

Feb. 6, 1968

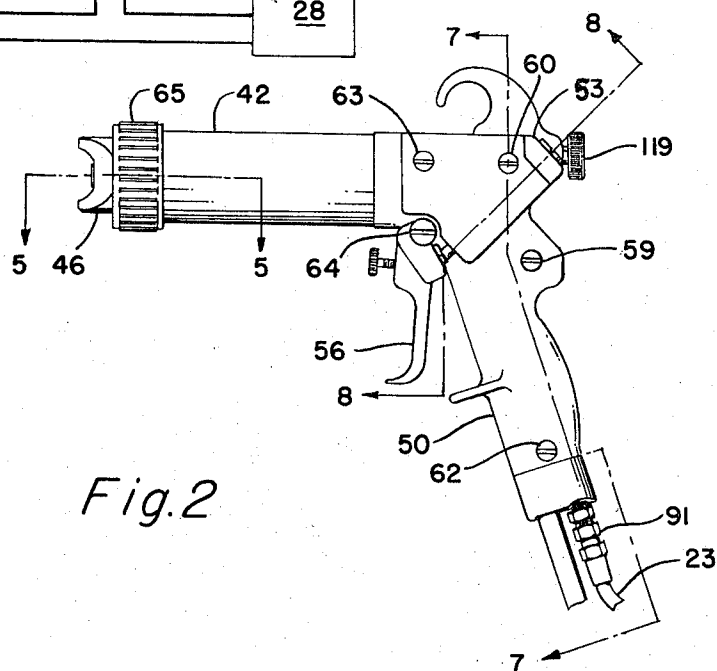
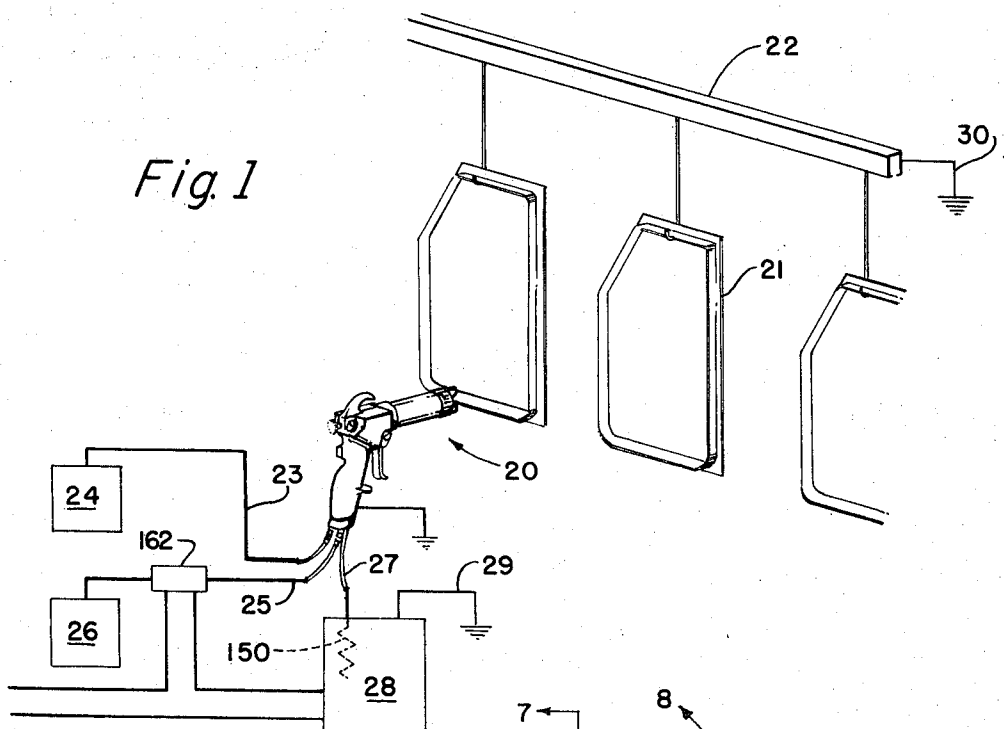
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3,367,578

ELECTROSTATIC SPRAY COATING APPARATUS

Original Filed Jan. 30, 1961

5 Sheets-Sheet 1



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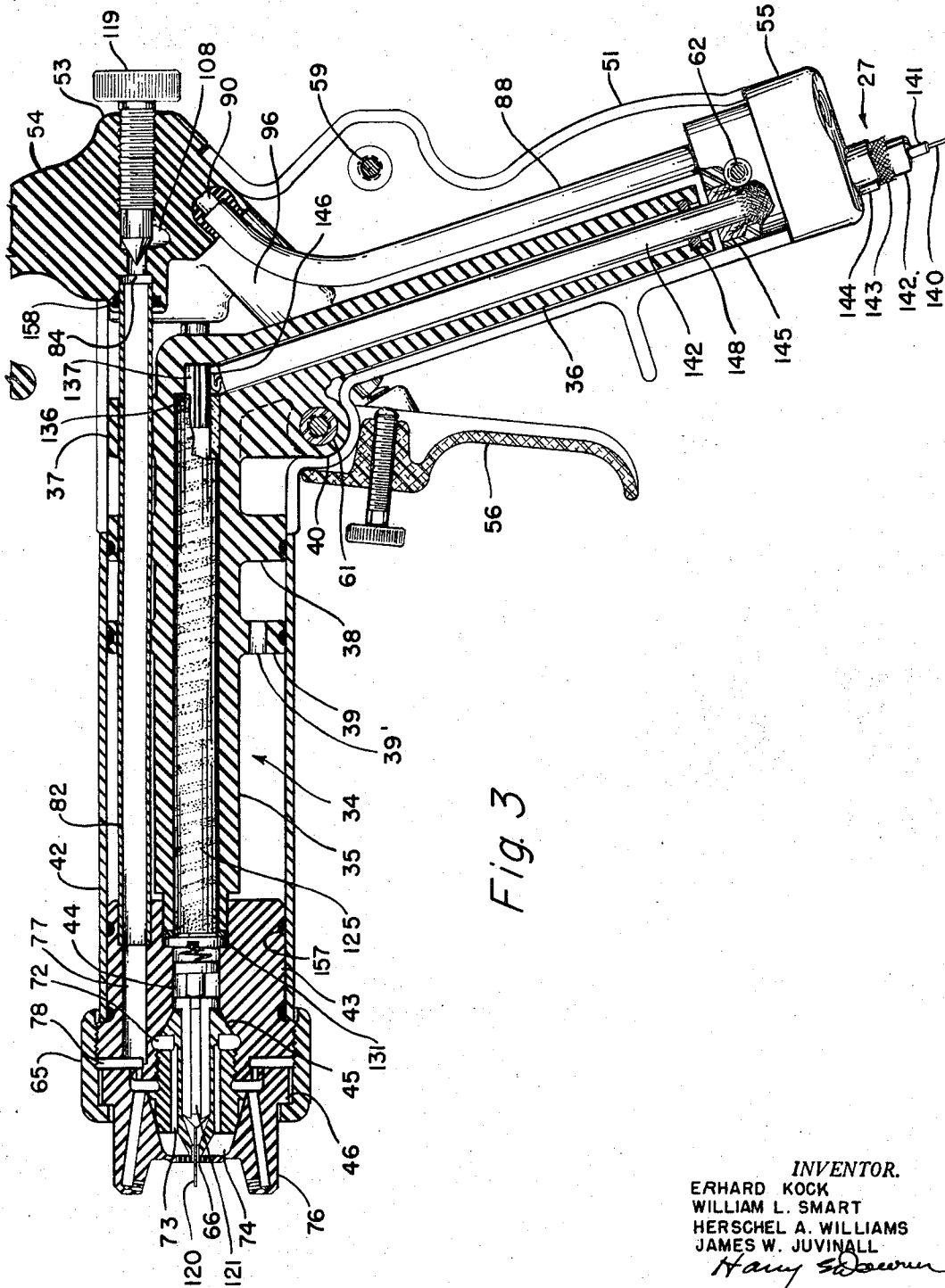
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ELECTROSTATIC SPRAY COATING APPARATUS

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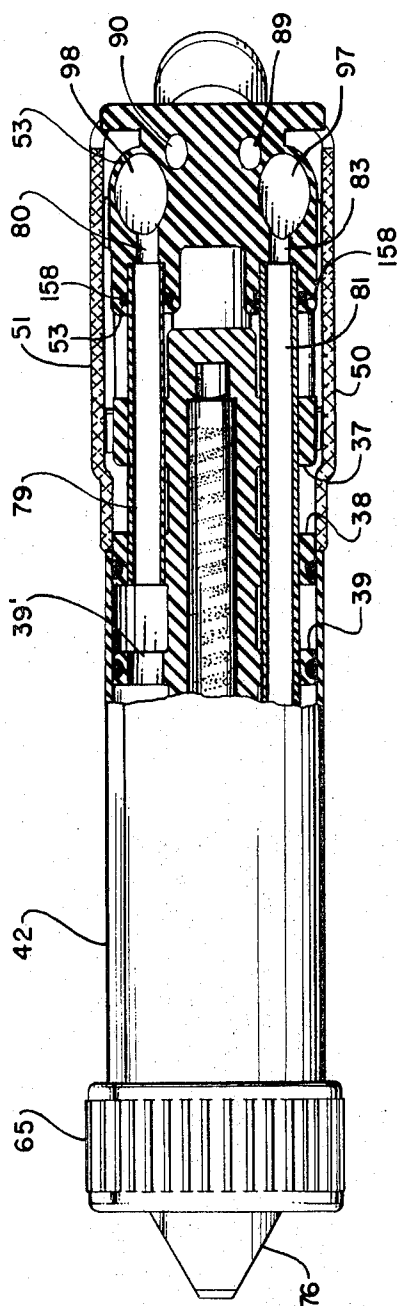


Fig. 4

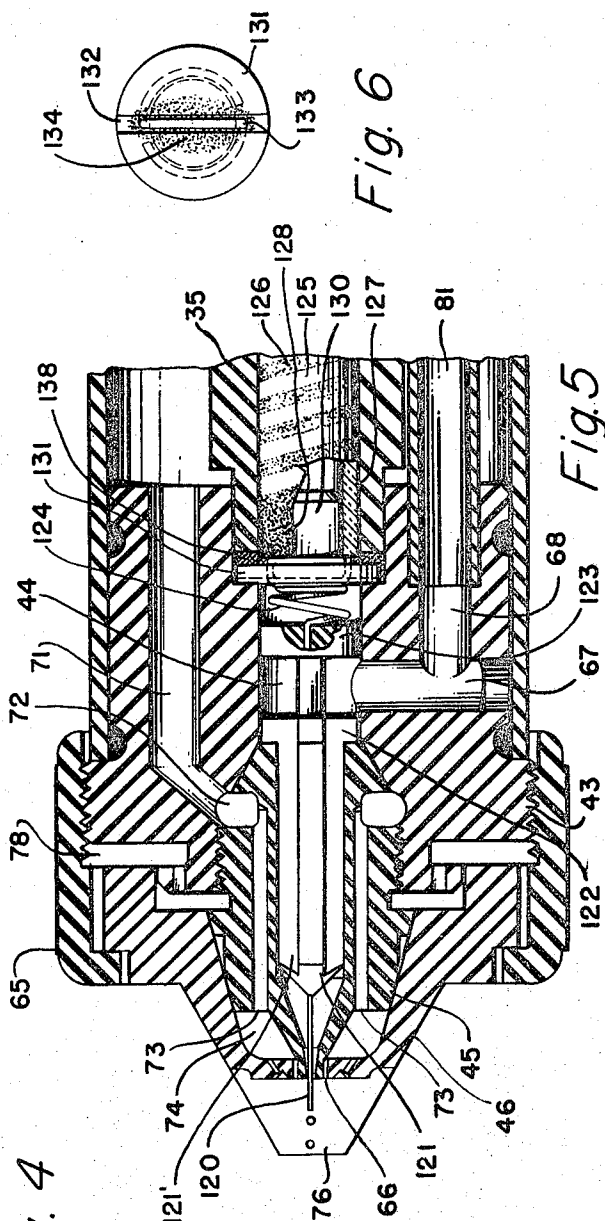


Fig. 6

Fig. 5

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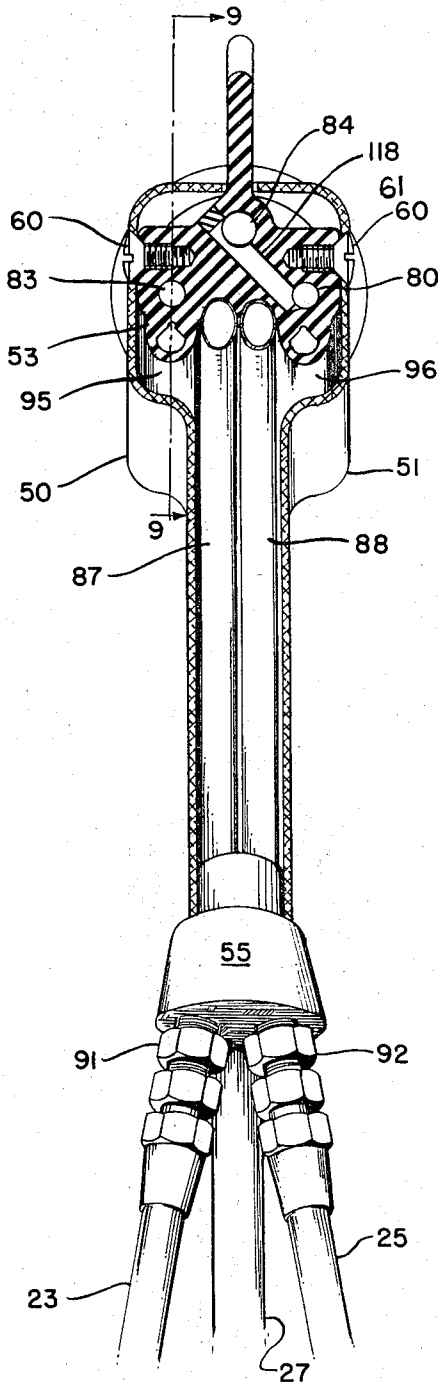


Fig. 7

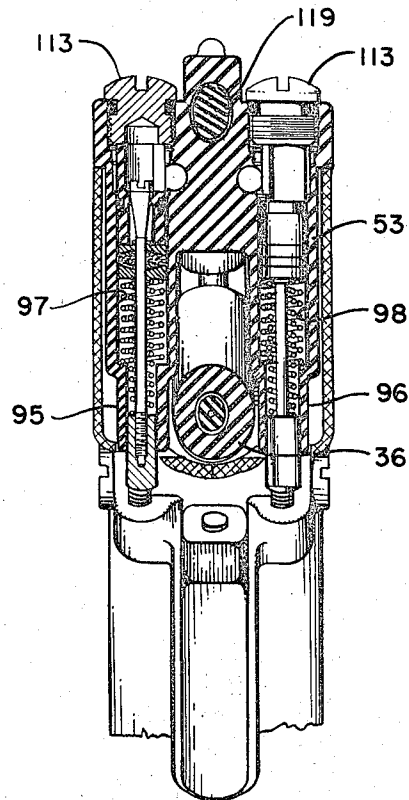


Fig. 8

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3,367,578

ELECTROSTATIC SPRAY COATING APPARATUS
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Continuation of application Ser. No. 306,808, Sept. 5,
1963, which is a continuation of application Ser. No.
85,532, Jan. 30, 1961. This application Dec. 27, 1966,
Ser. No. 605,085

18 Claims. (Cl. 239—15)

ABSTRACT OF THE DISCLOSURE

This application relates to an electrostatic hand spray gun of L shape designed for the spraying of liquids using air and electrostatic atomization and having an interior L shaped body of insulating material, one leg of the L receiving the high voltage cable and the second leg of the L containing a resistor which is connected to an electrode externally of the interior L body.

This application is a continuation of application Ser. No. 306,808, filed Sept. 5, 1963, now abandoned, which in turn is a continuation of application Ser. No. 85,532, filed Jan. 30, 1961, now abandoned.

This invention relates to electrostatic spray-painting systems and more particularly to a spray gun for use in such systems. It has heretofore been proposed to spray-paint articles by the use of a spray gun which atomizes paint mechanically, as through the use of compressed air, and which is provided at or near the site of the emerging spray with a spray-charging electrode between which and the articles to be coated an electrostatic field of substantial potential gradient is maintained. Usually, the articles to be coated are grounded and the charging electrode maintained at a substantial potential. In some instances, the gun has carried a grounded conductive element which, in the case of a hand-held gun, might be the handle.

The attainment of high deposition efficiencies by the use of such a gun requires that the spray-charging electrode be located close to the emerging spray, the highest efficiencies usually being attained when the charging electrode projects through the paint orifice of the gun. Considerations for safety against the dangers of sparking and shock to personnel have led to the incorporation in the gun of a high-resistance resistor located close to the charging electrode. Similar considerations have indicated the desirability of maintaining as low as possible the effective electrical capacity of the charging electrode or other electro-conductive elements impressed with a high potential through the resistor. In the case of a hand-held gun, light weight, ready maneuverability, as well as convenient and effective control of paint, air, and voltage are especially desirable. Such considerations, as well as others, are responsible for a number of problems which complicate the designing of a satisfactory spray gun of the type above mentioned. It is the object of this invention to solve those problems.

In one form, a hand spray gun of the compressed air type embodying the subject matter of this application comprises an elongated barrel and a hollow handle including an electroconductive grip portion projecting laterally from the barrel adjacent the rear end thereof. Rearwardly of the barrel there is supported within the handle valving mechanism controlling the discharge of paint and atomizing air from the gun, such mechanism being operated by a trigger conveniently disposed at the front side of the grip. The handle contains tubes or other passage-forming means for conveying paint and air under pressure to the

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valve mechanism from fittings carried at the lower end of the handle-grip and adapted for connection to flexible paint and air hoses. The barrel contains passages for conveying paint and air forwardly for discharge from paint and air orifices at the front end of the barrel.

In the particular form of hand spray gun described in detail hereinafter as a specific example, the barrel of the gun is a composite structure built up around the front leg of a generally L-shaped casing formed of insulating material and having a rear leg which is enclosed within the hollow handle-grip. Such front casing-leg houses the above mentioned resistor, while the rear leg houses the high-voltage lead-in which is connected to the rear end of the resistor. In such an arrangement, the front casing leg is provided with flanges received in and closing the front and rear ends of a tubular sleeve of insulating material constituting the outer element of the barrel. In this form of the invention, the flange closing the front end of the sleeve may be a separate element in the form of a plug of insulating material attached to the front end of the front casing-leg. The plug projects forwardly beyond the sleeve, supports removable paint and air caps, and is provided with passages through which paint and air flow to the caps, the paint-emitting orifice of the paint cap and the terminal portion of the paint passage in the plug desirably being coaxial with the resistor. If the gun includes air horns for shaping the spray, those horns are supplied with air through a separate passage formed in the plug and connected to an outlet port of the valve housing by a tube of insulating material extending through the sleeve. The paint is also supplied to the paint-passage in the plug by a tube of insulating material extending through the sleeve to the paint outlet port of the valve housing; but air for atomization preferably flows forwardly through a passage including a portion defined by the sleeve and the front casing-leg, whereby the atomizing air will aid in the dissipation of heat generated by the resistor enclosed in such casing-leg.

Preferably, the spray-charging electrode above referred to is carried by a support of insulating material which, together with the electrode, may be withdrawn from the gun upon removal of the paint cap. Such a construction requires a severable connection between the electrode and the resistor, and that connection is desirably located in a space protected against ready access by the paint.

The handle is conveniently formed by two complementary metal halves, and the valving mechanism includes a valve housing secured between these halves rearwardly of the barrel. At the outer, or lower, end of the grip portion of the handle there is a metal block having, preferably in line with the adjacent leg of the casing, an opening for the passage of high voltage lead. Such lead is desirably a flexible cable having a braided wire sheath grounded at the high voltage source and firmly secured to the metal block in electrical contact therewith to ground the handle. Inwardly beyond the metal block, the lead-in conductor continues into the adjacent leg of the casing for electrical connection to the rear end of the resistor as mentioned above. In addition to the opening for the high voltage lead, the metal block has two other openings receiving at their outer ends the aforesaid fittings which adapt the gun for connection to the paint and air hoses.

Other objects and features of the invention will become evident from the following more detailed description and from the accompanying drawings, in which:

FIG. 1 is a perspective view of a complete electrostatic spray-painting system;

FIG. 2 is a side elevation of a spray gun;

FIG. 3 is a vertical, medial section through the spray gun of FIG. 2;

FIG. 4 is a top plan view with parts at the rear of the gun broken away and showing a horizontal section;

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FIG. 5 is a fragmental horizontal section on an enlarged scale on the line 5—5 of FIG. 2;

FIG. 6 is a front elevation of the front leg of the resistor-casing showing a detail of a means for connecting the resistor to the electrode;

FIG. 7 is a generally vertical section through the gun handle on the line 7—7 of FIG. 2;

FIG. 8 is a section on the line 8—8 of FIG. 2;

FIG. 9 is a fragmental section on the line 9—9 of FIG. 7; and

FIG. 10 is a section on the line 10—10 of FIG. 9.

The painting system illustrated in FIG. 1 comprises a spray gun, designated in its entirety by the reference numeral 20, positioned to spray a series of articles 21 carried through a coating zone by a conveyor 22. The gun 20, as will appear more fully hereinafter, is adapted to be held in the hand of an operator and to be manipulated as necessary to spray-coat the articles passing through the coating zone. Paint is supplied to the gun through a flexible hose 23 extending from a paint tank 24 maintained under pressure in known manner to feed the paint. The particular gun 20 illustrated employs compressed air for atomizing the paint, such air being supplied through a flexible air line 25 from a source 26 under appropriate pressure. High voltage for charging the spray issuing from the gun 20 is conducted to the gun through a flexible cable 27 connected to one terminal of a high voltage source or power pack 28 the other terminal of which is grounded as indicated at 29. The articles 21 to be painted are maintained at a spray-attracting potential, conveniently by connecting them electrically to the conveyor 22, which is grounded as is indicated at 30. The output voltage of the power pack 28 may vary considerably depending upon circumstances, but for use with the particular gun hereinafter described, such output voltage is preferably in the neighborhood of 65,000 volts.

One form of spray gun embodying our invention and suitable for use in the system shown in FIG. 1 is illustrated in FIGS. 2—10. Such a gun comprises (FIG. 3) a generally L-shaped casing, designated in its entirety by the reference numeral 34, formed of insulating material, conveniently as an integral molding, and having front and rear tubular legs 35 and 36, the interiors of which communicate with each other at their junction. Formed integrally with the casing 34 at spaced points along the front leg 35 are a rear flange 37, an intermediate flange 38, and a front flange 39, the two latter flanges being circular. Also formed integrally with the casing 34 is a boss 40 located in the angle between the two legs 35 and 36. The flange 39, and also the flange 38 for a portion of its thickness, are received within the rear end of the sleeve 42 in the form of a cylindrical tube of insulating material which is the outer element of what may be regarded as the barrel of the gun. The front end of the casing-leg 35 is provided with still another flange, which closes the front end of the sleeve and which, in the gun shown, is a separate element in the form of a plug 43. Such plug is of insulating material and has, extending through it, a central opening 44 which, at its rear end, receives and is desirably cemented to the front end of the casing-leg 35. Supported at the front end of the plug 43 coaxially with the casing-leg 35 is a paint cap 45 surrounded by an air cap 46 also supported from the plug 43. The plug 43, the paint cap 45, and the air cap 46 will be described in greater detail hereinafter.

The gun handle, which is connected to the flanges 37 and 38, includes a shell conveniently formed of two complementary halves 50 and 51, desirably light weight sheet-metal stampings or die-castings. Together, the two handle-halves 50 and 51 form a grip portion and a collar portion, the former portion enclosing the casing-leg 36 and the latter embracing the flange 37 as well as the boss 40 and that portion of the flange 38 which projects

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rearwardly beyond the end of the sleeve 42. Disposed between the two halves of the handle-shell is a valve housing 53, located by its fit within the shell in fixed position at the rear of the barrel and conveniently provided with a hook 54 by means of which the gun may be hung up when not in use. Also received within the handle-shell is a metal connector block 55 located at the outer, and lower, end of the grip portion of the handle. Pivotaly mounted in the angle between the barrel and the grip portion of the handle is a trigger 56 which operates the valves contained in the valve housing 53.

The two halves of the handle shell are conveniently connected directly together by a bolt 59 (FIG. 2) located in rear of the casing-leg 36, while the valve housing 53 is secured to the shell by screws 60 passing into it through the walls of the shell. If the valve housing is a plastic molding, it is desirably provided (FIG. 7) with metal inserts 61 receiving the screws 60. The connector block 55 is conveniently held in position by a screw 62 extending into it through a wall of the grip portion of the handle. The handle shell is secured to the barrel of the gun through the casing 34, as by screws 63 and 64 which pass through the walls of the shell into the flange 37 and boss 40 respectively. The flange 37 and boss may be provided with metal inserts 61 for the reception of such screws. The screws 64 are conveniently shouldered screws providing a pivotal mounting for the trigger 56.

Turning to details of the construction at the front end of the gun, best shown in FIGS. 3—5, the paint cap 45 is screw-threaded into the plug 43 at the front end of the opening 44, projects forwardly therefrom, and is sealingly engaged at its front end by the inner frusto-conical wall of the air cap 46, which is held in position by an internally flanged collar 65 screw-threadedly mounted on the projecting front end of the plug 43. The tip of the paint cap is received in a central opening 66 in the face of the air cap, such opening being of larger diameter than the tip of the paint cap to provide an annular space for the passage of atomizing air. If desired, the air cap may have additional openings for the emission of auxiliary atomizing air.

Paint is supplied to the paint cap through the central opening 44, which communicates through a port 67 with an off-axis passage 68 provided in the plug 43 and opening in the rear face thereof. A second off-axis passage 71 in the plug 43 delivers atomizing air to an external annular groove 72 in the paint cap, such air flowing forwardly through longitudinal passages 73 in the wall of the paint cap into an annular space 74 surrounding the tip of the paint cap and communicating with the opening 66.

In the gun shown, the air cap 46 is provided with air horns 76 having forwardly and inwardly directed orifices for the discharge of spray-shaping air. The spray-shaping air reaches the interior of the air horns by way of a third off-axis passage 77 (FIG. 3) in the plug 43 and an annular space 78 between the air cap and such plug.

Paint, atomizing air, and spray-shaping air are supplied to the passages 68, 71 and 77 in the plug 43 under control of valves located in the housing 53. For a purpose which will become apparent hereinafter, the interior of the sleeve 42 is desirably used as a passage for the atomizing air. To that end, the passage 71 in the plug 43 opens into the interior of the sleeve, and the flange 39 is provided with one or more openings 39' for the passage of air supplied to the barrel ahead of the flange 38 through a tube 79 the rear end of which communicates with an atomizing-air outlet port 80 opening in the front face of the valve housing 53. The passages 68 and 77 in the plug 43 communicate respectively with tubes 81 and 82 whose rear ends communicate respectively with paint and shaping-air outlet ports 83 and 84 opening in the front face of the valve housing.

As will be clear from FIG. 7, paint and air are separately supplied to the valve housing 53 by way of passages

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which extend through the block 55 and communicate at their inner ends with tubes 87 and 88, respectively, extending to inlet ports 89 and 90 (FIGS. 3 and 10) in the valve housing. The outer ends of the passages in the block 55 are adapted for respective connection to the paint line 23 and air line 25, conveniently by being screw-threaded for the reception of suitable connector fittings 91 and 92.

The valve housing 53 includes a pair of spaced, parallel legs 95 and 96 which extend obliquely forwardly and downwardly from the body of the valve housing on opposite sides of the casing-leg 36. Each of such legs 95 and 96 is provided with a longitudinal hole which extends completely through it and continues rearwardly to open in the rear face of the valve housing, such holes being deeply counterbored from the rear to provide valve-receiving recesses 97 and 98. The rear ends of the paint outlet port 83 and the atomizing-air outlet port 80 open respectively into the recesses 97 and 98 intermediate the length thereof, as is shown in the case of the port 83 and recess 97 by FIG. 9. The recesses 97 and 98 lie outwardly of the inlet ports 89 and 90 (FIG. 10) and communicate therewith through housing-passage 100 and 101 opening into the recesses near the rear, or upper ends thereof.

Each of the recesses 97 and 98 contains a valving device controlling communication between the respectively associated inlet port (89 or 90) and outlet port (83 or 80). Except for such differences as may be required by the nature of the fluids they respectively control and/or by their spatial relation to the ports and passages whose interconnection they control, such valving devices may be similar, and only one of them need be described in detail. FIG. 9, which illustrates the valving device controlling paint delivery, shows a valve sleeve 103 located in the recess 97 in position to overlap axially of itself both the passage 100 and the port 83. At its ends, the sleeve 103 is provided with notches 104 and 105 which extend through the wall of the sleeve and communicate respectively with the paint outlet port 83 and passage 100. Between the notches 104 and 105 the sleeve is provided interiorly with a web 106 having a central opening serving as a seat for the frustoconical head of a valve 107. The valve 107 includes a stem 108 which extends downwardly in the recess 97 beyond the base thereof and is screw-threaded at its lower end for reception in the cap 109. The cap 109 is guided for sliding movement in the lower end of the leg 95 and projects therefrom for co-operation with the trigger 56. The valve 107 seats by inward, or downward, movement and is urged to seated position by a spring 111 acting between the cap 109 and a packing 112 surrounding the stem 108 at the inner end of the sleeve 103.

The sleeve 103 is slidable in the recess 97 and is located therein by its engagement with a plug 113 screw-threadedly received in the outer end of such recess. A compression spring 114 surrounds the previously mentioned spring 111 and acts between the base of the recess 97 and the packing 112 to hold the upper end of the sleeve 103 in contact with the inner end of the plug 113. In addition to serving to hold the sleeve 103 against the plug 113, the spring 114 also acts in cooperation with the spring 111 to compress the packing 112 and produce an effective seal between it and both the valve-stem 108 and the wall of the recess 97. To prevent leakage over the outer surface of the sleeve 103, such sleeve is provided between the notches 104 and 105 with an external annular groove receiving an O-ring seal 115.

Desirably, the spring 114 has an unstressed length such that, upon removal of the plug 113, the spring will elevate the sleeve 103 to a position in which it extends outwardly beyond the housing 53 so that it can be grasped and the entire valving device removed from the recess.

For the purpose of orienting the sleeve 103 about its axis to ensure alignment of the notches 104 and 105

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respectively with the port 83 and passage 100, the sleeve 103 is provided exteriorly with one or more locating ribs 116 which are receivable in grooves formed in the inner surface of the recess 97.

As previously indicated, the air-controlling valving device located in the recess 98 is generally similar to that located in the recess 97 and just described. As shown in FIG. 10, the valving device in the recess 98 includes a sleeve 103' provided exteriorly with locating ribs 116'. To prevent inadvertent interchange of the two valving devices in the recesses 97 and 98, the ribs 116' are spaced differently from the ribs 116 about the axes of the respective sleeves, 103' and 103.

The valve 107' in the sleeve 103' desirably controls the flow of both atomizing air and spray-shaping air to the front end of the gun. For that purpose the valve housing 53 is provided (FIG. 7) with an oblique passage 118 connecting the shaping-air outlet port 80, which communicates with the air inlet port 90 under control of the valve 107'. As shown in FIG. 3, the rate at which spray-shaping air flows through the port 84 when the valve 107' is open may be controlled by an adjustable valve 119 coaxial with the port 84 and preferably formed of plastic.

Referring to FIG. 5, it will be noted that the spray-charging electrode 120 projects forwardly through the orifice of the paint cap 45 and is supported within the paint cap by a support 121 of insulating material. Such support is received in the bore of the paint cap from the rear end and has a flange 122 engaging the inner end of the paint cap. Rearwardly from the flange 122, the support continues, at reduced diameter, and terminates at its inner end in a head 123 which fits the opening 44 in the plug 43. The flange 122 and head 123 are so spaced that the paint port 67 opens between them; and the body of the support 121 is provided externally with grooves 121' which continue rearwardly through the flange 122 to form passages through which the paint can reach the front end of the paint cap 45. The electrode 120, which is desirably formed of music wire about 0.020 inch in diameter, extends completely through the support 121 and projects rearwardly beyond the head 123, its rearwardly projecting portion being formed into a short helix 124 electrically connected, as by means hereinafter described, to the front end of the resistor 125, which is housed in the front leg 35 of the casing 34.

The resistor 125 is conveniently of a known type comprising a resistance element in the form of helical strip or stripe 126 of conductive ink deposited on the outer surface of a ceramic tube 127. At its front end, the strip 126 is continuous with a narrow belt 128 of conductive ink which extends over the front end face of the core or tube 127.

Means employed to establish an electrical connection between the conductive-ink belt 128 and the helical rear end 124 of the electrode 120 may include a plug 130 of insulating material received in the front end of the core 127. Such plug has a head 131 provided in its front face with a diametrically extending shallow groove 132 (FIG. 6) from the base of which two holes extend through the head. The plug carries a U-shaped conductor 133, preferably of soft copper wire, disposed with its intermediate leg received in the groove 132 and its parallel legs extending through the aforesaid holes and bent around the body of the plug in position to lie against the ink-coated face of the resistor-core 127.

The groove 132 in the head 131 has a depth somewhat less than the diameter of the wire, so that such wire projects above the face of the head for contact with the helical rear end 124 of the electrode. To insure electrical connection between the rear end of the electrode and the conductor 133 irrespective of the orientation of the electrode about its axis, it may be desirable to apply to the front face of the head 131 over the exposed conductor 133 a small quantity of a conductive cement

which will increase the effective area of conductive surface available for contact by the rear end of the electrode. Such cement, which is indicated by the stippled area 134 in FIG. 6, serves another desirable purpose by sealing the openings through which the parallel legs of the conductor pass.

The means just described provides an electrical connection between the front end of the resistor and the electrode while making it possible, upon removal of the air cap, to withdraw the electrode and its support for purposes of cleaning or replacement. At the same time, such connecting means possesses so low an effective electrical capacity that the energy stored by it and the electrode will be dissipated harmlessly should the electrode closely approach, or contact, a grounded object.

We have found that paint pigment has a tendency to separate and collect adjacent charged conductive elements to which the paint is exposed and that this tendency can be greatly reduced by eliminating as far as possible the exposure of such charged conductive elements to the flowing paint stream. It is therefore desirable that the head 123 of the electrode support have a reasonably close fit within the opening 44, so that paint in the space where connection is made between the rear end of the electrode and the conductor 133 will be relatively stagnant.

At the rear end of the resistor 125, the resistance element thereof is adapted for connection to the high voltage lead by applying to the extreme rear end of the resistor a conductive coating 136 which is continuous with the rear end of the resistance strip 126 and which extends over the end face of the core 127 and for a short distance into the interior thereof. Received within the rear end of the core 127 and in contact with the conductive coating is a terminal, preferably a split metal bushing 137 which projects rearwardly beyond the resistor into alignment with the interior of the casing-leg 36 so that it may serve as a terminal making contact with the high-voltage lead-in housed within that leg.

Preferably, the resistor 125, without the plug 130 and bushing 137 applied to it, is molded in place in the formation of the casing 34. In forming the casing the hollow resistor is supported in the mold on a core which fits the interior of the resistor to prevent the entrance of molding compound and projects beyond the rear end of the resistor to provide a recess for the reception of the rear end of the bushing 137 and to meet a second core forming the interior of the rear casing leg 36. Such bushing may be inserted through the interior of the resistor from the front end thereof after the molding operation is completed; and after the bushing has been positioned, the plug 130 may be applied.

In applying the plug to the resistor, the conductor 133 is first applied to the plug and its inner ends are bent around the body of the plug as above described. A coating of a suitable cement, preferably non-conductive, is then applied to the interior of the resistor-core 127 at its front end and the plug is inserted into the core, and bent ends of the conductor 133 being firmly held in contact with the coated conductive end face of the core 127 until the cement has set. Desirably, an insulating cement, indicated at 138 in FIG. 5, is then applied over the bent ends of the conductor to fill and seal the space between the head 131 and adjacent ends of the casing-leg and resistor 125. Thereafter, the conductive cement 134 (FIG. 6) may be applied to the face of the plug-head 131.

A preferred form of flexible high voltage cable 27 is shown in FIG. 3. Such cable comprises a central, small-diameter (about 26 gage) wire 140 to which there is applied a coating 141 of a conductive plastic having an external diameter of about one-eighth inch. Surrounding the conductive coating 141 is an insulating plastic coating 142, having a diameter of about three-eighths inch, which is surrounded by a braided wire sheath 143. The sheath 143, which is in turn covered by an outer covering 144 of a conductive plastic, is grounded, conveniently at the

power pack 28. Reference to the materials forming the coating 141 and covering 144 as being conductive is not to be taken as indicating that their conductivity need be of a high order. The outer covering 144 need only be sufficiently conductive to bleed off to the grounded sheath 143 the charges carried by atmospheric ions or other charged particles impinging upon it and thereby prevent the building up of a substantial surface charge on the covering. The conductivity of the inner coating 141 need be only that necessary to enable such coating to serve as an electrical shield preventing the existence of a local potential gradient sufficient to form corona at any breaks in the bond between the coating and the metal conductor 140.

The cable 27 enters the gun through the block 55, as above mentioned, the outer cover 144 terminating within the block and the wire sheath 143 terminating at about the inner face of the block. As a convenient method of securing the cable to the gun, the cable-receiving opening in the block may be countersunk at its inner end, the end of the braided sheath expanded, and the countersink filled with a low-melting-point metal alloy, such as Wood's metal or a suitable electrically conductive cement to form a ring 145. The material envelops the end portion of the braid immobilizing it and physically and electrically connecting it to the block 55. The central wire 140, with its two plastic coatings 141 and 142, continues upwardly in the rear casing-leg 36 to a point adjacent the rear resistor-terminal 137, where the two plastic coatings terminate and a short projecting end of the central wire is crumpled, as indicated at 146, to provide an effective contact with the terminal. The ring 145 not only forms a head preventing withdrawal of the cable 27 from the gun but also, by bonding with both the wire sheath 143 and the metal block 55, grounds the handle-shell 50-51 by electrically connecting it to the sheath, which is grounded as above mentioned.

It has been found desirable to insure as far as possible against the possibility that paint will come into contact with the resistor, and for that purpose the casing 34 is imperforate between the front end of the front leg 35 and the lower end of the rear leg 36. The cement applied to the face of the plug-head 131 and between such head and the front ends of the casing-leg 35 and the resistor seals the interior of the casing 34 at its front end, while an O-ring seal 148 around the lead-in performs a similar function at the rear of the casing.

Polyethylene has been found to be satisfactory material for the casing 34, although other appropriate moldable plastics possessing adequate electrically insulating properties may be used if desired. The plug 43 is desirably of some harder and more rigid material, such as the acetal resin marketed by E. I. du Pont de Nemours & Co., Inc. under the trademark "Delrin." A fabric-reinforced epoxy resin is preferred as a material for the sleeve 42, but again another insulating material possessing adequate strength may be used. The air and paint tubes within the barrel may be of any appropriate insulating material. Since the valve housing 53 is in contact with the conductive handle-shell 50-51, which is grounded as above set forth, it may be of metal; but for reasons of economy the valve housing may be a molding of some appropriate dimensionally stable plastic, such as glass-reinforced nylon. The trigger 56 and the paint and air tubes 87 and 88 within the handle-grip are desirably of metal.

With the gun constructed as above set forth, all exposed electroconductive elements, with the exception of the tip of the electrode 120, are located at the rear end of the gun and the only such element of appreciable size and electrical capacity (the handle) is at ground potential by virtue of its electrical connection to the grounded cable-sheath 143. The resistance of the resistor, desirably supplemented by additional resistance 150 (FIG. 1) in the voltage pack 28, limits current flow to the electrode 120; and the values of such resistances can be proportioned

to the rated voltage of the power pack so as to insure that any maintained discharge from the electrode will not constitute a fire hazard or be objectionable if sustained by personnel. Such a result is provided, for a power pack 28 having a rated output voltage of 65 kv., employing values of 160 and 100 megohms respectively for the resistor 125 and the resistance 150 in the power pack. The resistor 125 should of course have a length sufficient to prevent sparking between its terminals at the maximum voltage-drop which may occur across it; and the rear casing leg 36 should have a length sufficient to prevent sparking between the conductor-end 146 or the rear resistor terminal 137 and the grounded block 55 or handle-shell 50-51. With the voltage and resistance values above set forth, the resistor 125 may have a length of about four and one-half inches and the casing leg 36 a length of about five inches.

In assembling the barrel of the gun after the rear resistor terminal 137 and the plug 130 have been applied as set forth above, it is convenient first to cement the short atomizing-air tube 79 in position in the casing flanges 37 and 38 and to position and seal the longer paint and air tubes 81 and 82 in the plug 43. The plug 43 is then cemented in the front end of the sleeve 42, and the sleeve is slipped over the front casing-leg 35, the tubes 81 and 82 entering and passing through the casing flanges and the front end of the casing-leg 35 entering the rear end of the central opening 44 in the plug 43. Desirably, the tubes 81 and 82 are cemented to the casing flanges and the front end of the casing leg is cemented in the opening 44; and further to secure the sleeve 42 in position, it may be cemented to the casing flanges 38 and 39. If, as is found in the case of the specific sleeve, plug and casing materials mentioned above, it is difficult to obtain a cement which will bond well both to the sleeve and to the plug and casing flanges, the latter elements may be provided in their sleeve-engaging surfaces with annular grooves filled, as indicated at 157, with a cement which will bond well to the sleeve and which, when set, will in effect form on the sleeve internal annular ribs interlocked with the grooves in the plug and the casing-flanges 38 and 39.

The valve housing 53 may form part of a permanent subassembly embodying the block 55 and the paint and air tubes 87 and 88 extending between that block and the inlet ports of the valve housing, such tubes being cemented in the inlet ports and in the paint and air passages in the block. However, it is preferred that the valve housing be readily removable from the barrel with the rest of its subassembly, and the outlet ports of the valve housing are therefore shown (FIGS. 3 and 4) as provided with O-ring seals 158 receiving the rear ends of the tubes 79, 81 and 82 of the barrel. Before applying the aforesaid subassembly to the barrel the high-voltage cable, with its several coatings and sheath appropriately stripped, is passed through the opening provided for the purpose in the block 55 and secured thereto, as above described. Thereafter, the stripped end of the cable is inserted into the rear casing-leg 36 with the crumpled end 146 of its central wire forced into firm contact with the resistor terminal 137, and the valve housing is positioned on the rear ends of the tubes 79, 81 and 82. Application of the handle-halves 50 and 51 then readies the gun for insertion of the electrode 120 with its support 121 and application of the paint and air caps.

Operation of the gun 20 is controlled by the trigger 56. Until that trigger is depressed, the springs 111 associated with the paint and air valve-members 107 and 107' maintain both valves closed. Seating of the valves in closed position is aided by the feeding pressures to which the paint and air sources 24 and 26 are subjected. Upon rearward movement of the trigger, the valve-stem caps 109 are engaged and the two valve members moved rearwardly to open both valves. Preferably, the gun embodies adjustable means controlling the sequence in which the two valves open when the trigger is depressed; such means in the gun shown comprising screws 160 mounted in the

trigger in position to engage the respective valve-stem caps. A third adjustable screw 161 is carried by the trigger in position to engage the grip portion of the handle-shell 50-51 and limit opening of both valves. If desired, the trigger 56 can be made to control energization of the high-voltage source 28, as by incorporating in the supply line to such source a normally open switch 162 (FIG. 1) adapted to be closed in response to air flow in the air-line 25.

The gun described provides a spray of highly charged coating material particles which are efficiently deposited on the article or articles being coated with but little overspray loss. The general construction of the gun provides light weight and ready maneuverability. The metal handle-shell provides a grounded grip portion which serves to maintain the operator at ground potential and also provides a counterelectrode insuring the existence of a minimum average potential gradient for the electrostatic field extending from the spray-charging electrode. The effective electrical capacitance of the charging electrode and the means employed to connect it to the front end of the resistor is minimized to reduce the stored electrical energy dischargeable should the electrode approach or engage a person or a grounded object. The unitary casing 34, enclosing the resistor and the adjacent end portion of the lead-in conductor, is free from joints constituting potential paths over which sparks might jump or high voltage leak to grounded portions of the gun. The seals provided at opposite ends of the casing 34 protect the resistor from contact with paint or other matter which might damage it or interfere with its functioning. The contact of the exterior of the thin wall of the front casing leg 35 with the atomizing air flowing through the barrel to the air cap serves to dissipate heat generated by current in the resistor, and the flow-responsive switch 162 (which may be of known type) in the air line 25 insures the existence of resistor-cooling air flow whenever current is passing through the resistor. The manner in which the outer sleeve of the barrel is secured to the casing flanges enlarges the freedom of choice of appropriate materials for the sleeve and casing. Such features, as well as others set forth in the appended claims, contribute to the solution of problems which have heretofore limited the field of use and commercial acceptance of electrostatic spray guns of the type in which the atomization is effected essentially mechanically.

It should be understood that the specific gun illustrated and described is set forth merely by way of example and that our invention is not limited thereto. It is particularly noted that, in respect to certain features, our invention is not limited to use in hand-held guns or in guns employing compressed air to effect atomization.

We claim:

1. In an electrostatic spray-coating system:

- a spray gun having means including
 - an electrode,
 - a coating-material orifice, and
 - an atomizing-air orifice for forming a spray of electrically charged particles;
- a high-voltage source;
- conduits for supplying coating material and atomizing air respectively to said orifices;
- a valve for controlling flow through each of said conduits;
- means responsive to the flow of atomizing air through the atomizing-air conduits for effecting the supply of high voltage from said high-voltage source to said electrode;
- a common movable operating member for operating said valves; and
- adjustable means for varying the relation between the positions in movement of the operating member at which said valves are respectively opened.

2. In an electrostatic spray-coating system:

- a gun including a barrel having at its front end orifices for the emission of liquid coating material and air, said barrel being provided with a cavity for the re-

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ception of a resistor and with a passage for supplying air to the air orifice from a pressurized source;
 a resistor in said cavity, said passage and cavity being in heat-transfer relation whereby heat generated in said resistor is transmitted to the air flowing in said passage;
 a spray-charging electrode connected to a terminal of said resistor;
 a source of high-voltage operably connected with a second terminal of said resistor and having a control switch for actuating said high-voltage source; and means responsive to a flow of air to the air orifice of said gun for actuating said control switch, to insure flow of cooling air when said resistor is energized.

3. In a spray gun for use in an electrostatic spray-coating system:
 a barrel of insulating material;
 a resistor in said barrel,
 said gun having an orifice for the emission of liquid coating material located at the front end of the barrel,
 said barrel having a chamber communicating with said orifice and located between the orifice and the front end of said resistor,
 said chamber having a port for the admission of coating material,
 said chamber being formed in part by a removable cap having a rearwardly facing bearing surface in the chamber;
 means for connecting the rear end of said resistor to a high voltage source;
 a removable spray charging electrode located in said chamber having its front end projecting forwardly of said cap and its rear end electrically connected to the front end of said resistor and
 an electrode support,
 said electrode support having a forwardly facing bearing surface engageable with the rearwardly facing surface of said cap to maintain the electrical connection of the rear end of the electrode; and
 means defining a flow path for coating material between said chamber and said orifice.

4. In the spray gun of claim 3, a spring between said support and said resistor, urging the bearing surface of said support into engagement with the bearing surface of said cap and completing the circuit between the resistor and electrode.

5. The spray gun of claim 4 wherein said resistor is elongated and extends longitudinally within said barrel, said chamber having a port for the admission of coating material offset from the axis of the resistor, the electrode support being formed of insulating material and enclosing the intermediate portion of the electrode, preventing contact between the coating material and the intermediate portion of the electrode, said electrode support being provided with at least one longitudinal passage through which coating material may flow from said chamber to said orifice, said electrode support having a flange engageable with said shoulder, said spring urging said flange against said shoulder.

6. In a spray gun for use in an electrostatic spray-coating system:
 a barrel having a chamber adjacent its front end;
 means defining an orifice for emitting coating material and located in front of said chamber and in communication through the chamber with a rearwardly disposed inlet port in said chamber;
 a resistor member in said barrel and having a tubular body with an open end portion adjacent said chamber, said resistor member having a conductive terminal surface at the end face of said body electrically connected with the resistor member;
 connector means having a plug portion received in the open end of said body and an enlarged head portion

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overlying said end face, said plug and head portions being sealed with said body;
 electrically conductive means carried by said connector having a portion contacting the conductive terminal surface of the resistor, said conductive means having a further portion on the outer face of said head and exposed to the interior of said chamber;
 electroconductive means in said chamber having a portion projecting forwardly of said orifice constituting a spray-charging electrode and having a further portion in conductive engagement with the exposed conductive portion on said connector head.

7. The spray gun of claim 6 wherein said resistor member has a tubular body with an open end portion adjacent said chamber, said tubular body having a resistive element thereon and a conductive surface on the end face thereof, electrically connected with the resistive element, said connector means having a plug portion received in the open end of said body and an enlarged head portion overlying said end face, an electrical conductor carried thereon with a portion underlying said head and extending at least partially around said plug, said conductor having a further portion on the outer face of said head and exposed to the interior of said chamber.

8. In a spray gun for use in an electrostatic spray-coating system:
 an integral, L-shaped body of insulating material having tubular front and rear legs the interiors of which communicate at the junction of the two legs;
 means at the front of said front leg and including an electrode for forming a spray of electrically charged coating material particles;
 an elongated resistor located in said front leg and having a front terminal connected to said electrode, said resistor having a rear terminal in line with the interior of the rear leg of said body;
 a high-voltage cable comprising a conductor surrounded by a body of solid insulating material extending into the rear leg of said body, said conductor having an exposed inner end;
 means outside said body for holding the inner end of the conductor in contact with the rear terminal of said resistor; and
 a handle surrounding said rear leg.

9. The spray gun of claim 8 wherein said resistor has a tubular body and a conductive inner surface inside the rear end thereof, said rear resistor terminal comprising a conductive member having a portion inside said body engaging said conductive inner surface and another portion projecting beyond the rear end of the resistor and contacted by said high voltage conductor.

10. In a spray gun for use in an electrostatic spray coating system:
 an L-shaped body of insulating material having tubular front and rear legs, the interiors of which communicate at the junction of the two legs;
 means at the front of said front leg and including an electrode for forming a spray of electrically charged coating material particles;
 a resistor located in said front leg and having a front terminal connected to said electrode, said resistor having a rear terminal;
 a high voltage cable comprising a conductor surrounded by a body of insulating material extending into the rear leg of said body, said conductor being connected with the rear terminal of said resistor;
 a barrel member of rigid insulating material surrounding said tubular front leg; and
 a handle mounted on said rear leg for engagement by the hand of an operator.

11. The spray gun of claim 10 wherein said spray forming means includes a spray coating system, means including a body of insulating material mounted at the front end of said front leg and having orifices for the emission

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of liquid coating material and atomizing air and providing a support for said electrode,

the electrode projecting forwardly from its connection with said resistor generally along the axis of said front leg and barrel member,

means forming passages within said barrel for supplying atomizing air and liquid coating material to the orifices, said passages being operatively connected with said orifice forming means forwardly of said front leg and at points spaced radially outwardly from said axis, and valves controlling the flow of fluid through said passages.

12. The spray gun of claim 10 wherein said barrel member is an elongated tube spaced outwardly from the front leg of said body, there being a flange at the rear end of said leg supporting said barrel tube.

13. The spray gun of claim 12 wherein said barrel member is an elongated tube and said handle has a collar portion which extends rearwardly from the tube with a butt joint between the rear of the tube and said collar, the front leg of said body having an outwardly extending flange at the rear thereof with a generally cylindrical outer surface, the outer surface of said flange spanning said butt joint.

14. The spray gun of claim 10 wherein said barrel member is spaced from the front leg of said body defining an annular space therebetween and including means defining an air passage for delivering atomizing air to an orifice adjacent the coating material orifice, said passage means including said annular space whereby said resistor is cooled by the flow of air through said space.

15. The spray gun of claim 11 wherein said barrel is an elongated tube supported on the front leg of said L-shaped body by the body of insulating material at the front end thereof and by a flange on said front leg at the rear thereof.

16. A spray gun for use in an electrostatic spray-coating system, comprising:

a barrel and a laterally projecting handle adjacent the rear thereof, said gun having at the front of said barrel orifices for the emission of liquid coating material and atomizing air;

a spray charging electrode at the front of the barrel;

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conductive means connected to said electrode and extending rearwardly through said barrel, through said handle and outwardly therefrom;

passages for conveying liquid coating material and atomizing air to said orifices extending rearwardly therefrom through said barrel;

means for controlling the flow of coating material and air through said passages, said means including

a pair of valves located rearwardly of the electroconductive means in said handle, one valve in the coating material passage and the other in the atomizing air passage, said valves having stems extending forwardly on opposite sides of said electroconductive means, and

a trigger movably mounted on said gun in front of said handle and movable to actuate said valves through their stems.

17. The spray gun of claim 16 wherein said valves each include a removable sleeve and valve assembly held in a bore of said handle by removable plugs accessible from the rear of said handle.

18. The spray gun of claim 16 wherein a valve block at the rear of said barrel has two legs extending forwardly on either side of the conductive means in said handle, there being a bore in each of said legs, said valves having stems extending forwardly on opposite sides of said conductive means.

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