

- [54] **APPARATUS FOR SPRAYING A PLURALITY OF DIFFERENT POWDERS**
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 [73] Assignee: **Ransburg Corporation**, Indianapolis, Ind.
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Related U.S. Application Data

- [63] Continuation-in-part of Ser. No. 171,495, Aug. 13, 1971, abandoned.
 [52] U.S. Cl. **239/15**, 239/113, 239/305, 239/400
 [51] Int. Cl. **B05b 5/02**
 [58] Field of Search 239/15, 80.3, 112, 113, 239/304-307, 303, 397, 400, 399; 118/311

[56] **References Cited**
UNITED STATES PATENTS

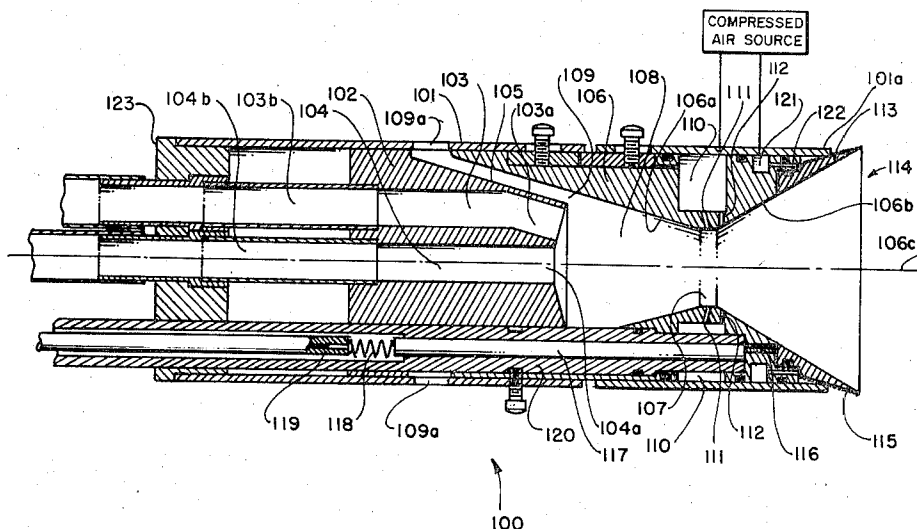
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3,021,077	2/1962	Gauthier	239/15
3,201,048	8/1965	Gibbs	239/412 X
3,240,432	3/1966	Boettler	239/112 X
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[57] **ABSTRACT**

This disclosure includes a color change means for and method of coating surfaces of articles with a spray of powder particles of one color or a spray including a plurality of different powder particles, the particles being entrained in a gas, such as air. The powder spray device is, preferably, an electrostatic spray device for depositing the particles of powder on a surface to be coated. A plurality of separate passageways in the spray device, one for conveying each powder, are connected to separate sources of powder. Particles of the desired powder or powders are withdrawn from the source or sources containing them. Powder particles flowing into the spray device are conveyed by the passageways to a chamber or compartment within the color change means. A flow of compressed air is introduced to the area where the powder particles emerge from the passageways. An induced flow of air is admitted into the spray device to the rear of termination of the passageways. In operation the powder being sprayed is not retained in the device in significant quantity, a substantially uniform powder distribution is achieved in the spray pattern and the powder particles are provided with momentum sufficient to carry the particles to the vicinity of the surface to be coated.

14 Claims, 7 Drawing Figures



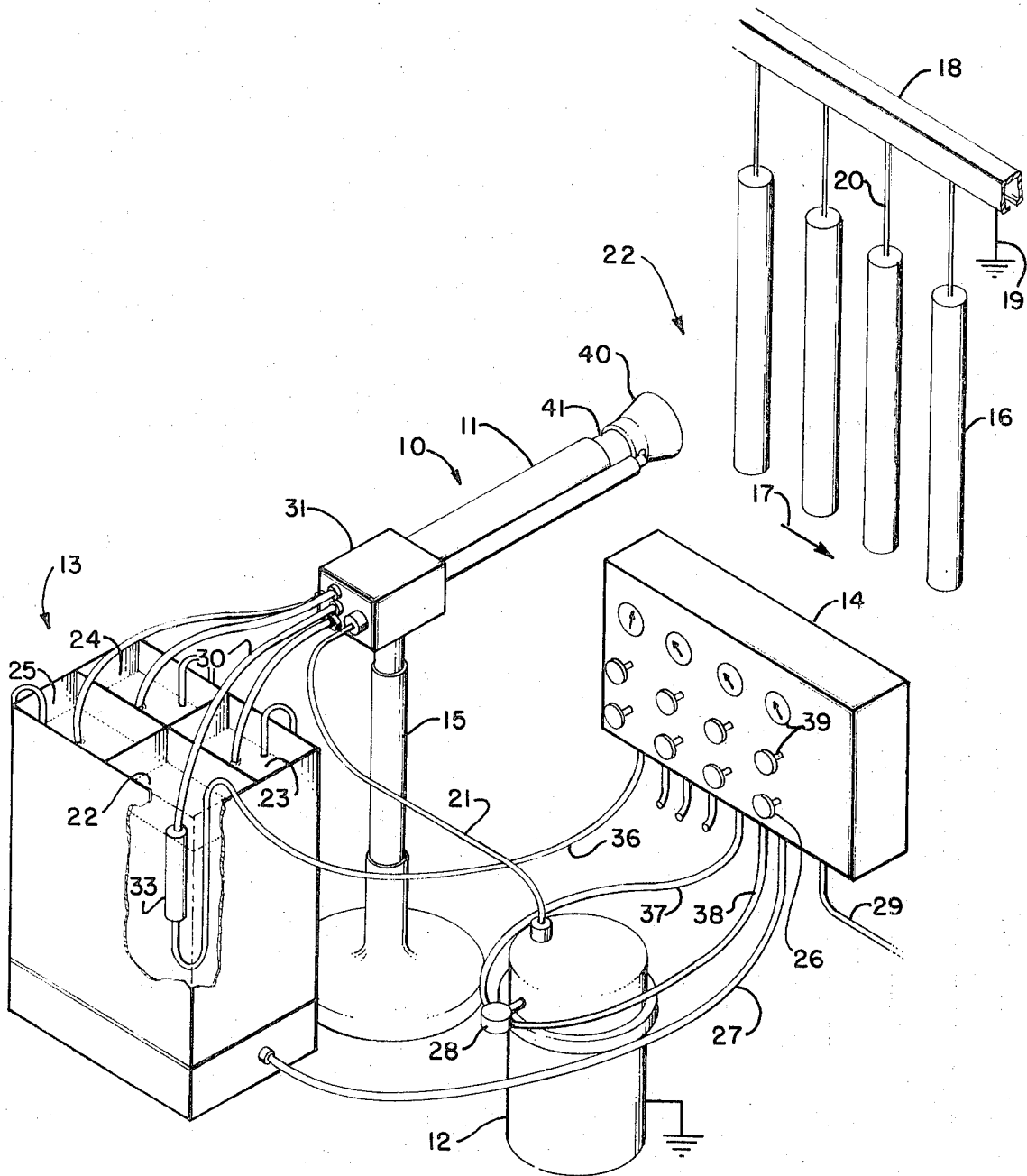
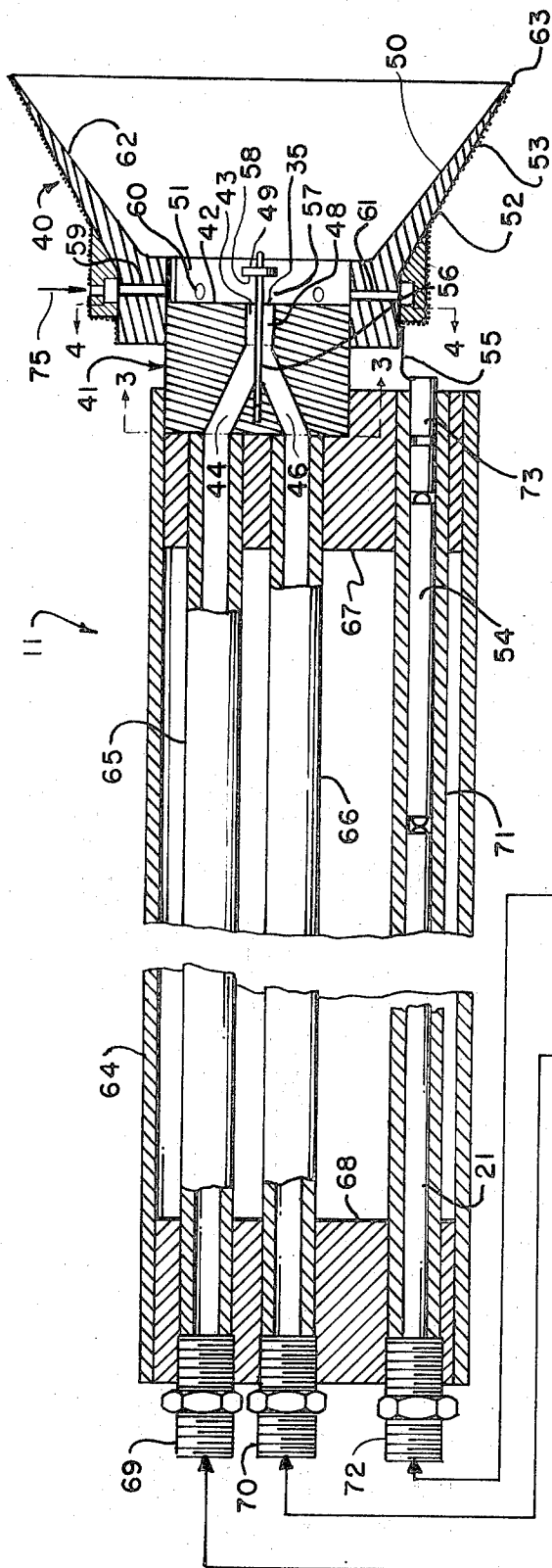


Fig. 1

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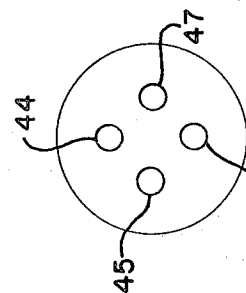


Fig. 3

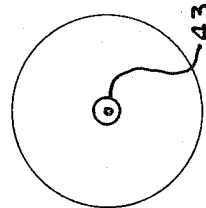


Fig. 4

Fig. 6

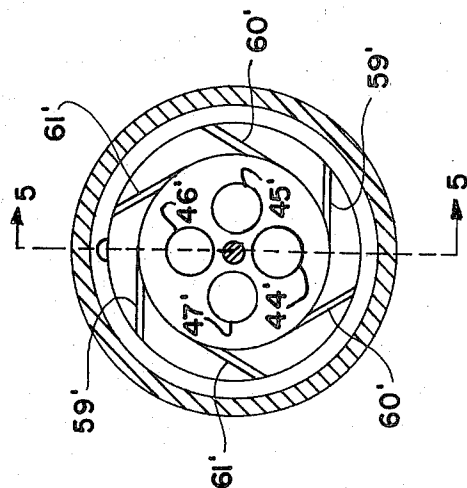
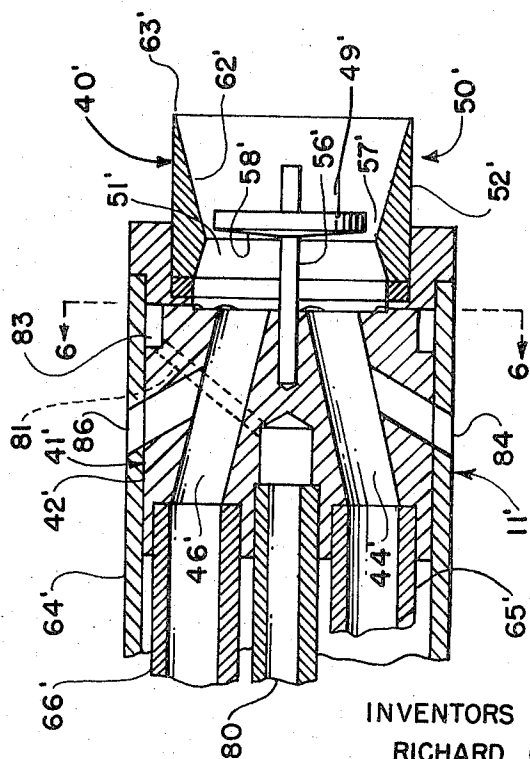


Fig. 5



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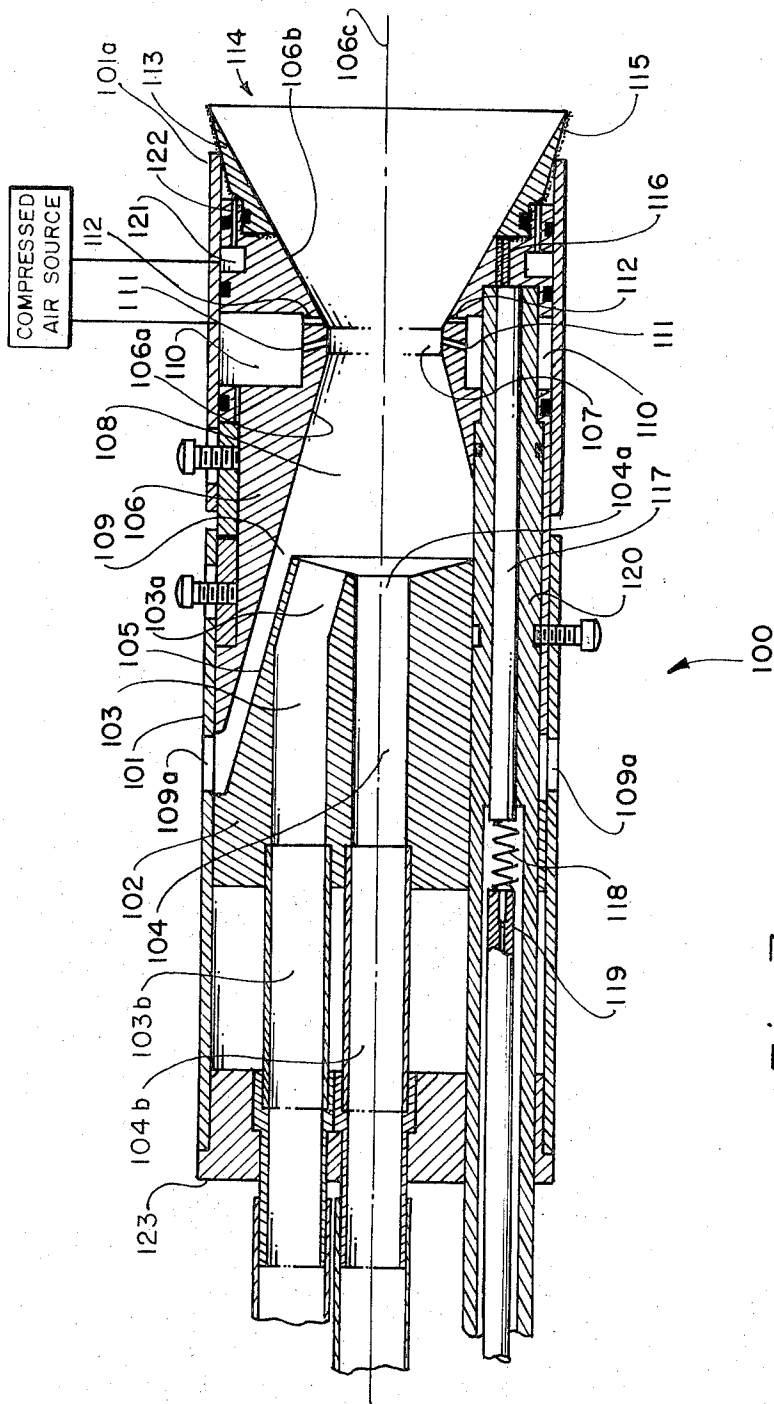


Fig. 7

APPARATUS FOR SPRAYING A PLURALITY OF DIFFERENT POWDERS

This patent application is a continuation-in-part of U.S. patent application Ser. No. 171,495 now abandoned which was filed on Aug. 13, 1971.

The present invention relates to coating surfaces of articles with a spray of dry particles of powder of one color or a spray of dry particles including a plurality of different particles. More particularly, the present invention relates to a powder spray device including a color change means for and method of quickly and conveniently changing from powder of a particular color to powder of another color. Preferably, the particles of powder are ejected from a powder spraying apparatus using electrostatic forces to assist in depositing particles of powder on a surface at a particle attracting potential.

In several of the available powder spray devices, if the user of the spray device wishes to change from spraying powder of one color to spraying powder of another color, the spray device is disconnected from a powder pump immersed in powder, purged of residue powder and connected to another pump in a bed containing powder of the desired color, and then powder of the newly selected color is sprayed. Alternatively, the spray device including the powder pump is purged of the residue powder, the pump is immersed in a bed containing powder of the desired color, and then powder of the newly selected color is sprayed. In any event, the necessity of disconnecting, purging and connecting the spray device to another powder bed does not readily lend itself to automated production techniques, and is a time consuming and expensive method of changing colors. Another suggested solution to the color change problem is to use an individual spray device for each color to be dispensed. It should be appreciated that such a solution is costly to the user, and requires unusual amounts of space for equipment.

Color change devices for liquid spraying devices are known. Generally, liquid color change devices use separate valves to control the flow of each color of paint to the spray device. Spray devices have been suggested that include in the device itself a plurality of passageways and valves, one for each color. Usually, however, the plurality of valves are located remotely from the spray device and a single hose is used between the valve means and the spray device. Although a color change device located remotely from the spray device functions well in liquid spray systems, it is not well suited for use in dry powder spraying systems. Among other things, such devices usually include sites or pockets at which particles of powder can accumulate so as to contaminate subsequently sprayed patterns of powder of a different color. Furthermore, locating a color change device remotely from a powder spray device generally means that subsequently sprayed patterns of different colored powder will be contaminated with previously sprayed powder due to the difficulty associated with removing residue powder particles from the length of hose extending between the spray device and the color change.

Patents showing such devices and other powder spray apparatus include U.S. Pat. Nos. 3,248,606; 3,458,137; 3,540,653; 3,691,991; 3,667,674 and 3,843,054.

It is, therefore, a desideratum to provide means for and method of changing from one color of dry powder

to another color of dry powder without disconnecting, purging and thereafter connecting hoses containing different colored powders. The invention includes color change means for a powder spray device that directs dry powder particles of one color entrained in a gas through one passageway of means containing a plurality of passageways to a powder ejecting orifice of the spray device. The powder spray device uses swirling gas to assist in preventing powder exiting from one passageway from backing up into the unused passageways, to assist in effecting a substantially uniform distribution of the particles of powder in the spray pattern ejected from the device and to assist in providing the powder with sufficient momentum to be propelled to the vicinity of the article to be coated.

The spray device also uses means to admit air into the device to the rear of the outlets of the plurality of passageways to minimize deleterious feedback of powdered material into the interior of unused powder passageways. This means preferably includes passageways and apertures in the device to admit an induced flow of air while the device is operating. This induced flow of air assists in purging the interior of the device of any significant accumulation of powdered material upon termination of its delivery.

Preferably, the spray device includes a non-rotating powder distributing means having an edge such that an electrostatic field is caused to be concentrated at the edge and appear between the edge and the surface to be coated, the surface being maintained at a particle attracting potential.

The appended drawings are intended to illustrate powder spraying apparatus embodying the concepts of the present invention. The illustrated apparatus are constructed to function in the most advantageous mode presently devised for the practical application of the invention. The powder spray devices illustrated in FIGS. 1 and 2 and FIG. 7 use electrostatic forces to assist in depositing the particles on a surface to be coated. It is to be understood that the concepts of the present invention can also be used with nonelectrostatic powder spray devices as shown in FIG. 5.

In the Drawings

FIG. 1 is a diagrammatic illustration of an electrostatic powder system embodying the powder color change means;

FIG. 2 is a partial cross sectional view of the color change means connected in a series with a powder spray device;

FIG. 3 is a rear view of the color change means taken across the lines 3—3 of FIG. 2;

FIG. 4 is a front view of the color change means taken across the lines 4—4 of FIG. 2;

FIG. 5 is a partial cross sectional view of a powder spray device using an embodiment of the concepts of the present invention;

FIG. 6 is a sectional view taken across the lines 6—6 of FIG. 5; and

FIG. 7 is a cross sectional view of another device embodying the concepts of this invention.

"Powder," as that word is used herein, means and includes thermoplastic dry powders such as polyester, polyvinyl chloride, polypropylene, polyethylene, nylon, cellulose acetate butyrate; thermosetting resins such as epoxies, polyesters, acrylics; other powder such as starch, talc, vitreous enamel; and the like. Preferably,

the individual powder particles are receptive to an electric charge or are capable of being suitably treated so as to accept an electric charge. The physical requirements of the powder should be such that the powder particle shape and size permit proper distribution on the surface to be coated so that the fused coating is of good structural strength and appearance. The melt viscosity and surface tension of the particles of powder should be such as to provide a film that adheres to the surface to protect and decorate that surface.

Many powders, and particularly synthetic thermosetting and thermoplastic powders, when fused, provide films which have characteristics such as corrosion resistance, color and dielectric strength which make them desirable as coating materials. For example, epoxy resins may be applied and fused to pipes and fittings used in handling corrosive materials; and fused polyesters and acrylics may be used as protective and decorative coatings for large flat surfaces such as surfaces of automobile parts, surfaces of appliance parts and the like, or for tubular surfaces such as the surfaces of bicycle frames and the like. Still other powders, such as powdered fluxes, can be applied to a surface to be used ultimately in the powder form. Also powdered talc can be applied to prevent self-adhesion of the surfaces being coated. The particular powder used to coat the surface will depend on, among other things, the purpose for which the coating is to be used, the nature of the finish required, the environmental conditions to which the surface is to be subjected and the like.

Generally, powders are prepared by grinding bulk material, usually at a low temperature. Powder having a particle size in the order of about 20 to about 250 microns is preferred for electrostatic powder spraying, however, the powder may be coarser or finer, depending on the particular material and application thereof.

Referring now to FIG. 1 of the drawing, an electrostatic powder spray system is illustrated by the reference numeral 10. The powder spray system 10 includes electrostatic spray gun 11, direct current power supply 12, powder reservoir 13, control panel 14 and means 15 for supporting spray gun 11.

Powder spray gun 11, as illustrated in FIG. 1, ejects electrically charged particles of powder toward the articles 16 suitably moved or displaced in the direction of arrow 17 by conveyor 18. For the purpose of illustration, articles 16 are cylindrically shaped. The articles 16 are maintained at a powder particle attracting potential, such as ground potential, by suitable electrical connection to earth or ground 19 through electrically conductive hangers 20 of conveyor 18. Charged particles of powder are propelled to the vicinity of articles 16 in the coating zone 22 and are guided to the surfaces of the articles 16 by electrostatic forces present in the coating zone. Coating zone 22 is the zone in which the powdered particles are deposited on the articles(s) to be coated.

Powder of a suitable color is withdrawn from reservoir 13 by means of a suitable pump, such as a venturi pump (indicated by reference numeral 33) that is immersed in the powder, and delivered to gun 11 through a suitable hose such as hose 30. The particles of powder are ejected from spray gun 11 and directed toward the surfaces of articles 16 in the coating zone 22.

A high voltage direct current power supply 12, capable of supplying a no-load voltage of from about 40,000 to 100,000 volts or more, is connected in series with

the spray gun 11 through cable 21. A suitable electrostatic field is established from the forwardmost edge of assembly 40 of gun 11 to the surfaces of articles 16 present in the coating zone 22. The polarity of the direct current voltage as supplied to gun 11 may be either negative or positive, depending upon, among other things, the type of powder to be sprayed from the powder spraying means 10. Some powder particles are more advantageously charged by a negative voltage than by a positive voltage and vice versa. The particles of powder are electrically charged and ejected into an electrostatic field between the assembly 40 of gun 11 and the surfaces of articles 16 to be coated with sufficient momentum to carry the particles of powder to the vicinity of the articles. The particles in the vicinity of articles 16 in the coating zone 22 are assisted in being attracted to and deposited on the surfaces of such articles by the electrostatic forces present in the coating zone.

The powder reservoir 13, as shown in FIG. 1, is divided into a plurality of compartments each containing a fluidized bed. For the purpose of illustration, reservoir 13 as shown includes fluidized beds 22, 23, 24, and 25. The reservoir 13 may have more or less than four fluidized beds depending primarily on the requirements of the user. For example, the reservoir 13 may contain as few as two beds or as many as eight beds or more. Each fluidized bed includes means (not shown) for fluidizing the powder particles by passing flowing gas such as air through a foraminous sheet (not shown) located near the bottom of each bed. Gas flows through the foraminous sheet and is directed upwardly through the powder causing the powder to expand in volume and become "fluidized."

Control panel 14, cooperatively associated with each of the illustrated fluidized beds 22, 23, 24, and 25, includes a suitable valve means (not shown) which controls the flow of air from a compressed air source (not shown) through hose 29, panel 14 and hose 27 to fluidizing beds 22, 23, 24, and 25, respectively.

Each of the pumps used to withdraw powder from the reservoir 13 is, preferably, a venturi pump. Preferably, a separate venturi pump is immersed in the powder of each of the remaining beds. For the purpose of illustration, a venturi pump 33 is shown immersed in fluidizing bed 22. Air from the compressed air source flows through hose 29, a master inlet valve (not shown) carried in the panel 14, air hose 38, solenoid operated air valve 28, air hose 37, a pressure regulating valve and gauge combination 39 in panel 14, and an air inlet hose 36 to pump 33. The outlet of venturi pump 33 is connected through hose 30 to the rear end 31 of spray gun 11. Activation of valve knob 26 either initiates or terminates air flow from valve and gauge combination 39 to hose 36. It is to be understood that a venturi pump like venturi pump 33 is immersed in each of the fluidized beds 23, 24, and 25 and that suitable hoses, regulating valves and gauges, and the like are used to connect each venturi pump to the source of compressed air and to the rear end of spray gun 11 in substantially the same manner as venturi pump 33 is connected to the source of compressed air and to the rear end of gun 11. In the interest of clarity, hose connections and the like for the other venturi pumps have been omitted from FIG. 1.

Referring now to FIG. 2, spray gun 11 includes assembly 40 mounted at the forward end of powder color

change means 41. The assembly 40 can take any one of a plurality of shapes such as bell-shaped shown in FIG. 2, cylindrical-shaped as shown in FIG. 5, and the like. Referring again to FIG. 2, the powder color change means 41 includes block 42, a single outlet passageway 43 terminating in orifice 35 and plurality of inlet passageways 44, 45, 46, and 47, shown in FIG. 3, brought or joined together in chamber 48, as shown in FIG. 2. Although four (4) inlet passageways are illustrated, it is to be understood that as few as two and as many as eight or more inlet passageways may be formed in block 42. The number of inlet passageways correspond in number to the number of fluidized beds used in reservoir 13. Generally, the number of inlet passageways is limited by the number of different colored powders to be sprayed and by the physical size of block 42.

The axes of the inlet passageways 44, 45, 46 and 47, as shown in FIG. 2, are each at an acute angle with the axis of outlet passageway 43. The magnitude of the acute angle of each of the inlet passageways with the axis of the outlet passageway 43 is such that feedback of powder of the selected color flowing through an inlet passageway into the remaining, unused inlet passageways is minimized. If powder of one color is permitted to flow into an inlet passageway or passageways which will be used subsequently to convey powder of a different color, such powder will mix with the powder of a different color when it is ejected from the spray gun 11 thereby providing a multi-colored powder coating on some or perhaps all of the articles 16. Preferably, the acute angle that each of the inlet passageways has with the axis of outlet passageway 43 is less than about 60°, and preferably about 15 to 45 degrees. In the event that the acute angle of the inlet passageways exceeds about 60°, some of the powder particles may be deflected into the then unused inlet passageways. In the event that the acute angle of the inlet passageways is less than 15 degrees, the number of inlet passageways that can be formed in the block 42 is thought to be limited to about two (2) or three (3) inlet passageways because the length of block 42 to accommodate the inlet passageways would be unusually long.

Block 42 of the color change means 41 is fabricated from any suitable erosion resistant, dielectric material such as nylon and the like in order to minimize wear sites and prevent the block from becoming electrostatically charged during the operation of the spray gun 11. Preferably, the inlet and outlet passageways of the color change means 41 should have side walls as smooth as is possible in order to minimize sites at which the entrained powder accumulates. Undesirable accumulation of particles of powder within the color change means 41 can result in either article 16 not receiving a sufficient coating of powder; or upon release of the accumulated powder, an article having a coating too heavy; or if the color of the powder has been changed, an article having a multi-colored coating.

Referring again to FIG. 2, assembly 40 is mounted at the forwardmost end of the color change means 41 of gun 11. The venturi pumps immersed in the reservoir 13 and power supply 12 are connected to the spray gun 11 as described above. Assembly 40, as illustrated in FIG. 2, includes a powder particle baffle or deflector 49, a non-rotating or stationary bell-shaped means 50 and compartment 51 formed by the structural cooperation between the bell-shaped means and the forward-

most surface of the color change means 41. The deflector 49 and bell 50 are fabricated from a suitable non-conductive or dielectric and erosion resistant material such as nylon or the like.

The rear face or outer surface 52 of bell 50 is provided with a substantially continuous conductive coating 53 having a high resistivity. A suitable material for coating 53 is described in U.S. Pat. No. 3,021,077. An end of high voltage cable 21 is connected to the rearward end of current limiting, multi-megohm resistor 54 which in turn is connected to the conductive coating 53 through electrically conductive plug 73 and brush 55. It is desirable to minimize the quantity of metallic conductive material associated with assembly 40 so as to minimize the effective electrical capacity of the powder spraying apparatus. The advantages of minimizing the effective capacity are disclosed in U.S. Pat. No. 3,048,498. The safety features disclosed in that patent are desirably incorporated in the spray gun 11.

Powder baffle or deflector 49 is carried by rod 56. Rod 56 is fixedly carried by color change means 41. Powder deflector 49 and the block 42 of color change means 41 cooperate so as to provide annular opening 57. The extent of opening 57 may be varied by moving deflector 49 along rod 56. After selecting the desired location of deflector 49 on rod 56, the deflector is fixed in position by any suitable means such as by frictional engagement of the deflector with the rod. The configuration of the periphery of deflector 49 may be round, ellipsoidal, or the like so as to provide a substantially uniform distribution of powder particles in annular opening 57. The radial extent of deflector 49 should be greater than the radial extent of orifice 35 of outlet passageway 43. Orifice 35 is the powder outlet orifice. The forward velocity of the particles of powder ejected from orifice 35 is decreased when the particles strike the rear surface 58 of deflector 49. The powder is deflected about 90 degrees in all directions. Preferably, the axes of the deflector 49 and the orifice 35 are coincident.

Powder particles are deflected toward compartment 51 at a reduced velocity after striking the rear surface 58 of the deflector 49. Jets of air are introduced into the compartment 51 substantially tangentially to the direction of the flow of powder particles ejected from orifice 35. The jets of air are introduced through a plurality of apertures illustrated, in part, by apertures 59, 60, and 61 formed in the side walls of compartment 51 to thereby assist in preventing powder from backing up into the then unused passageways and in effecting a uniform distribution of the powder over surface 62 of bell 50. As many apertures as are necessary to achieve the desired results may be formed in the walls of the compartment 51. The jets of air intercept and swirl the powder over surface 62 in a substantially whirling cyclone-type fashion. The velocity of air entraining the powder and the velocity of the jets of air entering the compartment 51 are so inter-related that the powder moves in a substantially helical fashion outwardly along the surface 62 of bell 50.

The apertures 59, 60 and 61 are substantially tangent to the circumference of compartment 51. Air from a compressed air source (not shown) is caused to flow to the apertures 59, 60 and 61 through an air hose (not shown) in the direction of arrow 75. It is to be understood that apertures 59, 60 and 61 may intersect compartment 51 chordally so long as appropriate distribu-

tion of the particles of powder over the bell surface 62 is realized.

The deflector 49 functions to assist in "locking" the air-entrained powder to surface 62 so that the powder does not prematurely leave such surface, and so that substantially all of the powder particles pass in close proximity to sharp edge 63 of bell 50.

The swirl air flowing from apertures 59, 60 and 61 assists in providing the powder particles with the momentum necessary to carry the powder to the article to be coated. It should be understood that the cross sectional flow area increases as the powder moves outwardly along surface 62 of bell 50, and, therefore, a large volume of air is required to provide an air velocity at the edge 63 of the bell 50 that is sufficiently high to maintain the powder entrained in air and to propel it to the vicinity of the article to be coated thereby. The use of swirl air tends to minimize build-up of powder particles in compartment 51 and on surface 62 of bell 50 during the spraying operation. If powder particles have a tendency to build up in these areas, agglomerated particles are formed and deposited on the articles. Such agglomerations form a roughness in the coating that are visible after curing. Agglomerations of particles may also result in a multicolor coating. In addition, the swirl air tends to provide a low pressure in the vicinity of orifice 35 which assists in minimizing the feedback of powder to the remaining, unused passageways.

The helical flow of powder across surface 62 of the bell 50 tends to substantially prevent the establishment of an air flow in the direction of articles 16 being coated which would blow from the articles powder particles already deposited thereon. Assembly 40 should not have any air flows associated with it that are likely to blow off powder that has heretofore been deposited on the articles.

Edge 63 of bell 50 is sharp so that the electrical field gradient at the edge is sufficiently high to provide the powder particles with a high charge-to-mass ratio. However, the sharpness of edge 63 can be varied considerably consistent with physical strength required of assembly 40 and the field gradient required to adequately charge the particles of powder.

Upon being propelled to the vicinity of the article, the electrostatic forces guide the powder particles to the surface to be coated. The electrostatic field for charging and depositing the powder ejected from the gun 11 extends from sharp edge 63 of bell 50 to surfaces of articles 16 to be coated. The charge on the particles is great when the powder particles are caused to pass in close proximity to the edge 63 of bell 50 since the field gradient is great at the edge of the bell.

During the coating operation, the grounded articles 16 are moved to a coating zone where charged particles of powder ejected from the spray gun 11 are attracted by the articles 16 to be coated and are retained on the articles by electrostatic attraction. As the coating becomes thicker, a surface charge is established on the articles because the particles tend to retain their electric charges. This charge tends to inhibit the accumulation of additional powder. The maximum thickness of the coating which can be applied varies with the electrical properties of the different powdered materials and with the voltage applied to sharp edge 63 of the bell 50. The particle powder deposited on the articles being coated will tend to accumulate first in the area most closely aligned with edge 63 of the bell 50. As the maxi-

mum coating thickness on this area is achieved, the deposition pattern expands and the particles are deposited on more distant portions of the article surfaces. The result is that the entire article 16 tends to acquire a substantially uniform coating with a minimum of relative movement between the gun 11 and the article 16. If spraying is continued after the surface is coated to maximum thickness, the powder particles will merely fail to be deposited on the article. Such excess particles of powder will go past the articles 16 as oversprayed material, accumulate within a suitable powder collecting enclosure (not shown) and may be recovered in any suitable manner as by a filter-separator (not shown). It should be understood that the spray device illustrated in FIG. 2 can be operated as a non-electrostatic powder spray device by terminating the flow of electrical energy from power supply 12 to bell 50 of spray device 11.

After a coating of the desired thickness is deposited on article 16, it is removed from the coating zone 22, and the powder is cured in a suitable manner, as by heating to the melting point temperature of the powder particles. In some cases additional applications of powder may be necessary to achieve a thicker coating. Preheating of article to be coated increases the maximum thickness of the coating which can be achieved. The powder particles are heated upon contact with the article and since the electrical properties of the hot material are different from those of the cold, the charge is dissipated rapidly permitting the deposition of additional powder particles.

Referring again to FIG. 2, the spray gun 11 includes an elongated tubular barrel 64 enclosing four (4) longitudinally extending tubes, of which two (2) are shown in FIG. 2. The illustrated tubes 65 and 66 are supported in plugs 67 and 68, respectively, at the front and rear ends of the barrel 64. Desirably, the barrel, the tubes and the plugs are formed from a non-conductive or dielectric material such as phenolic and the like. At their front ends, tubes 65 and 66 project beyond their cooperatively associated plugs to abut with the rear surface of color change means 41 and are axially aligned with the appropriate inlet passageways of the color change means. At their rear, tubes 65 and 66 are connected through fittings 69 and 70, respectively, to reservoir 13. Each hose is in turn connected to its cooperatively associated venturi pump for delivering powder entrained in a gas to the spray gun 11.

Tube 71 houses near its front end multi-megohm resistor 54. The rear end of resistor 54 is electrically connected to cable 21 secured to plug 68 by fitting 72. Cable 21 is connected to the ungrounded terminal of power supply 12; the remaining terminal of the power supply being grounded. Received in the front end of tube 71 is an electrically conductive plug 73 which is electrically connected to the front end of the resistor 54 and which has at its front end brush 55 making electrical contact with coating 53 on the rear surface of bell 50.

Referring now to FIG. 5, an embodiment of the color change means is illustrated. The primary difference between the color change means 41 of FIG. 2 and color change means 41' of FIG. 5 is that in FIG. 2 the inlet passageways merge internally and powder flow exits through a single orifice 35, whereas in FIG. 5 powder flow in each passageway exits block 42' through a separate and distinct orifice. In addition, assembly 40' of

FIG. 5 takes a slightly different configuration from assembly 40 illustrated in FIG. 2. The assembly 40', as illustrated in FIG. 5, includes a powder particle baffle or deflector 49', a nonrotating generally cylindrically means 50' and compartment 51' formed by the structural cooperation between the cylindrical-shaped means and the forwardmost surface of the color change means 41'.

Assembly 40' is generally mounted at the forward end of color change means 41'. The color change means 41' includes block 42' and a plurality of passageways 44', 45', 46' and 47'. Although four passageways are illustrated in FIG. 6, it is to be understood that as few as two or as many as eight or more passageways may be formed in the block 42'. Powder deflector 49' has a radially extent sufficient to cover the total of the radial extent of each of the orifices of the passageways 44', 45' 46' and 47'.

The device 11' is a non-electrostatic powder spray device. The rear face and outer surface 52' of means 50' is not provided with conductive coating, although such surface may be coated with a suitable conductive coating.

Powder baffle or deflector 49' is carried by rod 56'. Rod 56' is fixedly carried by color change means 41'. Powder deflector 49' and the block 42' of color change means 41' cooperate so as to provide annular opening 57'. The extent of the opening 57' may be varied by moving deflector 49' along rod 56'. The forward velocity of the particles of powder ejected from an orifice of the passageway is decreased when the particles strike the rear surface 58' of deflector 49'. The powder is deflected about 90° in all directions.

Powder particles are deflected toward compartment 51' at a reduced velocity after striking the rear surface 58' of the deflector 49'. Jets of air are introduced into the compartment 51' substantially tangentially to the general direction of the flow of powder particles ejected from the passageway. The jets of air are introduced through a plurality of apertures illustrated by apertures 59', 60' and 61' formed in the side walls of compartment 51' to thereby assist in effecting a uniform distribution of the powder over surface 62'. As many apertures as are necessary to achieve the desired results may be formed in the walls of the compartment 51'. The jets of air intercept and swirl the powder over surface 62' in a substantially whirling cyclone-type fashion.

The apertures 59', 60' and 61' are tangent to the circumference to compartment 51'. Air from a compressed air source (not shown) is caused to flow to the apertures 59', 60' and 61' through tube 80, aperture 81 and circular channel 83 formed in block 42'. It is to be understood that apertures 59', 60' and 61' may intersect compartment 51' chordally so long as appropriate distribution of the particles of powder over the surface 62' is realized.

The swirl air flowing from apertures 61', 62' and 63' assists in maintaining the desired velocity of the air used to entrain and carry the powder particles as the particles move radially out toward edge 63' of means 50' and toward the articles to be coated with the momentum necessary to carry the powder to the article to be coated and to minimize powder exiting from one passageway from backing up into unused passageways.

Referring again to FIGS. 5 and 6, the spray gun 11' includes an elongated tubular barrel 64' enclosing four

(4) longitudinally extending tubes, of which two are shown in FIG. 5. The illustrated tubes 65' and 66' and the remainder of the non-illustrated tubes are supported at their front ends by color change means 41 and at the rear end of barrel 64' by a plug (not shown). At their front ends the tubes project a suitable distance into the rear of color change means 41' and are axially aligned with the appropriate passageways of the color change means. At their rear the tubes are connected to a powder hose (not shown). Each hose is in turn connected to its cooperatively associated venturi pump (not shown) immersed in a powder reservoir (not shown) for delivering powder entrained in a gas to the spray gun 11'.

It should be appreciated that both illustrated color change means 41 and 41' can be used to eject one or more different colored particles of powder simultaneously toward articles 16. If more than one color of powder is projected toward the articles, the resultant film will have a multicolored appearance. Further, apparatus embodying this invention can be used to mix and spray two different and chemically reactive powders. One component, such as a reactive polymer and a second co-active chemical component can be put into separate fluidized beds and separately supplied to the interior of the spray device. Upon delivering to the interior of the spray device and adjacent to the spray orifice, the two powder components will be mixed together by the action of the compressed air jets and sprayed as a mixture from the spray orifice. Because of the features of this invention, the interior of the apparatus is kept free of any significant amount of the mixture.

The following examples are given to further illustrate the concepts of the present invention.

EXAMPLE 1

Unheated, cylindrical metal articles 16 having a length of about 42 inches, a diameter of about 1 inch and arranged on about 3-inch centers are conveyed past the spray gun 11 including the color change means 41 as illustrated in FIG. 2 at a rate of about 9 to 10 feet per minute. Powdered epoxy 202, manufactured by Minnesota Mining and Manufacturing Company, green in color, having an average particle size of about 20 to 250 microns, is ejected from the bell 50 using air pressure at the pump of about 45 pounds per square inch and having an air flow rate of about 1.5 scfm with a delivery rate of about 240 grams of powder per minute. The spacing between the bell edge 63 and articles 16, when the articles are in front of the spray gun 11, is about 10 inches. The no-load voltage at the output terminal of the direct current supply 12 is approximately 100 kilovolts. A reciprocator (not shown) moves the spray gun 11 vertically over the length of the articles about 10 times per minute. After the desired number of articles 16 are coated with green epoxy powder the flow of such powder to spray gun 11 is terminated. However, swirl air continues to flow to the gun in order to clean residue green epoxy powder from surface 62 of bell 50 in order to minimize contamination of subsequently ejected powder with the previously ejected green powder. After about 2 or more seconds, powdered epoxy 1001 manufactured by Minnesota Mining and Manufacturing Company, blue in color, is fed to and ejected from the bell 50 and deposited on the desired number of articles 16. The operating conditions

of the gun remain substantially the same as they were when epoxy 202 is ejected from the gun. After spraying the articles with the epoxy powder, whether green or blue, the coated articles are subjected to a fusing cycle of about 375°-450°F for about 2 minutes or more depending on the thickness of the metal wall of the cylindrical articles. A smooth, adherent epoxy film of two to three mils thickness is formed on each coated rod. The films are either green or blue and not multi-colored. It is to be understood that the length of time required to fuse the epoxy powder can be reduced if the articles are appropriately preheated prior to depositing powder thereon.

EXAMPLE 2

Example 1 is repeated except that epoxy powder 202 and 1001 are ejected simultaneously from the spray device 11 so as to provide a multi-colored green and blue powder coating.

Referring again to FIG. 5, individual air aspirating apertures are provided to each of the passageways 44', 45', 46' and 47'. In the interest of clarity, FIG. 5 shows only air aspirating aperture 84 connected to passageway 44' and air aspirating aperture 86 connected to passageway 46'. The axis of each of the air aspirating apertures is, preferably, at an acute angle with the axis of its cooperatively associated passageway to minimize blow-back of powder from the air aspirating aperture during the time powder flows through its cooperatively associated passageway. During the operation of the spray device 11' shown in FIG. 6, the swirl air tends to provide a low pressure in the vicinity of the orifices of each of the then unused passageways thereby aspirating air through the air aspirating apertures which further assists in minimizing feed back of powder to such unused passageways. It is to be understood that, if desired, suitable air aspirating apertures can be provided in the spray device 11 illustrated in FIG. 2.

The apparatus shown in FIG. 7, like those shown in FIGS. 1-6, also embodies this invention.

Different powdered materials may be sprayed from this device one after the other with insignificant contamination of the individual materials. Such a device is well suited to automatic color change systems where it is desirable to spray a plurality of colors from one device while maintaining color purity. As with the other apparatus disclosed above, a plurality of passageways, one for each different powdered material, are used to deliver the powdered material to a compartment adjacent the spray nozzle, and maintain segregation of the material until it is formed into a spray. The device includes means to admit a flow of air into the rear of the compartment, preferably a separate passageway between the compartment and the exterior of the device adapted to admit an induced flow of air. Jets of compressed air are directed into the compartment encouraging an induced flow of air into the separate passageway, interacting with the powdered material and the spray nozzle to form a spray, and upon termination of delivery of powdered material purging the compartment and spray nozzle of the residue of the powder. The outer surface of the spray nozzle is coated, like 53 of FIG. 2, to form an electrostatic charging electrode. A flow of compressed air is directed over the outer surface of the spray nozzle and the electrode. An accumulation of powdered material of one color on the outside of the spray device is likely to be dislodged and spoil

the color purity of another color. In addition the device shown in FIG. 7 is suited to mix and spray a plurality of different powder materials without an accumulation of mixed material within the apparatus.

Referring now to FIG. 7, the body 100 of the apparatus is preferably composed of several parts, preferably circular in cross section, for ease of manufacture. It includes an outer sleeve 101 made, for example, of glass-reinforced epoxy material to maintain the several parts of the body in cooperative association. A block 102 within the outer sleeve 101 includes a plurality of passageways, two (103 and 104) of which are shown in the cross section of FIG. 7. The number of passageways that can be formed in block 102 is determined by the size of the device and machinability of the block material, and within these constraints, the block may contain any desired number of passageways. Block 102 has a conical outer surface 105.

Forwardly of block 102 within outer sleeve 101 is a cylindrical member 106 having covering and diverging conical inner walls, 106a and 106b respectively, that form a throat 107. Block 102 and walls 106a and 106b of cylindrical member 106 form a compartment 108 into which the plurality of passageways direct the flowing powdered material. In the device of FIG. 7 each of the plurality of passageways have a forward portion (103a and 104a) adjacent compartment 108 to direct the flow of powdered material leaving the passageway at the center of throat 107.

In addition to compartment 108, block 102 and cylindrical member 106 form a separate passageway 109 between the conical inner wall 106a of member 106 and the conical outer wall 105 of block 102. Apertures 109a in outer sleeve 101 open passageway 109 to atmosphere and permit communication between the rear of compartment 108 and atmosphere. In operation of the spray device a flow of air is induced into the rear of compartment 108. This means to admit air to the rear of the compartment 108 minimizes feedback of the powdered material from chamber 108 into the interior of the passageways not in use and assists in purging the interior of the device of powder upon the termination of delivery of powdered material.

The device includes additional means to admit air into compartment 108. This means delivers a flow of compressed air into compartment 108 of the device at throat 107, and includes an air chamber 110 formed by an annular groove in cylindrical member 106 and outer sleeve 101 and a plurality of air passageways arranged around the periphery of throat 107, 111 and 112 in the FIG. 7 cross-section. Air chamber 110 is adapted to be connected to a source of compressed air (not shown). Compressed air delivered from this source is directed into compartment 108 at throat 107 through the plurality passageways 111 and 112. The flow of compressed air is directed substantially tangentially to the inner surface of cylindrical member 106 so that it swirls about the axis 106c of the inner surface. Powdered material reaching throat 17 interacts with this flow of compressed air and is encouraged to swirl about the axis 106c of the inner surface and expand along the diverging inner surface 106b of the device. The flow of compressed air admitted to compartment 108 encourages an induced flow of air through separate passageway 109 into the rear of compartment 108 and purges the compartment 108 and inner surfaces 106a and 106b of

powdered material upon the termination of delivery of powder material to compartment 108.

The forwardmost part 113 of body 100 mates with cylindrical member 106 and has diverging inner walls that provide a continuation of the diverging inner walls 106b. The forwardmost part 113 provides the spray orifice 114 of the spray forming means. The outer surface 115 of the forwardmost part 113 of the body is coated a conductive coating having a high resistivity, like the apparatus of FIG. 2. This coating forms an electrostatic spray charging electrode adjacent the spray nozzle. This coating is connected with a source of high voltage (not shown), typically 100,000 volts, at the rear of forwardmost part 113 by means of a small wire 116, a resistor 117 (on the order of 160 megohms), a small spring 118 and a high voltage cable 119. The resistor 117 and its connection 118 to the high voltage cable 119 are conveniently insulated by a polyethylene sleeve 120 carried within the body.

In operation, a swirling divergent spray of powder material is formed in the forwardmost part of the body of the device and emitted from orifice 114. The outer surface of the forwardmost part of the body is charged and an electrostatic field is established from adjacent the spray orifice 114 to the article to be coated. The expanding spray powdered material is charged in this electrostatic field and urged under its influence to be deposited on the article.

To keep the outer surface of the forwardmost part of the device free of accumulated powder, the device includes means to direct a flow of compressed air at its outer surface. Specifically, this means includes a second air chamber 121 formed by an annular groove in cylindrical member 106 and the outer sleeve 101. This air chamber is adapted to be connected to a source of compressed air (not shown). This means also includes a plurality of passageways 122 to direct a flow of compressed air at the outer surface of forwardmost part 113 which forms the spray forming nozzle and the electrostatic charging electrode. Conveniently, the forward end of outer sleeve 101 has been made axially adjustable as at 101a. The forward end of outer sleeve 101a and the outer surface 115 of forwardmost part 113, when assembled, provide a small annular slot that tends to spread the flow from the plurality of passageways 122 and to direct it uniformly over outer surface 115.

Except for the conductive coating on surface 115, wire 116, resistor 117, spring 118 and the high voltage conductor of cable 119, the apparatus shown in FIG. 7 is constructed of parts made from nonconductive materials such as nylon, acetal resin, polyethylene, glass-reinforced epoxy and the like. Nonelectrostatic devices may, of course, be made of conductive or metallic materials. To simplify the description above, no specific description is included of the O-ring seals for the air chambers formed within the body of the device by its parts, or of the nonconductive fasteners used to hold the parts together, but these are standard parts available in the marketplace.

Rearwardly of block 102 the plurality of passageways (103, 104) are connected through a plurality of tubes (103b, 104b) to a plug 123 to which the hoses leading from the sources of different powders are connected. The manner of connection is convenient to the embodiment shown in FIG. 7; the sources of powder can be connected with the device in many ways. The block at the rear of the compartment may not have any appre-

ciable length along the central axis of the device. It may be relatively thin holding tubes that form the plurality of passageways leading from the powder sources in the desired configuration to direct powder into the compartment, and may be provided with apertures to atmosphere to admit a flow of air at the rear of the compartment.

While the invention is illustrated and described in its presently preferred embodiments, it will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of this invention and as set forth in the appended claims.

We claim:

1. Apparatus for spraying one or more different powdered materials entrained in air comprising

means forming a compartment, a spray orifice connected with the compartment, a plurality of substantially straight passageways with openings to direct a flow of each of the different powdered materials into the compartment, means directing air flow into the compartment and out of the spray orifice to act on the flow of powdered material from each passageway in the compartment, and means for introducing an additional flow of air into the apparatus rearwardly of the compartment to assist in minimizing deleterious feedback of the powder to the unused passageways and to affect its spraying from the spray orifice.

2. The apparatus as claimed in claim 1, wherein the means for introducing an additional flow of air into the apparatus rearwardly of the compartment includes a separate passageway communicating with the atmosphere.

3. The apparatus as set forth in claim 1 wherein the means forming a compartment includes converging and diverging walls forwardly of the openings of the passageways, a first annular air chamber surrounding the compartment and a plurality of air passageways between the annular air chamber and the compartment forwardly of its converging wall, and a second annular air chamber adjacent the forwardmost part of the apparatus with openings adjacent the outer surface of the spray orifice to clean the outer surface at the spray orifice.

4. Apparatus as set forth in claim 1, wherein said means for introducing an additional flow of air into the apparatus includes separate passageways communicating with atmosphere and adapted to admit a flow of air to be induced into the passageways during operation of the apparatus.

5. Apparatus as set forth in claim 4 wherein the axis of each of the separate passageways is at an acute angle with respect to the axis of the passageway with which it communicates.

6. Apparatus for spraying one or more different powdered materials comprising

spray forming means, a compartment in the apparatus adjacent the spray-forming means, a plurality of passageways leading to the compartment, each connected with one of a plurality of sources of different powdered material and having terminal portions adapted to deliver one or more of a plurality of different powdered materials into the compartment without delivery of powdered material into the unused passageways, and

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means to admit air into the compartment including passageways arranged to cooperate with said spray-forming means and to minimize deleterious feedback of powdered material being sprayed into the unused passageways of the apparatus.

7. A device for spraying one or more different powdered materials comprising

a body, a spray nozzle formed at the front of the body, a compartment in the body adjacent the spray nozzle, a plurality of passageways in the body opening into the compartment to direct a flow of powdered material into the compartment, a separate passageway between the exterior of the body and the rear of the compartment and adapted to admit a flow of air to be induced into the separate passageway during operation of the device, a first air chamber in the body adapted to communicate with a source of compressed air and communicating with first means in the body to direct a flow of compressed air into the compartment to interact with other body portions encouraging an induced flow of air through the separate passageways into the rear of the compartment, interacting with the powdered material from the plurality of passageways and the spray nozzle in producing a spray, and purging the compartment and nozzle of powdered material upon termination of its delivery to the compartment,

an electrostatic charging electrode carried by the body and cooperatively associated with the spray to produce charged spray particles, and

a second air chamber in the body communicating with the source of compressed air and with second means to direct a flow of compressed air at the outer surface of the spray nozzle and the electrostatic charging electrode.

8. The device as claimed in claim 7, wherein the spray nozzle and compartment are formed by converging and diverging interior walls of the body, the walls converging forwardly of the passageways, forming a throat adjacent the first means in the body and diverging forwardly of the throat to form the orifice of the spray nozzle, said first means directing air into the compartment substantially tangentially to the diverging walls to swirl the powder about the axis of the spray nozzle.

9. The device as claimed in claim 8, wherein each of the plurality of passageways include a portion adjacent the compartment to direct powdered material from it at the center of the throat formed by converging and diverging walls.

10. A device for mixing and spraying a plurality of different powdered materials comprising

a spray-forming means,

a compartment in the device adjacent the spray-forming means,

a plurality of passageways opening into the compartment, each connected with one of a plurality of sources of different powdered materials to be mixed and sprayed,

means to admit air into the compartment at its rear

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to minimize feedback of powdered material into unused passageways of the apparatus, and

means adapted to be connected to a source of compressed air and to deliver into the compartment a flow of air to mix the powder materials from the plurality of passages, to interact with the spray forming means to form a spray of mixed powdered material and to purge the compartment and the spray nozzle of mixed powdered material upon termination of its delivery to the compartment.

11. The device as claimed in claim 10, including an electrostatic charging electrode cooperatively associated with the spray from the spray-forming means and means adapted to be connected to a source of compressed air to direct a flow of compressed air at the outer surface of the spray-forming means and the electrode.

12. The device as set forth in claim 10, wherein said spray-forming means includes a bell-shaped nozzle, said means to admit air into the compartment at its rear includes separate passageways communicating with atmosphere and adapted to admit a flow of air to be induced into the passageways, and said means adapted to be connected to a source of compressed air includes an air chamber in the apparatus communicating with a source of compressed air and means to direct a flow of compressed air into the compartment to interact with the bell-shaped nozzle, encouraging a flow of air through the separate passageways into the rear of the compartment, producing a soft divergent spray from the nozzle and purging the compartment and nozzle of powdered material upon termination of its delivery to the compartment.

13. Apparatus for mixing and spraying a plurality of different powder materials comprising a spray nozzle, a compartment in the apparatus adjacent the spray-nozzle, a plurality of passageways opening into the compartment, each connected with one of a plurality of sources of different powder materials to be mixed and sprayed, means to operate simultaneously a plurality of sources of different powder material and to deliver the different powder materials to different ones of the plurality of passageways, means to admit air into the compartment at its rear to minimize feedback of powder material into the unused passageways of the apparatus, and means adapted to be connected to a source of compressed air and to deliver into the compartment a flow of air to mix the powder materials from the plurality of passageways, to interact with the spray nozzle to form a spray of mixed powder material and to purge the compartment and the spray nozzle of mixed powder material upon termination of its delivery to the compartment.

14. Apparatus as claimed in claim 13, including an electrostatic charging electrode cooperatively associated with the spray from the spray nozzle and means adapted to be connected to a source of compressed air to direct a flow of compressed air at the outer surface of the spray nozzle and the electrode.

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