migration of the particles rearwardly to the spray apparatus or the operator. In addition, it enhances the quality of the finish given to a workpiece by increasing the spatial density of the charged spray and by forcing the particles to move principally in the downstream direction thereby to acquire high electrical potentials upon moving against the repelling force of the space charge field set up in the spray. The moving air shroud, therefore, causes large concentrations of coating material particles at high electrical potential to be delivered to the vicinity of the workpiece, where they are influenced by correspondingly strong electrostatic forces extending between the charged particle spray and the workpiece and are attracted with little waste to all workpiece surfaces. Accordingly, increased efficiency of operation and flexibility of use of electrostatic spray coating systems are realized.

In a refinement of the invention, the air shroud is formed by a multiplicity of separate airstreams spaced in a generally circular pattern around the particle spray. The individual shroud airstreams may be directed at an angle relative to the longitudinal axis of the spray so as together to define a cone of air diverging in the downstream direction. Variation of the velocity of the shroud air allows control of the extent of radial dispersal of the spray and the degree of particle turbulence within the spray pattern.

One embodiment of spray apparatus according to the invention, is a hand-held, air-type spray gun. It atomizes a supply of coating material, which may be a liquid, including electrically conductive liquids, powder slurry or other sprayable material, by discharging a stream of coating material through a central orifice into an intersecting, coaxial annulus of atomizing fluid, normally air. A corona electrode mounted on an insulator piece on the spray head extends transversely into the spray stream before curving rearwardly to terminate in a point in front of the air and material discharge orifices. Electrostatic charges are imparted to the atomized coating material particles as they pass through the corona discharge field established between the corona electrode and a ring attractor which encircles the material discharge orifice.

A needle valve hollow over a portion of its length is retracted, upon depression of the trigger, to disengage a valve seat at the discharge orifice and allow coating material to flow through the orifice. The rate of material flow is regulated by adjustably limiting the total rearward travel of the needle valve.

Air under pressure is supplied to the spray gun through a trigger-operated air valve in the handle and is thereafter delivered to the spray head along two separate paths. Part of the air, the atomizing air, flows through the hollow portion of the needle valve and appropriate passages in the gun body and spray head to exit through an annular orifice defined between the attractor ring and the central material orifice.

Another part of the air is delivered to a fan ring assembly on the spray head along a separate passage, where it exits through pattern-shaping orifices in the air horns and, additionally, through a multiplicity of inclined passages which form a generally circular pattern around the atomizing air and coating material discharge orifices. The airstreams discharged through those inclined passages form the diverging conical air shroud which confines the spray as it travels toward the workpiece. An annular reservoir in the fan ring assembly communicates with the upstream ends of the inclined air passages, so that a continuous flow of air of substantial equal velocity is maintained through each of the separate passages. An adjustable valve located in the shroud air passage allows regulation of the velocity of the shroud air so that optimum matching of the coating material and air shroud velocities can be achieved.

Sparking between the corona electrode and the attractor ring prior to the issuance of the coating material spray is prevented by immersing the corona electrode in a flow of air prior to its energization. This is accomplished by locating an air-operated switch in communication with the air passage leading to the spray head. Upon depression of the trigger, and the consequent flow of air to the spray head, an air-actuated plunger closes the normally open contacts of the switch to connect input low voltage to a power supply which delivers approximately 5 to 10 kv. to the electrode to establish the corona discharge. A dielectric coating on the corona electrode shank prevents sparking to surfaces outside the airflow.

By the foregoing construction, spray controlling and anti-sparking features are provided in an electrostatic spray device without any increase in weight or bulkiness of the device. Consequently, a lightweight, well-balanced unit is achieved which may be easily manipulated by hand even for extended periods of time, and which possesses great versatility of use and economy of manufacture.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of these and other features of the invention, as well as the objects and advantages thereof, reference may be made to the following detailed description and to the drawings, in which:

FIG. 1 is a side elevational view of an electrostatic spray gun constructed according to the invention, with the operating parts in the closed position and with parts broken away for clarity;

FIG. 2 is a front end view of the spray gun of FIG. 1, taken along the line 2—2 of FIG. 1 and looking in the direction of the arrows;

FIG. 3 is an expanded detail view of the spray head and fan ring assembly, taken along the line 3—3 of FIG. 2 and looking in the direction of the arrows; and

FIG. 4 is a schematic illustration showing the moving air shroud of the present invention confining the charged particle spray and directing the spray toward a workpiece to be coated.

DESCRIPTION OF A REPRESENTATIVE EMBODIMENT

In FIG. 1, a representative embodiment of an air-type spray gun constructed according to the invention includes a body section 10, a spray head 12, a detachable fan ring assembly 14 and an electrostatic, particle charging unit 16 supported on the fan ring assembly.

The gun body 10 preferably is formed of lightweight, high-strength plastic, and conveniently is molded as two separate halves which, when joined together, define a pistol-grip-type handle 18 and a generally cylindrical housing 20. This molded plastic construction of the gun body 10 affords a spray device light in weight and having good balance, and facilitates cleaning.

Stainless steel plates 22 and screws 24 on both sides of the handle 18 secure the molded plastic halves of the gun body to internal air and electrical conduits (not shown) and, in addition, serve as a convenient electrical ground for the operator's hand.

A fitting 26 at the base of the handle 18 connects the internal air conduit to an external supply of air under pressure, while a fitting 28 admits to the electrical conduit within the handle a multiple-conductor cable 30 leading to the low-voltage source and high-voltage power supply for energizing the charging unit 16.

A main air supply air valve 32 allows the flow of air to the spray head 12 and fan ring assembly 14 when the trigger 34 is actuated and, as shown in FIG. 1, completely shuts off the flow of air to the gun when the trigger is released. Air valves for this purpose are widely known, and any valve of suitable construction may be used.

An air passage 36 connects the main air supply valve 32 with a main air chamber 38 defined by a tubular member 40, a

forward end closure member 42 and a rearward end closure member 44. The tubular member 40 is formed with a circumferential flange 45 of reduced diameter at the forward end for a purpose hereinafter described. Therefore, the member 40 is threaded internally throughout its length and in a counterbore at the rearward end so that both of the correspondingly threaded closure members 42 and 44 can be inserted from the rearward end of the member.

Air flowing to the main air chamber 38 is exhausted therefrom along three separate paths. Part of the air, as indicated by the arrows in FIG. 1, enters a bore 46 in the stem 48 of the spray material control valve, the stem 48 traversing the closure members 42 and 44 and chamber 38 to extend forward to the spray head 12. Another part of the air in the main air chamber 38 passes through an adjustable valve 49 threaded to the tubular member 40 and is conducted to the fan ring assembly 14 through an elongate tube 50. The quantity of air flowing to the fan ring assembly 14 is adjusted as desired by manipulation of the operator knob 52 of the valve 49.

Still another portion of the air escapes from the main air chamber 38 by way of a nipple 54 extending through the rearward closure member 44. This air is delivered through a short section of flexible tubing 56 to the inlet port 58 of an air cylinder 60.

Turning now to the spray head 12, it consists essentially of a body 62, a fluid cap 64 and an attractor ring 66 (see FIGS. 1 and 3). The body 62, fluid cap 64 and attractor ring 66 are preferably metallic and may be conveniently constructed of aluminum or other suitable metal. A central bore 68 in the spray head body 62 is aligned with the tubular member 40 so as to receive the forward portion of the coating material valve stem 48. Sealing gaskets 70 are positioned between the valve stem 48 and the bore 68, closure member 42 and closure member 44 to prevent the leakage of air along the stem. Low-friction material, such as silicone rubber, polytetrafluoroethylene or the like, is preferred for the gaskets 70 to facilitate sliding movement of the stem 48.

The material to be sprayed, for example, a paint of appropriate viscosity, is delivered under pressure to the spray head 12 through a spigot 74 and is conveyed through a bore 76 in the body 62 to a chamber 78 behind the fluid cap 64. Flow of paint from the chamber 78 is controlled by the operation of the trigger in a manner more fully set forth below.

Air exiting from the bore 46 in the valve stem 48 enters the central bore 68 in the spray head body 62 and thereafter flows through passages 80 and 82 to an annular air chamber 84 formed between the attractor ring 66 and the front surfaces of the body 62. From there, the air is directed through an annular orifice 86 (see FIG. 3) to admix with and atomize the paint as it issues from the chamber 78. The airflow from the orifice 86 additionally serves to prevent the gun from fouling by carrying the charged paint particles away from the spray head, where they might otherwise be deposited by electrostatic attraction.

Referring now to FIG. 1, the fan ring assembly 14 includes an annular fan ring 88, and a cooperating fan ring seat member 90, both of which preferably are formed of dielectric material. The fan ring 88 and seat member 90 fit snugly over the attractor ring 66, and are held together in sealing engagement along mating, tapered surfaces 92 by a metallic lock ring 94 (see FIG. 3).

Air reaching the fan ring assembly 14 through the tube 50 (see FIG. 1) is admitted to an annular air reservoir 96 through a T-shaped tubular connector 98, which abuts against a shoulder 100 on the fan seat 90 and is threadedly received by the forward end of the tube 50 to hold the fan ring assembly 14 securely in position against the gun body 10. From the reservoir 96, the air passes through passages 102 and orifices 104 in the air horns 106 to control the pattern of the spray in the well-known manner.

Additional passages 108 (see FIGS. 2 and 3) leading from the air reservoir 96 open into the front surface of the fan ring 88 to form a generally circular configuration of orifices 110

around the spray head 12. As an important feature of the present invention, the multiplicity of air jets issuing through the orifices 110 from a shroud of moving air around the emerging spray to confine the charged paint particles and to direct the spray toward the workpiece to be coated.

Normally, an unconfined electrified spray tends to disperse widely, the charged particles drifting outwardly for considerable distances from the center of the spray. Indeed, they often migrate rearwardly to collect on the spray apparatus or the operator. Such scattering of the spray particles is caused mainly by turbulence within the spray, coulomb-repulsion forces acting between the individual charged particles and electrostatic attraction of the particles to electrically grounded surfaces near the spray.

It is desirable, of course, that spray dispersal be controlled so that as many as possible of the charged spray particles are delivered to the workpiece, not only for reasons of economy but also to protect objects in the vicinity of the workpiece and especially to protect the operator of the spray gun.

It is significant that, according to the invention, dispersal of the charged spray is controlled through the use of the moving air shroud, as this technique eliminates the need for this purpose of cumbersome and elaborate mechanical or electrostatic shielding. Operation of the air shroud is illustrated schematically in FIG. 4, in which a spray gun 112 is shown issuing a negatively charged spray towards a workpiece 114.

The air shroud, represented by the dashed lines 116, defines a bounded flow path for the paint spray, functioning, in effect, as a mechanical dielectric shield. That is, the air jets forming the shroud are effective to confine the charged particles within the annulus of the shroud, thus retarding radial dispersal of the charged paint particles to objects outside of the shroud and substantially eliminating migration of the particles rearwardly to the spray gun 112 or the operator. Additionally, by confining the spray within a limited volume, the shroud 116 increases the spatial density of the spray and forces the particles to move principally in the downstream direction. Both of these characteristics cause the particles to acquire higher electrical potentials than they normally would since they are forced to move against the axial repelling space charge field set up in the spray. The particles, therefore, have a high electrostatic mobility, and the electrical field gradients to the workpiece 114 created by the cloud of charged particles tend to be of high value.

Ideally, the velocity of the air shroud is adjusted so that its spray confining influence extends toward the workpiece 114 a distance sufficient that the predominant, unopposed electrostatic attractive forces acting on the spray particles are those extending from the "image charges" on the surfaces of the workpiece. In this way, the moving air shroud delivers large concentrations of paint particles at high electrical potential to the immediate vicinity of the workpiece, where as indicated in FIG. 4, they are attracted with little waste to all surfaces of the workpiece, including interior and remote surfaces. Accordingly, the quality of the finish given the workpiece is enhanced inasmuch as all surfaces are uniformly coated.

As indicated in FIG. 3, the air jet passages 108 are inclined so as to form a generally conical air shroud that diverges in the downstream direction. This conical configuration of the shroud is preferred since it has been found to provide good spray dispersal control, while, at the same time, allowing for required shaping of the spray.

Spray shaping is, of course, accomplished by the airflow through the opposed orifices 104 in the air horns 106, and, if desired, additional shaping is possible by varying the velocity of the air shroud jets. Adjustment of both of these airflows is readily carried out by opening or closing the valve 49 to the extent necessary. With regard to the air shroud, generally the higher the velocity of the air the flatter, or narrower, the spray pattern; conversely, wider patterns are obtainable with reduced air velocities.

Moreover, high shroud air velocities have been found to reduce turbulence within the spray, although the mechanism

by which this reduction is produced is not fully understood at this time. As a consequence, however, spray dispersal is further retarded and particle concentrations and space charge potentials are increased. On the other hand, "roll back" of the charged spray particles is prevented even with low-speed shrouds. It is possible, therefore, to develop large diameter sprays when needed without sacrifice of the operational and safety features of the invention flowing from the prevention of particle "roll back."

Representative shroud air parameters which have been tested successfully are: (1) an inclination of the air jet passages 108 of 30° and (2) an air velocity approximately equal to the downstream velocity of the spray particles. Other air jet orientations and velocities may, of course, be used with good results; and it will be understood that the air jets may be discharged parallel to the longitudinal axis of the spray, or to converge in the downstream direction, without departing from the scope of the invention. Also, the number and arrangement of the jet passages 108 and orifices 110 in the fan ring 88 may be varied from the structure portrayed in FIG. 2, the configuration there shown merely being one possible arrangement.

Referring briefly to the annular reservoir 96 in the spray head 12 (see FIG. 3), the volume enclosed by the reservoir preferably is substantially larger than the total volume of the air passages 102 and 108 leading from it. So sized, the reservoir functions as a manifold to maintain a continuous, smooth flow of air at equal velocity through each of the respective passages 102 and 108.

Turning now to FIG. 1, the upper half of the trigger 34 is bifurcated, with each of the legs 118 pivoted at its upper end to the gun body. Upon depression of the trigger beyond the position at which it opens the main valve 32, a bar 120 extending between the legs 118 engages a metal washer 122 fixed to the paint valve stem 48 to cause a tapered needle valve 124 at the forward end of the stem to be withdrawn from engagement with a mating valve seat 126 (see FIG. 3) formed on the fluid cap 64 at the inner end of a paint outlet orifice 128. The paint thereupon flows through the orifice 128 into the path of the annulus of air extending from the air orifice 86, and atomization of the paint occurs.

Regulation of the rate of paint flow through the orifice 128 is accomplished by limiting the rearward travel of the valve stem 48 through adjustment of an operator knob 130 at the rear of the gun (see FIG. 1). For this purpose, stem 132 on the knob 130 is threadedly received within a gland nut 134 to abut against the rearward end of the valve stem 48 after it has been retracted a predetermined distance. A compression spring 138 extending between a washer 140 adjustably mounted on the valve 48 and the inner surface of the gland nut 134 urges the needle valve 124 to the closed position upon release of the trigger.

Leakage of paint along the shank of the valve 124 is precluded by a low-friction seal 142 at the upstream end of the paint chamber 78, while alignment of the valve stem 48 within the gun is maintained by a slotted connector 143 (see FIG. 1) threaded at the forward end to the spray head 12 and clamped at the rearward end between the closure member 42 and the circumferential flange 45 on the tubular member 40. The crossbar 120 of the trigger 34 passes through axially extending slots 145 in the connector 143, to be guided thereby in its movement when the trigger is depressed or released.

As the paint emerges from the orifices and is atomized, it is charged electrically by a corona discharge field established in opposition to the particle flow between the spray head and a corona electrode 144 supported in an insulator piece 146 which, as shown in FIG. 1, is positioned on one of the air horns 106 of the fan ring 88. The insulator piece 146 may be secured to the air horn 106 in any suitable manner, but, if desired, the insulator piece may be eliminated and the electrode 144 supported directly by the air horn. The corona electrode 144 and the insulator piece 146 form the basic particle charging unit 16.

Agglomeration of the paint on the electrode 144 is avoided by mounting it to first extend transversely into the spray pattern and then to curve rearwardly to terminate at a point in front of, and preferably on, the longitudinal axis of the paint discharge orifice 12. With this arrangement, an intense ion concentration is created at the immediate region where the particles issue from the gun. Suitably, the corona electrode is constructed of wire, for example, piano wire, of a diameter such that the electrode will be self-cleaning due to vibrations induced by the impinging spray and airstreams. For safety purposes, a coating of dielectric material is provided on the electrode 144, except for approximately one thirty-second inch at the tip.

As previously mentioned, when the trigger 34 is depressed, part of the air flowing through the main air chamber 38 is conducted to an air cylinder 60 located at the rear of the gun. Upon entering the cylinder 60, the air causes a piston 148 to move upwardly and engage the spring arm 150 of a microswitch 152, thereby closing the normally open contacts of the switch to connect the input low voltage to the power supply (see FIG. 1). The power supply then delivers approximately 5 to 10 kv. to the electrode 144 to establish the corona discharge.

When the trigger is released, airflow to the cylinder is interrupted by the closing of the main air valve 32. The piston 148, which may be spring loaded or otherwise biased against the lifting force of the air, then returns to the rest position, releasing the spring arm 150 and returning the microswitch 152 to the normally open position. The corona discharge is accordingly terminated.

For convenience, the electrical wiring leading from the low-voltage source to the switch, from the switch to the power supply, and from the power supply to the corona electrode is all contained within the multiple-conductor cable 30 which enters the gun through the fitting 28 in the handle. That portion 154 of the high-voltage lead immediately adjacent the electrode 144 (see FIG. 1) is enclosed within an elongate tube 156 that extends forward to the rearward end of the insulator piece 146 and which, together with the fan ring air tube 50, also serves to support the fan ring assembly 14 and particle charging unit 16. Additional rigidity is thereby given to the spray gun while allowing the weight of the gun to be kept to a minimum.

Ideally, the entire gun, including the attractor ring 66 and the fluid cap 64, is connected to electrical ground, and a ground shield conductor may be included in the cable 30 for this purpose (see FIG. 1).

A feature of the present invention of particular importance is that the microswitch 152 for energizing the high-voltage power supply, and through it the corona electrode 144, is not actuated until airflow to the gun is established. Accordingly, a flow of air through the annular air orifice 86 and over the corona electrode 144 will exist whenever electrical power is supplied to the electrode 144, regardless of whether paint is also being discharged through the central orifice 128. Sparking between the electrode 144 and the spray head will therefore be prevented at all times since the flow of air from the orifice 86 alone is sufficient to prevent the generation of sparking conditions in the region of the charging electrodes. To this end, the annular air orifice 86 preferably is inclined with respect to the axis of the paint discharge orifice 128 to an extent that the air passing through the orifice converges toward and impinges upon the horizontal portion, that is, the rearwardly extending portion, of the corona electrode. This configuration of the air orifice 86 ensures that the corona electrode tip will always be bathed in the airflow. The dielectric coating on the corona electrode prevents sparking to other surfaces approached by the spray gun.

As sparking between the corona electrode 144 and the spray head is prevented by the foregoing airflow feature, the positions of travel of the trigger 34 at which the paint needle valve 124 and the main air valve 32 are opened are preferably such that the air valve 32 is opened first, so that the atomizing

air and spray controlling air are supplied to the spray head 12 and the fan ring assembly 14, respectively, before the flow of paint from the chamber 78 begins. Thus, when the trigger is fully depressed, and the needle valve 124 is retracted from the valve seat 126 to begin the paint flow, a fully atomized and charged spray will be discharged from the gun with virtually no waste of the material being sprayed.

In order that the gun may be used for nonelectrostatic spraying, a switch (not shown) is provided, in a location convenient to the operator, to open the circuit between the high-voltage power supply and the corona electrode 144.

It will be understood by those skilled in the art that the above-described embodiment is intended to be merely exemplary, in that it is susceptible of modification and variation without departing from the spirit and scope of the invention. For example, although a hand-held spray gun of the air type has been illustrated and described, it will be apparent that the air-shroud and spark-preventing features of the present invention may be used both with airless-type guns and in fixed electrostatic spray installations. Similarly, the apparatus and methods of the invention are not limited to spraying paint and, in fact, may be used with a wide variety of sprayable materials, including liquids, slurries, free-flowing powders, most types of coating materials and preservatives and, in particular, may also be used in complete safety to spray electroconductive liquids. Thus, water-base paints, ceramic slurries, porcelain-enamel frits or the like may be sprayed and charged electrically in accordance with the invention. All such modifications and variations, therefore, are intended to be included with the scope and spirit of the invention as defined in the appended claims.

We claim:

1. An electrostatic spray gun of the type in which a spray of coating material particles is produced by interacting streams of coating material and air under pressure comprising:

an electrically conductive spray head for issuing intersecting streams of coating material and air to produce a spray of coating material particles,

means, including an emitter electrode disposed in the path of the particle spray in downstream spaced relation to the spray head, for establishing a rearwardly directed corona discharge terminating at the spray head to charge the coating material particles electrostatically, and

means for preventing sparking between the emitter electrode and the spray head, the spark-preventing means including switch means responsive to the flow of air to the spray head for energizing the emitter electrode, whereby air flows from the spray head and over the emitter electrode prior to the initiation of the corona discharge, said flow of air being effective to prevent sparking between the emitter electrode and the spray head in the absence of the particle spray.

2. A spray gun according to claim 1 further comprising:

means defining at least one passage within the gun for conducting air to the spray head, the switch means being located within the gun in communication with the air passage to the spray head.

3. A spray gun according to claim 2 further comprising:

individually operable valves for controlling the flow of coating material and air from the spray head, and

operator means for sequentially opening the air and coating material valves, the operator means being arranged to open the air valve prior to opening the coating material valve so that air is delivered to and discharged from the spray head, and the airflow-responsive switch is actuated to energize the emitter electrode, before coating material is issued from the spray head.

4. A spray gun according to claim 3 in which the spray head includes a centrally disposed coating material orifice and an annular air discharge orifice in surrounding relation to, and substantially coaxial with, the coating material orifice, and in which the emitter electrode comprises a needlelike member having a pointed tip, the tip being disposed substantially on

the longitudinal axis of the coating material and air discharge orifices, whereby air exiting from the annular air discharge orifice surrounds the electrode tip in a spark-preventing air-flow.

5. A spray gun according to claim 4 in which the emitter electrode is supported by the spray head and extends transversely into the spray and thereafter curves rearwardly to terminate at a point in front of the coating material orifice, and in which the annular air discharge orifice is inclined with respect to the axis of the coating material orifice to an extent that the air exiting from the air discharge orifice converges toward and impinges upon the rearwardly extending portion of the electrode.

6. A spray gun according to claim 1 further comprising means for issuing a moving air shroud in surrounding relation to the particle spray simultaneously to control turbulence within the particle spray and to control radial and rearward dispersal of the charged spray particles downstream of the spray head, thereby causing the particles to move principally in the downstream direction and acquire increased charge potentials.

7. A spray gun according to claim 6 in which the shroud air issuing means includes means for adjusting the velocity of the shroud air to allow regulation of spray turbulence and the extent of dispersion of the spray particles.

8. A spray gun according to claim 7 further comprising means defining at least one passage within the gun for conducting the shroud forming air, and in which the velocity adjusting means includes a valve located in the air passage for regulating the flow of air through the passage.

9. A spray gun according to claim 8 in which the spray head includes a centrally disposed orifice for discharging the particle spray, and in which the shroud air issuing means includes means at the forward end of the gun defining a plurality of separate air passage opening in the downstream direction and disposed in a generally circular pattern around the centrally disposed orifice, the shroud air being issued from the plurality of separate air passages in a corresponding number of separate air jets.

10. A spray gun according to claim 9 in which the separate air passages are inclined with respect to the longitudinal axis of the particle spray so as to discharge the shroud air along a generally cone-shaped path diverging in the downstream direction.

11. A spray gun according to claim 9 further including an annular air reservoir located upstream of the separate air passages and having a volume substantially greater than the combined volumes of the separate air passages, so that a continuous flow of air of substantially equal velocity is maintained through each of the separate air shroud passages.

12. In an electrostatic spray system, the combination comprising:

a spray gun having a spray head for interacting streams of coating material and air under pressure to produce a spray of coating material particles,

means for supplying air under pressure to the spray gun,

means for supplying coating material under pressure to the spray gun,

means, including an emitter electrode disposed in the path

of the particle spray in downstream spaced relation to the

spray head, for establishing a rearwardly directed corona discharge terminating at the spray head to charge the coating material particles electrostatically, a high-voltage power supply for energizing the emitter electrode, and

means for preventing sparking between the emitter electrode and the spray head, the spark preventing means including switch means disposed within the spray gun and responsive to the flow of air to the spray head for electrically connecting the high-voltage power supply to the emitter electrode to establish the corona discharge, whereby air flows from the spray head and over the emitter electrode prior to the initiation of the corona discharge, said flow of air being effective to prevent sparking between the emitter electrode and the spray head in the absence of the particle spray.

13. An electrostatic spray system according to claim 12, further comprising:

means defining at least one passage within the spray gun for conducting air to the spray head, the switch means being located in communication with the air passage and being responsive to the flow of air through the passage to connect the high-voltage power supply electrically to the emitter electrode.

14. An electrostatic spray system according to claim 13, further comprising means for confining the charged spray particles downstream of the spray gun, thereby to control dispersal of the particle spray and to cause the particles to move principally in the downstream direction and acquire increased charge potentials, the spray-controlling means including means associated with the spray head for issuing a moving air shroud in surrounding relation to the particle spray.

15. An electrostatic spray system according to claim 14, in which the spray-controlling means includes means for adjusting the relative velocity between the shroud air and the spray particles to regulate the extent of radial dispersal of the spray particles.

16. An electrostatic spray system according to claim 15, in which the spray head includes a centrally disposed orifice for discharging the coating material, and in which the spray confining means includes means associated with the spray head defining a plurality of separate air passages opening in the downstream direction and disposed in a generally circular pattern around the central coating material orifice, the air jets issuing from the plurality of separate air passages constituting the air shroud surrounding the particle spray.

17. An electrostatic spray system according to claim 16, further comprising:

individually operable valves in the spray gun for controlling the flow of coating material and air from the spray head, and

operator means associated with the spray gun for sequentially opening the air and coating material valves, the operator means being arranged to open the air valve prior to opening the coating material valve so that the air is delivered to and discharged from the spray head, and the airflow-responsive switch is actuated to energize the emitter electrode, before coating material is issued from the spray head.

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