

[54] COATING SYSTEM
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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 73,700, Sept. 21, 1970, Pat. No. 3,692,241.
[52] U.S. Cl. 239/15, 239/3, 239/291
[51] Int. Cl. B05b 5/02
[58] Field of Search 239/3, 15, 422, 291, 239/292, 424

References Cited

UNITED STATES PATENTS

2,626,122	1/1953	Lammiman	239/292 X
3,219,276	11/1965	Norris	239/15 X
3,504,861	4/1970	Peeps et al.	239/291 X
3,317,138	5/1967	Fraser	239/15
3,589,607	6/1971	Wolf et al.	239/15
3,048,498	8/1962	Juvinall et al.	239/15 X
3,265,306	8/1966	Fischer et al.	239/15

3,037,703 6/1962 Croskey et al. 239/15

FOREIGN PATENTS OR APPLICATIONS

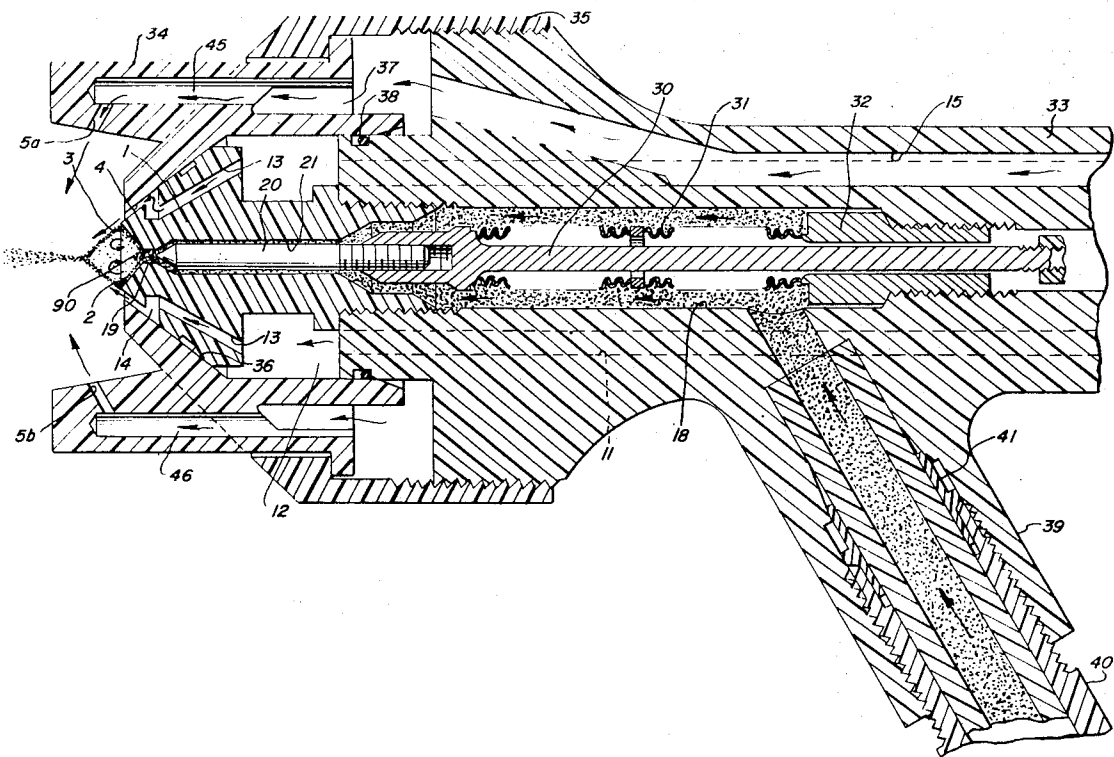
1,066,919 10/1959 Germany 239/291

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ABSTRACT

An atomization of coating material is accomplished by ejecting coating material through the orifice of the nozzle forcing it to flow across a forward facing diverging surface to the edge of an annular conical air orifice which directs air to an intersecting point forward of the nozzle orifice and thereby atomizes the coating material as it reached the annular edge of the air orifice. This type of atomization is used for conventional spray guns and for electrostatic spray guns with either completely electrically non-conductive forward ends for use with conductive coating materials such as water based coatings or with conductive fluid tips for use with either conductive or non-conductive coating materials. The forms of the invention employing water base coating materials provide an air pollution free system.

52 Claims, 7 Drawing Figures



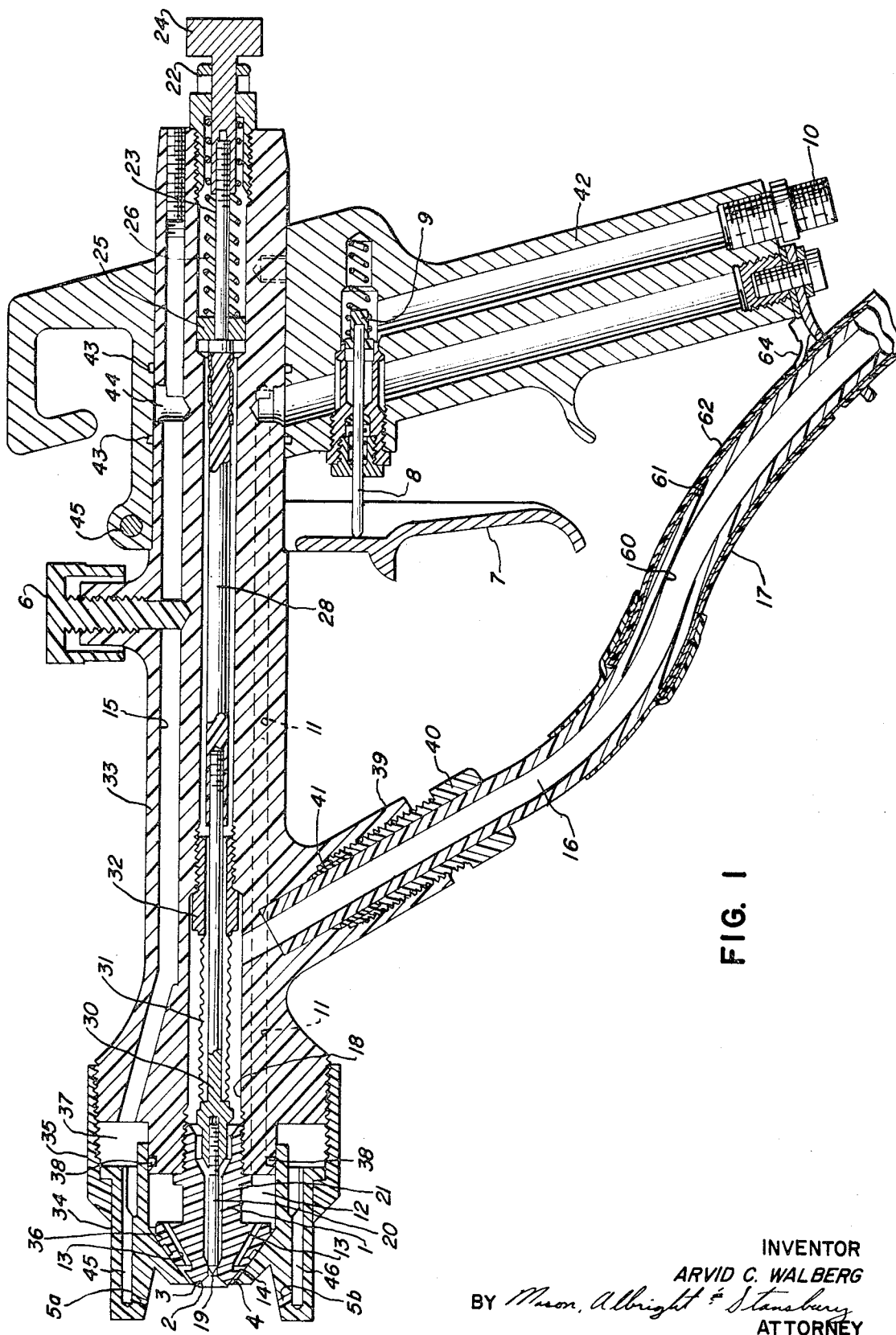


FIG. 1

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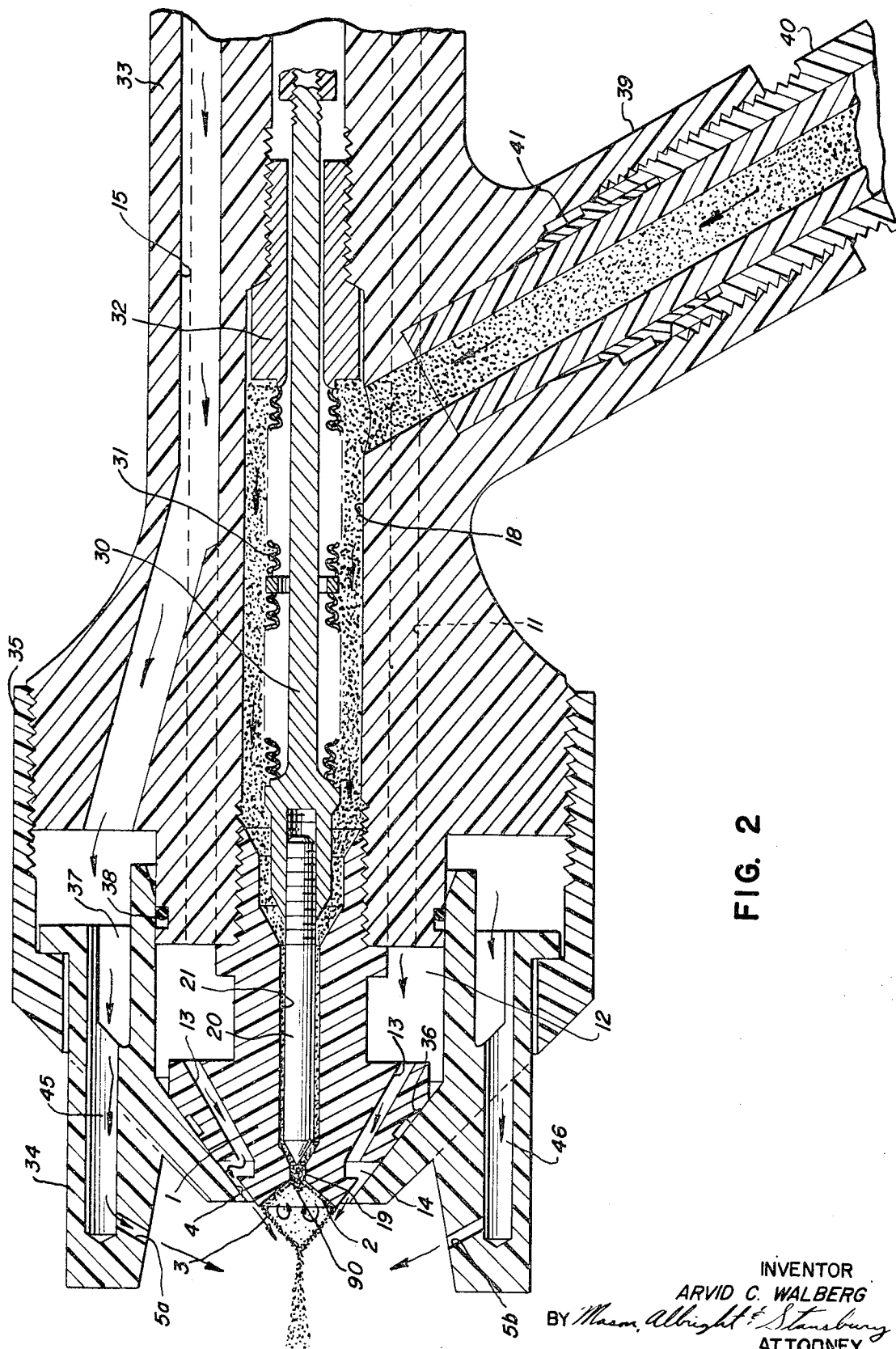


FIG. 2

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FIG. 3

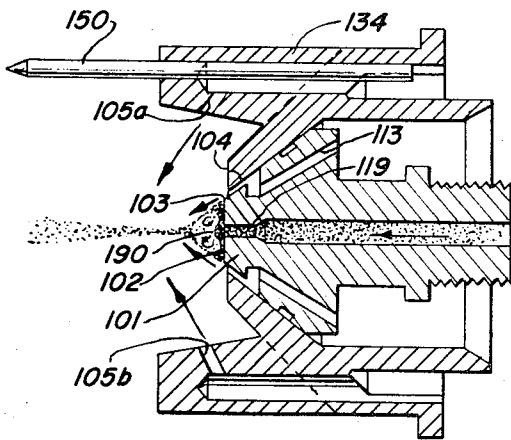


FIG. 4

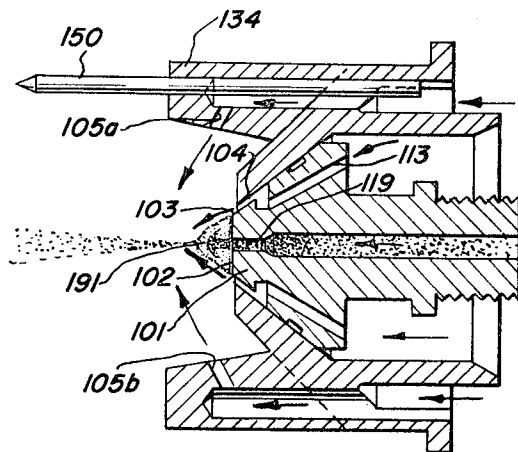


FIG. 5

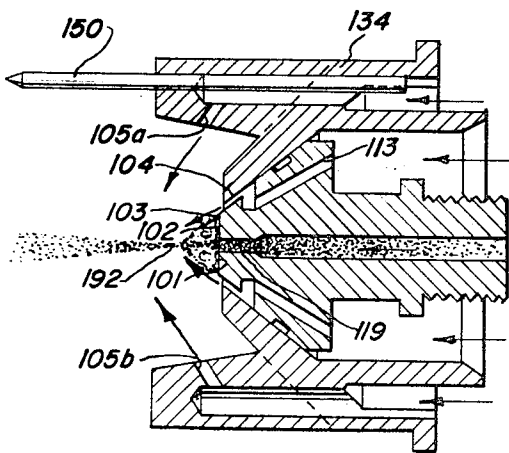


FIG. 6

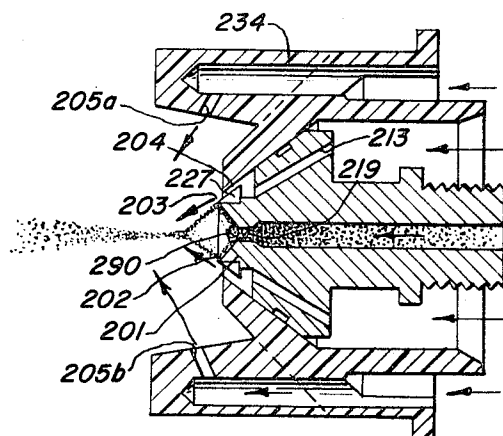
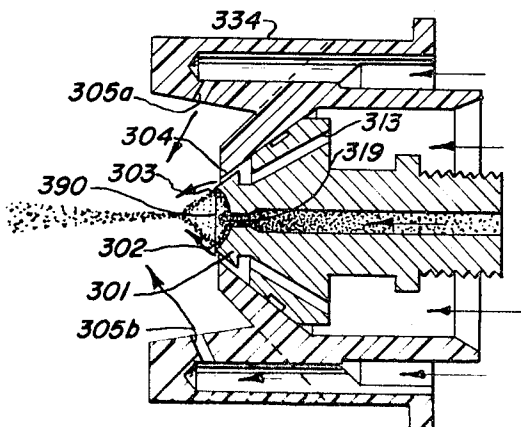


FIG. 7



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COATING SYSTEM

This application is a continuation-in-part of my earlier filed application Ser. No. 73,700, filed Sept. 21, 1970, now U.S. Pat. No. 3,692,241 issued Sept. 19, 1972.

The present invention relates to spray coating systems and more particularly to methods and apparatus for improved air atomization of coating materials. In my aforementioned application Ser. No. 73,700 there is described a nozzle used for atomization of material which has an exposed surface to atmosphere. This surface is continually wiped by the flow of material dispersed therefrom. The disclosed atomization device has an annular conical air orifice surrounding the nozzle through which air is ejected to converge at a point forward of the nozzle. The coating material flows over the exposed forward surface of the nozzle until it reaches its outer edge. Here the air from the air orifice impinges upon the outwardly flowing film of coating material to atomize it. The atomized particles are carried along with the converging air, and, as they meet at this convergence point, they form a stream of atomized particles. This stream is then shaped into a fan pattern by a pair of opposing air jets.

The present invention provides several forms of improved atomization devices which not only keep the exposed area of the nozzle wiped, but in addition provides improved ionizing and electrostatic field characteristics over the prior art.

As disclosed in my U. S. Pat. No. 3,251,551 issued May 17, 1966, it is desirable to provide a second electrode in the center of the material issuing from an air gun nozzle in addition to charging the nozzle itself in guns having 0.040 inch diameter orifice or larger. Thus, the thickness of the ejected stream is controlled so that none of the particles being atomized is a great distance from one or another of the electrode edges. In the present invention, the material upon being ejected from the nozzle orifice flows over a forward facing surface which increases in radius and thereby thins the moving film. When the film reaches the edge of this surface an angular converging jet of air strikes the film to atomize it into small particles. This in itself provides improved atomization over conventional air guns. When this arrangement is utilized in electrostatic deposition coating systems, the sharp edge formed by the forward facing surface and the converging outer nozzle surface provides a sharp annular edge which acts as an electrode. This annular edge charges the particles substantially at the point they are atomized into a spray and provides an electrostatic deposition field whose highest intensity is essentially at the point of atomization. This point of atomization and ionization is a circle of atomization and ionization at the annular edge.

There are several major advantages to my new air atomizing spray device. A thin film rather than a solid liquid stream is atomized by the compressed air. Since the thin film is much easier to atomize, it requires less compressed air, produces lower spray velocity and thereby achieves greater operating efficiency. The atomization is carried out at the forward edge of the film in a zone of maximum electrostatic stress. This imparts maximum electrostatic charge to each of the spray particles.

An electrostatic field is established between the film edge and the grounded product being coated, thus superimposing another strong field force in addition to the small field set up between individual charged parti-

cles and the grounded ware as produced with the spray gun illustrated and described in my aforementioned co-pending application, Ser. No. 73,700, now U.S. Pat. No. 3,692,241. This extra field force assures that the charged particles are collected on the grounded ware with a higher degree of certainty. Better electrostatic wrap-around is provided.

The present invention charges the paint in a very efficient manner similar to the spinning bell and spinning cone electrostatic atomizers well known in the prior art. While bell and cone electrostatic hand guns use an atomizer approximately 4 inches in diameter, the small cone or bell on the front of my gun is only about three-eighths inch in diameter. The bell or cone of prior art devices spin. The bell or cone in the invention is stationary, although it could be spun to give an element of centrifugal atomization and thereby permit further reduction in the compressed air required. The prior bell devices deliver paint formed into a film by centrifugal force. The invention causes a paint film to flow over the surface of the cone or bell by the aspirating action of an annular air orifice. While a spinning bell cannot electrostatically atomize highly conductive coatings, the present device is designed specifically for atomizing highly conductive coatings. A 4 inches diameter spinning bell for example, can atomize 100 c.c. of paint per minute, the present gun can easily atomize 4 to 5 times as much and can handle 10 times as much paint if the need arises. A spinning bell forms a round doughnut shaped spray pattern. The present gun produces a flat spray pattern which permits applying a far more uniform paint film.

Other prior art air atomizing electrostatic spray guns have formed the paint into a thin film prior to atomization with compressed air, but these prior art guns had serious limitations. One such gun utilized an annular slot fluid orifice about three-eighths inch in diameter with a slot opening only a few thousandths in width. The spray flared out in an expanding cone, producing a doughnut shaped pattern. The spray could not be shaped into a fan spray for applying a uniform paint film as is accomplished with the present invention. The gun could not spray conductive paint since the fluid system was not insulated as in the present invention.

Another prior art electrostatic gun also utilized an annular fluid orifice with backward aiming air horns. This gun achieved some degree of a flat spray pattern, but the rearward aiming air caused the gun to become excessively coated with paint. It became virtually non-operative in a relatively short period of time such as two or three minutes or less. The accumulation of dirt on the gun interfered with atomization of the paint.

Both of the aforementioned guns had a center core in the middle of their annular fluid orifices. These center cores would collect excessive amounts of paint. When the paint was accumulated in sufficient quantities, it would be thrown from the center core in the form of unatomized slugs to collect on the ware in large lumps. This caused rejects.

In the present gun the paint is delivered through an ordinary, easily manufactured, round orifice and then is made to disperse over a forward surface to form a thin film for air atomization at the outer edge of a large diameter cone or bell shaped fluid tip surface. The core inside the atomizing zone collects paint as in the prior art guns, but the collecting surface is constantly washed by a continuous flowing wet paint film so that collected

particles are recycled and not permitted to accumulate to a point where they would interfere with the spraying operation.

Another important feature of the present gun in an annular air orifice that converges the atomizing air stream from a large diameter to a point where it is quite small in diameter. The converging annular air jet is an important factor in achieving the proper condition to permit the formation of a fan-shaped spray. Just forward of the intersecting point of the converging atomizing air stream, additional sharply converging air jets intersect the central atomizing air jet to shape the spray pattern into the desired fan shaped pattern similar to that achieved with a conventional air atomizing spray gun. The conventional gun utilizes a much smaller diameter annular air orifice with a straight-forward projecting air stream. The uniform fan-shaped spray pattern is very desirable in any spraying operation since a uniform film is applied to the product with such a pattern. There is no need for the spray operator to try to compensate for a non-uniformly applied film. His job is much easier as a result.

The present type of thin paint film air atomizer can also be used with a charged metal fluid tip instead of a plastic tip in a manner similar to that described in U. S. Letters Patent, 3,056,557. With the fluid tip made of metal, the ionizing edge is substantially removed from the fluid orifice. The paint of course, converts from a solid stream into a thin liquid film that flows over the concave or cone-shaped forward surface of the fluid tip to be atomized at the outer forward projecting ionizing edge of the metal fluid tip. This type of arrangement can handle non-conductive paint as well as the conductive coatings discussed earlier in this disclosure.

The present thin-film atomizer has some substantial advantages over old prior art patents of the inventor. The electrostatic charging characteristics are superior for example. In the prior art patents that utilized a sharp-edged orifice, the paint was discharged as a solid liquid stream instead of a thin film. The solid liquid stream started to atomize immediately, but the final atomization occurred some distance in front of the ionizing edge of the orifice. The particles formed later were farther removed from the strong ionization zone and picked up a somewhat weaker charge. This was also true of the single needle-type electrode. Many of the spray particles were formed prior to reaching the ionizing point of the needle. They were dispersed somewhat away from the needle point and picked up a weaker charge. In the invention, the paint film is atomized into small uniform particles immediately at the ionizing edge in the strongest possible ionizing zone and immediately pick up a maximum charge on each particle.

In the inventor's prior art air gun, a substantial amount of atomizing air was needed to atomize the paint. This produced relatively high spray velocity and was the chief cause of paint waste. Since a thin paint film is much easier to atomize, a smaller quantity of atomizing air is needed. This results in lower spray velocity and higher operating efficiency.

Because of the superior atomizing characteristics, the new thin-film atomizer can also handle higher viscosity paint than the inventor's prior guns. This broadens the working range of the new gun design.

Now, therefore, it is an object of the present invention to provide a new and improved method of air atomizing coating material.

Another object is to provide new and improved electrostatic deposition coating system which utilizes water based rather than solvents based paints.

A still further object is to provide a new and improved electrostatic deposition coating system for conductive coating material.

Yet another object of the present invention is to force coating material ejected from an orifice to flow out in a thinning film over an expanding radius of a sloped surface so that when it reaches the edge of this surface it may be simultaneously air atomized, charged electrostatically and placed in a high electrostatic gradient portion of an electrostatic field which extends from the area of atomization to the work to be coated.

Still another object of the present invention is to provide an improved flexible cable between a highly charged container and the spraying gun.

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

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

FIG. 2 is an enlarged sectional view of the hand gun shown in FIG. 1;

FIG. 3 through FIG. 5 are sectional views of a modified form of the nozzle and air cap portions of the hand gun illustrated in FIG. 1 shown operating under different amounts of coating material pressure;

FIG. 6 is another form of air cap and nozzle portion of the hand gun illustrated in FIG. 1; and

FIG. 7 is yet another modification of the air cap and nozzle illustrated in FIG. 1.

While this invention is susceptible of embodiment in many different forms, there are 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.

FIGS. 1 and 2 show an external mix air atomizing electrostatic gun designed to handle water based paints and other conductive materials. The principal structural elements of the gun are a grounded handle portion 42 of conventional construction, a barrel 33 mounted on the handle portion 42, a fluid tip 1 and an air cap 34 secured to the forward end of the barrel 33 by a retaining ring 35. The fluid tip 1 has a conical shaped forward surface 2. This construction allows a thin paint film to flow over the surface to be atomized at a slightly projected forward edge 3 by compressed air discharged from a converging annular air orifice 4. The atomized spray is then formed into a flat spray pattern by air jets from air horn orifices 5a and 5b. The size of the flat pattern is fully adjustable by controlling the amount of air delivered through the orifices 5a and 5b. This is accomplished by adjusting a fan air valve 6 from fully closed to a wide open position. A manual trigger 7 operates an air valve 9 mounted in handle portion 42 by depressing a shaft 8. Trigger 7 is pivotally mounted on the handle by a shaft 45. The compressed air is delivered to the gun by pulling trigger 7 and de-

pressing air valve stem 8 to open spring loaded valve 9. Air is fed to valve 9 from an air hose (not shown) attached to an air hose connection 10 at the base of the metal gun handle 42. Air passes through valve 9 into a chamber 44 when gun trigger 7 is pulled. Air for atomizing the paint is fed through a plurality of passages generally indicated as 11 to a chamber 12 in the front end of the gun. The compressed air is then fed through several passageways 13 and fluid tip 1 into a chamber 14 for discharge at high velocity through the converging annular orifice 4. Compressed air from chamber 44 is also delivered through a passageway 15, the fan air valve 6, a chamber 37 and passages 45 and 46 to the pair of fan air orifices 5a and 5b to shape the atomized spray into a flat fan-shaped spray pattern.

Conductive fluid such as water based paint is delivered through a passageway 16 of an insulated cable-hose 17 into a chamber 18 at the head of the gun. Paint is then delivered through an orifice 19 when a nylon needle 20 is retracted. Paint is delivered to orifice 19 through a narrow angular passageway 21 surrounding needle 20. The annular passageway 21 may be used as a restrictive passageway to reduce the velocity of paint flowing through orifice 19 in order to permit the paint to flow more readily as a thin film over conical surface 2. A satisfactory size for annular passage 21 has been found to be 0.010 inch wide or less when the fluid orifice 19 is about 0.070 inch in diameter or larger. For example, if the needle 20 has an outside diameter of 0.125 inch, the inside diameter of fluid passage 21 would be 0.145 inch or less to provide a 0.010 inch annular passageway or less. The narrow annular passageway provides the desired restricting action in order to provide a relatively low velocity for the fluid flowing through the orifice 19. It has been determined that the velocity of the fluid stream through orifice 19 should normally not exceed about 500 feet per minute if the best degree of atomization is to be obtained. The best atomization occurs when all of the paint is formed into a thin film and flows over the surface of cone 2 to be atomized by compressed air at forward edge 3. When only a portion of the paint follows this path, the atomization quality tends to decrease but the gun is still functional.

In order to retract the nylon needle 20 it is necessary to pull trigger 7 which in turn is connected to a linkage 22 which passes around the outside of the gun. The linkage 22 is attached to the trigger 7 on each side of the gun by suitable pivots (not shown). The linkage 22 moves forward and backward with the trigger 7. An adjustable stop nut 24 is threaded onto the needle rear extension 23 and passes through a hole in linkage 22. When trigger 7 is pulled, the linkage 22 is moved back to contact stop nut 24. Further backward movement of trigger 7 moves stop nut 24 backward and in turn moves extension 23 and a metal washer 25, which slips over extension 23, backward. This movement compresses a valve spring 26 because the metal washer 25 pushes against valve spring 26. An insulated needle section 28 is also moved back since metal rear extension 23 is crimped around the outside end of the insulated needle section 28.

The insulated needle section 28 is attached at its forward end to a forward bellows attachment 30 which in turn holds nylon needle 20. The backward movement of insulated needle section 28 moves bellows attachment 30 backward and in turn opens the fluid valve by

moving nylon needle 20 backward. To prevent paint leadage out of the back of the gun the forward bellows attachment is soldered to a metal bellows 31. A rear bellows attachment 32 is soldered to the rear of metal bellows 31. The bellows attachment 30 and 32 are made of metal. The rear bellows attachment is threaded into insulating barrel 33 of the gun. The barrel 33 may be made of nylon, delrin, celcon or similar electrically non-conducting materials.

By removing the air cap 34 and fluid tip 1 the entire needle assembly can be removed through the head of the gun. The stop nut 24 is first removed and a special tool is inserted to unthread the rear bellows attachment 32 from insulating barrel 33.

The entire front end of the gun is made of plastic material except for bellows 31 and bellows attachments 30 and 32. As aforementioned the plastic retaining ring 35 holds plastic air cap 34 in place. The plastic air cap 34 seats against fluid tip 1 at a tapered seat 36. Atomizing air fed to chamber 12 and fan air fed to chamber 37 behind air cap 34 are kept separated by a seal 38. This seal may be a suitable O-ring or a special C shaped teflon ring with an internal expansion spring.

The cable-hose 17 is attached to a cable-hose connector portion 39 of barrel 33 by a compression nut 40 and a compression ferrule 41. The cable-hose 17 can readily be assembled and disassembled from the gun.

Metal handle 42 slips over plastic barrel 32 and is attached with screw-fasteners (not shown). Compressed air from chamber 44 is prevented from leaking through the handle portion 42 by seals 43. The cable-hose 17 has an inner polyethylene tube 60 with a 0.250 inch i.d. and a 0.500 inch o.d. Conductive paint or other conductive coating material flows through the interior of this tube and serves as the electrical conductor to supply electrical energy to the head of the electrostatic hand gun in the same manner as is more fully described in my co-pending application Ser. No. 24,104 filed March 31, 1970. Normally the conductive paint will be a water based paint. If a solvent based paint is used in the gun, the resistance of the paint is increased substantially and greatly limits the amount of electrical energy available at the tip of the gun. This extra resistance is enough to prevent ignition upon approaching the grounded work. By limiting the gun for use with water based paint, the electrical discharge will be substantially higher but will still not be harmful since the water based paint cannot ignite. A close fitting, tinned copper braid 61 is placed over the exterior of the polyethylene tube 60. This copper braid 61 serves as a grounded shield over the polyethylene tube 60 and prevents the build-up of static charge on the exterior of the tube. This eliminates a source of annoyance to the spray operator.

The copper braid 61 cannot stand very much abrasion and can easily be damaged when a cable-hose is dragged over a floor as the spray operator moves about during his normal spraying operations. To overcome the abrasion problem, a polyurethane jacket 62 is extruded over the copper ground shield 61. The polyurethane jacket is tough and resists abrasion. It is quite flexible and the high voltage cable-hose 17 provides the necessary flexibility of a paint hose as well as the insulation requirements of a high voltage cable with a working potential of 60,000 volts. The urethane jacket provides a cable-hose with a diameter of 0.605 inch plus or minus 5 percent. A standard hose length of 25 feet

is most often utilized but other lengths may be used as desired.

In order to use solvent based paint in the spray gun the cable-hose should be constructed with a thin nylon liner with a wall thickness of the order of one thirty-second inch. Such a nylon liner will provide superior resistance to paint solvents. The polyethylene tube is satisfactory for water based materials but it will be attacked by some paint solvents. If a solvent based paint is used its resistance in a 25 foot cable will usually exceed 50,000 megohms. Such a high value of paint resistance will provide non-arcing characteristics and safe operation should someone put solvent based paint in the spray gun. If the cable is long enough to provide a sufficiently high resistance when a solvent based paint is placed in the system to prevent drawing an arc when ground is approached, no fire or explosion can result from such an error.

Coating material flowing through the cable-hose 17 resists ionization and electrical breakdown because the old material is constantly being replaced with fresh new material. If a stagnant paint remained in the fluid hose, the material can be decomposed by electrolysis. Water, for example, can be decomposed into oxygen and hydrogen. The formation of a gas in the cable-hose can form a pocket of non-conductive material that will greatly increase the resistance and can make the cable-hose fail to function as a high voltage cable. The continuous flow of fresh material overcomes this problem. The grounded shield 61 is stripped back about 4.75 inches at the gun end and about 18 inches at the pressure tank end. This prevents arc-over of high voltage to the ground shield over the exterior surface of the polyethylene tube. A grounded lead is provided at or near each end of the tinned copper shield 61. A lead 64 at the gun end connects to the handle of the spray gun and a lead (not shown) near the paint pressure tank is connected to the high voltage power supply and is grounded through the power supply. The grounded copper braid 61 on the cable-hose provides good electrical stress distribution and prevents electrical breakdown of the cable-hose insulation.

Referring now to FIGS. 3 through 5, a modified form of the nozzle and air cap portions of the hand gun illustrated in FIG. 1 is shown under different amounts of operating coating pressure. Functionally corresponding elements to the elements of FIGS. 1 and 2 have corresponding identification numerals in the one hundred series. In FIGS. 3-5 the fluid tips and air caps as illustrated are constructed of electrically conducting material such as steel or other metal. A metal needle 150 serves as the ionizing electrode. In the absence of the needle the sharp corners of the metal air horns will serve as charging electrodes. A fluid tip 101 has a flat forward surface 102. This construction allows a thin paint film to flow over the surface 102 to be atomized at an edge 103 by compressed air from the converging annular air orifice 104. The atomized spray is then formed into a flat spray pattern by air ejected from air horn orifices 105a and 105b as was done in the operation of the nozzle illustrated in FIGS. 1 and 2. At a proper operating coating flow rate and air flow rate, a thin film of coating material flows outwardly from the nozzle orifice 119. It is drawn by a vacuum in the cone of atomizing air along the surface 102 outwardly to the edge 103 as is illustrated in FIG. 3. Upon reaching the edge 103, the thin film of coating materials is atomized

and is moved forwardly by the atomizing air from the air orifice 104 until it reaches approximately the apex of the cone of atomized coating material where it is forced into a circular cross sectional spray as is shown in FIG. 3. A bubble of paint 190 is formed at the orifice 119.

The 0.010 inch wide annular coating material flow around the needle 20 in FIGS. 1 and 2 provide a cross sectional flow area which is approximately equal to the cross sectional flow area of a 0.070 inch diameter circular orifice.

The restrictive opening around needle 20 can be greatly enlarged to provide a large passageway for very high viscosity coating material. The ratio of orifice area to passageway area will be about 1 to 1 for high viscosity coating materials, 3 to 1 for medium viscosity coating materials and 5 to 1 for very thin, low viscosity materials. For applying these ratios low viscosity materials are in the order of 17 seconds in a No. 2 Zahn viscosity cup. Medium viscosity materials are 25-30 seconds in a No. 2 Zahn viscosity cup and high viscosity materials are 40-45 seconds in a No. 2 Zahn viscosity cup. The very high viscosity materials cannot be measured with the No. 2 Zahn viscosity cup. As aforementioned it has been found desirable to restrict the ejection of coating material through the nozzle orifice to less than approximately 500 feet per minute. Those skilled in the art will recognize that if it is desired to increase the flow rate, larger orifices can be utilized with proportionately larger flow cross sectional areas in the passageway, and when smaller fluid delivery rates are desired, smaller orifices may be utilized with proportionately smaller flow cross sectional areas. The restrictions can be provided by other equivalent means other than the needle 20 illustrated in FIGS. 1 and 2. Such restrictions, for example, may be a smaller orifice placed in the passageway or at least a portion of the passage may be made of a smaller diameter than the orifice itself. All such variations are intended to be within the scope of the appended claims. As the coating material flows out over the forward facing surfaces as illustrated in FIGS. 2, 3, 6, and 7, after being ejected at less than approximately 500 feet per minute, the film spreads out until it reaches the edge of the forward facing surface and is atomized by the converging air. For good atomization the velocity of the air flow impinging upon the thin film should be greater than the velocity of the film. Further, the velocity of the air should be greater than the velocity of the flow of the coating material being ejected from the nozzle orifice. In this manner any paint which separates itself from the ejection bubble illustrated in FIGS. 2, 3, 6 and 7, and proceeds directly towards the apex of the converging air will be thoroughly atomized even though it did not flow with the film to the atomizing edge of the forward surface. If the guns are operated as illustrated in FIGS. 4 and 5, the coating material would nevertheless be atomized as long as the air flow is substantially greater than the velocity of ejection of the coating material through the orifice.

Turning now to FIG. 4, the bubble of paint has moved forward due to the increased volume of paint being delivered. Thus, as an increased volume of paint is delivered by increasing the coating material pressure, the bubble of paint forms into a mushroom shaped jet 191 as is illustrated in FIG. 4.

Additional pressure causes the fluid jet 191 to pass completely through the conical shaped spray pattern 7

to be fully atomized in a convergent zone 192 as shown in FIG. 5. Of course a large portion of paint still forms into a paint film on the flat face 102 and is fully atomized at the outer edge 103 by the converging annular air jet 104.

types of spray guns, coating materials, forward end spray gun construction, fluid tips and electrodes which are preferable from a standpoint of economy, deposition efficiency and safety are set forth in the following table.

Gun type	Conductive or non-conductive			
	Coating	Air cap	Fluid tip	Electrode
Non-electrostatic, manual and automatic	Either	Either	Either	None.
Electrostatic, automatic	Non-conductive	do	Conductive, flat	Needle.
Do	do	Non-conductive	Conductive, cone or concave	Annular, sharp edge.
Do	Conductive	do	Conductive, flat	Film.
Do	do	do	Conductive, cone or concave	Annular, sharp edge and film.
Do	do	do	Non-conductive, any form	Film.
Electrostatic manual	Non-conductive	do	Conductive, flat	Needle.
Do	do	do	Conductive, cone or concave	Annular, sharp edge.
Do	Conductive	do	Conductive, flat	Film.
Do	do	do	Conductive, cone or concave	Annular, sharp edge and film.
Do	do	do	Non-conductive, any form	Film.

In FIGS. 6 and 7, the air caps are non-conducting and the fluid tips are made of electrically conducting material such as steel. FIG. 6 shows a conical shaped forward facing surface 202 that functions in a manner similar to FIGS. 1 and 2. Functionally corresponding elements to the elements of FIGS. 1-5 have corresponding numerals in the two hundred series. This arrangement makes a much better high voltage electrostatic gun since the paint is charged at the zone of atomization by a sharp annular ionizing electrode 203. The metal fluid tip 201 has a plastic ring 227 that is used to make the metal ionizing edge 203 sharper.

FIG. 7 shows a concave shaped forward facing surface 302 which supplies a particularly sharp annular forward facing edge 303 that functions in a manner similar to FIG. 6. Functionally corresponding elements to the elements of FIGS. 1-6 have corresponding numerals in the 300 series. There is no difference between the basic operation of the modification shown in FIGS. 6 and 7 except that the concave shaped forward surface provides a relatively sharper annular edge than an equivalent conical surface. The cone-shaped forward surface is easier to manufacture than the concave shaped surface, and it is more than adequate for most coating materials. However, for some materials which are non-conductive and particularly difficult to ionize, it is desirable to make the annular edge as sharp as possible by using a concave forward facing surface. The ionizing edge can be made even sharper by having a portion on the forward face made of non-conductive material as well. Only a thin sharp annular ionizing ring would be exposed. The metal electrode could be connected to the source of high voltage through the conductive coating material or directly in a conventional manner.

The cone-shaped and concave shaped forward surfaces on the fluid tips represent the preferred forms of the present invention. The atomization and ionization occur in close proximity to each other. A thin paint film of formed by all the devices illustrated in FIGS. 1 through 7, and all or a large portion of the paint is atomized by air after it has been formed into a thin film. Atomizing a thin film is much easier than atomizing a thick liquid stream. In summary, the present invention, encompassing the various forms and modifications which are illustrated and described herein, is applicable to conventional non-electrostatic and electrostatic spray guns, manual and automatic spray guns, conductive and non-conductive coating materials, solvent and non-polluting coating carriers, and various types of ionizing and electrostatic field electrodes. The various

The conductive fluid tips listed may be partially constructed of plastic or other non-conductors such as illustrated in FIG. 6 if the annular edge is conductive. Regardless of which type of fluid tip set forth herein is utilized for non-electrostatic coating it does not matter whether the coating material is conductive or non-conductive or whether any of the components of the spray gun are either conductive or non-conductive for there are no electrical circuits involved. However, by use of any of the atomizing fluid tips and air caps illustrated herein, coating materials can be better atomized by spreading it into a thin film prior to the impinging of the atomized air. Thus the present invention provides improved performance in atomization of both solvent and water based coating materials in non-electrostatic coating systems.

While a manual or hand gun has been illustrated in the drawings, it will be understood by those skilled in the art that by changing the handle of the gun for a mounting and adding an air cylinder for triggering, the illustrated spray gun may be used in an automatic coating system either as a stationary gun or one which is reciprocated in a conventional manner.

If the present invention is to be utilized in an electrostatic deposition automatic gun for spraying non-conductive coating material the entire forward end of the gun including the fluid tip may be composed of electrically conductive material such as various metals. However, with a metal air cap the horns become the electrode and better ionization can be achieved by the utilization of a needle electrode 150 as illustrated in FIGS. 3-5. Although the edge formed by the obtuse angle between the flat forward facing surface illustrated in FIGS. 3-5 and the fluid tip's converging outer surface 104 does act as an electrode when the air cap is non-conductive, this edge is not as sharp as the right angle edges such as were illustrated in my U. S. Pat. Nos. 3,056,557 issued Oct. 2, 1962 and 3,251,551 issued May 17, 1966. Therefore it has been found that to maintain the highest possible efficiency a sharper edge as formed with a cone or concave shaped forward facing surface is preferred.

If a cone-shaped or concave shaped forward facing surface is utilized, the sharp annular edge produced by these shapes will form a sharp annular edged electrode which ionizes the coating particles at the point where they are being atomized by the cone of converging air. As aforementioned, it is preferable to atomize and ionize at the same point or annular line. It is further preferable to have the electrostatic deposition field emanate from the atomization and ionization point so that the

particles when first atomized and ionized are placed in the area of greatest electrostatic stress of the electrostatic deposition field. This is accomplished by use of the cone-shaped and concave shaped fluid tips.

When an electrostatic manual spray gun, constructed in accordance with the present invention, is utilized to spray non-conductive coating materials, it is desirable to have the metal parts which are charged to a high voltage enclosed in electrically non-conductive material or have most of the forward elements of the spray gun constructed of such electrically non-conductive materials from a safety standpoint. Since for efficiency, it is necessary to have a metal electrode, either the sharp edge annular fluid tip with a conical or concave surface is desirable. It is preferable to use the conical or concave fluid tips because when the gun is spraying the sharp edge causes greater current flow, thus imparting a stronger charge to the strongest particles, and reduces the arc-over voltage to improve safety. When a conductive coating material is being sprayed, the fluid tip may be composed of electrically non-conductive material since as aforementioned the film itself will provide the electrode at the point of atomization, the solid portion of the film being against the forward facing surface as long as the fluid velocity in relationship to the air converging cone velocity is maintained at a sufficiently low value. Thus with both a non-conducting forward end and a non-conducting fluid tip, a manual spray gun will produce a minimum shock even if the operator should somehow turn on the electrical power and simultaneously place his hand directly onto the forward end of the gun.

Whenever non-conductive material is to be sprayed in an electrostatic system constructed in accordance with the present invention, thereby requiring an electrically conductive fluid tip or needle, it is necessary to provide a directly wired connection between the high voltage power supply and the electrically conductive fluid tip or needle since the coating material itself cannot be used as the electrical conduit to the spray gun. Such direct connections can be made in any one of the conventional manners well known to those skilled in the art.

When the forward end of the gun is shielded or made up of electrically non-conductive material and the fluid tip is electrically conductive it will be charged from the column of coating material passing through it and therefore as indicated in the table above, both the fluid tip and the film become the ionizing point or annular line and also the terminus for one end of the electrostatic deposition field. Therefore, regardless of whether an electrically conductive or electrically non-conductive fluid tip is utilized in a spray gun constructed in accordance with the present invention and having all of the highly charged metal parts shielded by electrically insulating material or by making all of the exterior portions not grounded of electrically non-conductive material, the structure of such a system employs fully the inventor's discovery set forth in his U.S. Pat. Nos. 3,056,557 issued Oct. 2, 1962 and 3,251,551 issued May 17, 1966 that for the purpose of maximum efficiency, a spray gun having a highly charged electrically conducting member having a sharp tip or edge right at the region of discharge of a blast of coating material and free of any adjacent charged metal surfaces exposed to atmosphere in the vicinity of the atomizing

region will greatly improve the efficiency of the operation of the spray gun. Whether the thin film edge alone is used as the electrode or the combined fluid tip and film edges are utilized as the electrode, the sharp tip or edge is right at the point of atomization of the thin film. Therefore the inventor's earlier discovery has been optimized in the spray gun illustrated in FIGS. 1 and 2 with either a conductive or non-conductive fluid tip inserted therein. The gun illustrated in FIGS. 1 and 2 when used to spray water based coating material solves the solvent air pollution problem, eliminates the necessity of a separate electrical cable to the gun, eliminates the need of providing a safety device to prevent fire and explosion, and provides better atomization while maintaining a fan-shaped spray pattern. If a person attempts to put his hand in the atomized spray he will not receive an excessive shock as was possible in prior art spray guns. Therefore, the present invention in its most preferred form provides not only a more efficient spray coating system but also one that is inherently safer than prior art systems and eliminates the air pollution problems created by prior art systems.

I claim:

1. A 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 pressurized coating material and an outlet terminating in a nozzle through which coating material is ejected from the forward end of the body, said nozzle having an internal orifice surface, a forward facing surface joining said internal orifice surface and a conical outer surface converging to join said forward facing surface,

a conical forwardly converging surface in said forward end around said nozzle conical outer surface to form an annular converging orifice for ejecting air to atomize said ejected coating material,

a passage in said forward end to provide air under pressure having an outlet connected to said annular converging orifice and having an intake, and

a source of air connected to said intake and means for providing air in a sufficient quantity and under sufficient high pressure to eject a converging atomizing air stream through said annular converging orifice to an intersecting point where the converging air stream is transformed into a smaller diameter non-converging air stream combined with atomized coating material.

2. A coating system as specified in claim 1, wherein said forward facing surface is in a plane perpendicular to said internal orifice surface.

3. A coating system as specified in claim 1, wherein said forward facing surface is conical and diverges forwardly to form an obtuse angle with said internal orifice surface and an edge with said conical outer surface.

4. A coating system as specified in claim 1, wherein said forward facing surface is concave and forms an edge with said conical outer surface.

5. In combination with the coating system specified in claim 1:

a pair of opposed orifices mounted in said body outwardly of said annular orifice through which air is ejected to converge at a point forward of said point where air from said annular orifice converges.

6. A coating system as specified in claim 5, wherein said forward facing surface is in a plane perpendicular to said internal orifice surface.

7. A coating system as specified in claim 5, wherein said forward facing surface is conical and diverges forwardly to form an obtuse angle with said internal orifice surface and an edge with said conical outer surface.

8. A spray gun as specified in claim 5, wherein said forward facing surface is concave and forms an edge with said conical outer surface.

9. A coating system in accordance with claim 1, wherein said nozzle is electrically conductive and a source of electrical potential is connected between said nozzle and work to be coated.

10. In combination with the coating system specified in claim 1,

a container for holding conductive coating,
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 including said nozzle.

11. A coating system in accordance with claim 10, wherein said body forward end including said nozzle is electrically non-conducting.

12. In combination with the coating system specified in claim 1,

a restriction in said passage providing a coating flow cross section area which is less than a minimum coating flow cross section area of said nozzle internal orifice.

13. A coating system as specified in claim 12, wherein said nozzle flow cross section area bears a ratio of approximately three to one to said restriction flow cross section area in said passage.

14. In combination with the coating system specified in claim 1,

a needle valve movable longitudinally in said passage to seat against a valve seat adjacent said nozzle orifice having a cross sectional area sufficient to reduce the coating flow area around said needle valve to a cross sectional area less than a minimal cross sectional area of said internal orifice.

15. A coating system in accordance with claim 1, wherein at least a portion of said passage has a coating flow cross sectional area less than a minimal cross sectional flow area of said internal orifice.

16. The coating system specified in claim 1, wherein the velocity of said air being forced over said sharp edge exceeds the velocity of coating material being ejected from said orifice.

17. In combination with the coating system specified in claim 1,

a container for holding coating material,
a fluid conduit connecting said container and said intake to transport coating material from said container to said spray gun body passage,
means applying an electrostatic field to the atomized coating material including an electrical conducting element extending forwardly of said body, and
a high voltage supply connected between said electrical conducting element and work to be coated.

18. A coating system as specified in claim 17, wherein said body forward end is electrically non-conducting.

19. In combination with the coating system specified in claim 1,

a container for holding coating material,
a fluid conduit connecting said container and said intake to transport coating material from said container to said spray gun passage,
means applying an electrostatic field to the atomized coating material including said nozzle, and
a high voltage supply connected between said nozzle and work to be coated.

20. A coating system in accordance with claim 19, wherein said body forward end is electrically non-conducting except for said nozzle.

21. In combination with the coating system specified in claim 1,

a valve moveable in said passage to seat against a valve seat.

22. A coating system comprising a spray gun body having a forward end provided with a nozzle having an orifice through which coating material is ejected at a velocity from the forward end of the body, wherein the improvement comprises an annular conical orifice surrounding and spaced from said nozzle orifice and means for ejecting air through said annular converging orifice at a higher velocity than said ejected coating material velocity to converge at a point forward of said nozzle and there form a non-converging stream of air and atomized coating material.

23. A coating system as specified in claim 22, wherein said nozzle has a forward facing surface which lies in a plane perpendicular to the direction of coating fluid flow through said nozzle.

24. A coating system as specified in claim 22, wherein said nozzle has a conical forward facing surface that diverges forwardly.

25. A coating system as specified in claim 22, wherein said nozzle has a concave forward facing surface that terminates in a sharp annular edge.

26. In combination with the coating system specified in claim 22, a pair of opposed orifices mounted outwardly of said nozzle through which air is ejected to converge at a point forward of the point where air from said annular conical orifice converges.

27. A coating system as specified in claim 26, wherein said nozzle has a forward facing surface lying in a plane perpendicular to the direction of coating fluid flow through said nozzle.

28. A coating system as specified in claim 26, wherein said nozzle has a conical facing surface that diverges forwardly to an annular edge.

29. A coating system as specified in claim 26, wherein said nozzle has a concave forward facing surface which terminates in an annular edge.

30. A coating system as specified in claim 22, wherein said nozzle is electrically conductive and a source of electrical potential is connected between said nozzle and work to be coated.

31. In combination with the coating system specified in claim 22, means for restricting an ejection flow of coating material through said nozzle to less than approximately 500 feet per minute.

32. In combination with the coating system specified in claim 22,

- a shield of electrical non-conductive material surrounding all electrical conducting portions of said body,
- means applying an electrostatic field to the material passing from the nozzle including an electrical conducting element extending through said shield at said nozzle, and
- a high voltage supply connected between said electrical conducting element and work to be coated.
33. In combination with the coating system specified in claim 22,
- a shield of electrical non-conductive material surrounding all electrical conducting portions of said body,
- means applying an electrostatic field to the material passing from the nozzle including said nozzle extending through said shield, and
- a high voltage supply connected between said nozzle extending through said shield and work to be coated.
34. A coating system as specified in claim 33, wherein said forward facing surface is conical and diverges forwardly to form an obtuse angle with said internal orifice surface and an edge with said conical outer surface.
35. A coating system as specified in claim 33, wherein said forward facing surface is concave and forms an edge with said conical outer surface.
36. A coating system comprising,
- a nozzle having an orifice and a forward facing surface extending outwardly from said orifice,
- means for forming coating material ejected from said orifice into a thin film spreading outwardly over said forwardly facing surface to an outer edge of said converging surface, and
- means for forcing air over said sharp edge to a point forward of said orifice to atomize said thin film of coating material and to transport the atomized coating material to said point.
37. In combination with the coating system specified in claim 36, means for spreading said atomized coating material into a fan-shaped pattern at a second point forward of said orifice and forward of said point.
38. A coating system as specified in claim 36, wherein said nozzle is electrically conductive and a source of electrical potential is connected between said nozzle and work to be coated.
39. In combination with the coating system specified in claim 36,
- means for restricting an ejection flow of coating material through said nozzle to less than approximately 500 feet per minute.
40. The coating system specified in claim 36, wherein the velocity of said ejected air exceeds the velocity of said ejected coating material.
41. A 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 pressurized coating material and an outlet terminating in a nozzle through which coating material is ejected from the forward end of said body, said nozzle having an internal orifice surface, a forward facing surface joining said internal orifice surface and a conical outer surface converging to join said forward facing surface,

- a conical forwardly converging surface in said forward end around said nozzle conical outer surface to form an annular converging orifice for ejecting air to atomize said ejected coating material,
- a passage in said forward end to provide air under pressure having an outlet connected to said annular converging orifice and having an intake connected to a source of air,
- a container for holding conductive coating,
- 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 including an electrical conducting element extending forwardly of said body and connected to said conducting coating material.
42. A coating system in accordance with claim 41, wherein said body forward end including said nozzle is electrically non-conducting.
43. A coating system comprising a spray gun body having a forward end provided with a nozzle having an orifice through which coating material is ejected from the forward end of the body, wherein the improvement comprises:
- an annular conical orifice surrounding and spaced from said nozzle orifice through which air is ejected to converge at a point forward of said nozzle,
- a container for holding conductive coating,
- 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,
- means applying an electrostatic field to the atomized coating material including an electrical conducting element extending forwardly of said body and connected to said conducting coating material,
- a shield of electrical non-conductive material surrounding all conducting portions of said body, and
- means applying an electrostatic field to the material passing from the nozzle including an electrical conducting element extending through said shield at said nozzle.
44. A coating system as specified in claim 43, wherein said forward facing surface is conical and diverges forwardly to form an obtuse angle with said internal orifice surface and an edge with said conical outer surface.
45. A coating system as specified in claim 43, wherein said forward facing surface is concave and forms an edge with said conical outer surface.
46. 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 pressurized coating material and an outlet terminating in a means through which coating material is ejected from the forward end of the body,
- a container for holding conductive coating,
- a flexible electrical non-conducting fluid conduit

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connecting said container and said intake to transport conductive coating material from said container to said spray gun body passage,
 a flexible shield of electrical conducting material surrounding said fluid conduit and connected to work to be coated, 5
 a high voltage supply connected between conductive coating material in said container and work to be coated,
 means applying an electrostatic field to the ejected coating material, and 10
 a flexible layer of electrical non-conductive material surrounding said flexible shield.

47. A method of coating comprising,
 ejecting coating material from an orifice, 15
 spreading said coating material onto a diverging surface to form a thin film,
 providing a converging cone-shaped pattern of air which impinges upon said thin film prior to the air reaching an apex of said cone-shaped pattern to atomize said thin film of material and shape the atomized material into a column. 20

48. In combination with the method of coating specified in claim 47, the step of impinging opposing jets of air against said column of atomized material to form it into a fan-shaped pattern. 25

49. In combination with the method of coating specified in claim 47, the step of establishing an electrostatic field between said thin film, at an intersection of said thin film and said cone-shaped pattern of air, and work to be coated. 30

50. A coating system comprising:
 a spray gun having a forward end provided with a first

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passage therein having an intake for connection to a source of pressurized coating material and an outlet terminating in a nozzle having an orifice through which coating material is ejected from the forward end of the body and with a second passage therein for connection to a source of pressurized air,
 an annular conical orifice surrounding and spaced from said nozzle orifice through which air is ejected to converge at a point forward of said nozzle and connected to said second passage,
 first means operatively connected to said first passage to control the velocity of coating material ejection through said orifice,
 second means operatively connected to said second passage to control the velocity of air ejection through said annular conical orifice, said first and second means being adjusted to eject air at a greater velocity than the ejection velocity of said coating material.

51. A coating system in accordance with claim 50, wherein said first and second means are adjusted to provide a generally circular flow of air from said annular conical orifice toward the converging point, back toward the nozzle orifice and across a space between said nozzle orifice and said annular conical orifice.

52. A coating system in accordance with claim 50, wherein said first and second means are adjusted to force said coating material to flow from said nozzle orifice across a surface joining said orifices to said annular conical orifice where the ejected air impinges on said coating material to atomize it.

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