United States Patent

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[54] **APPARATUS FOR DISPERSING AND ELECTRICALLY CHARGING SUBSTANCES IN DISCRETE PARTICULATE FORM**
15 Claims, 1 Drawing Fig.

[52] **U.S. Cl.** **239/15,** 239/3
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[50] **Field of Search** 239/3, 15

[56] **References Cited**

UNITED STATES PATENTS

3,248,606	4/1966	Fraser	239/15

FOREIGN PATENTS

1,038,865	8/1966	Great Britain	239/15
429,517	1/1967	Switzerland	239/15

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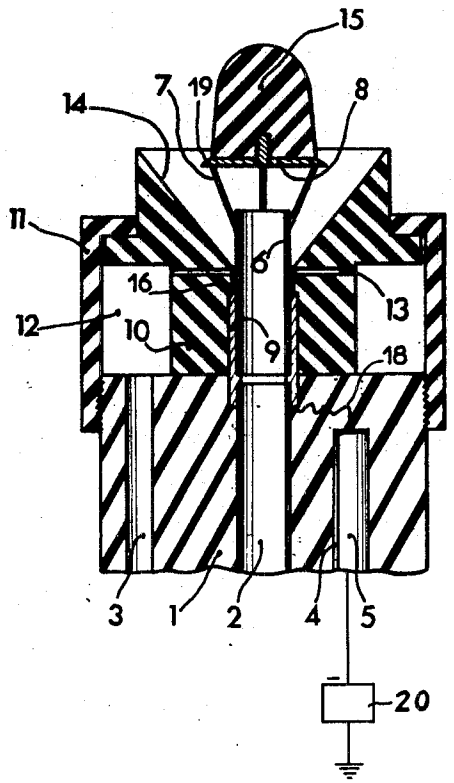
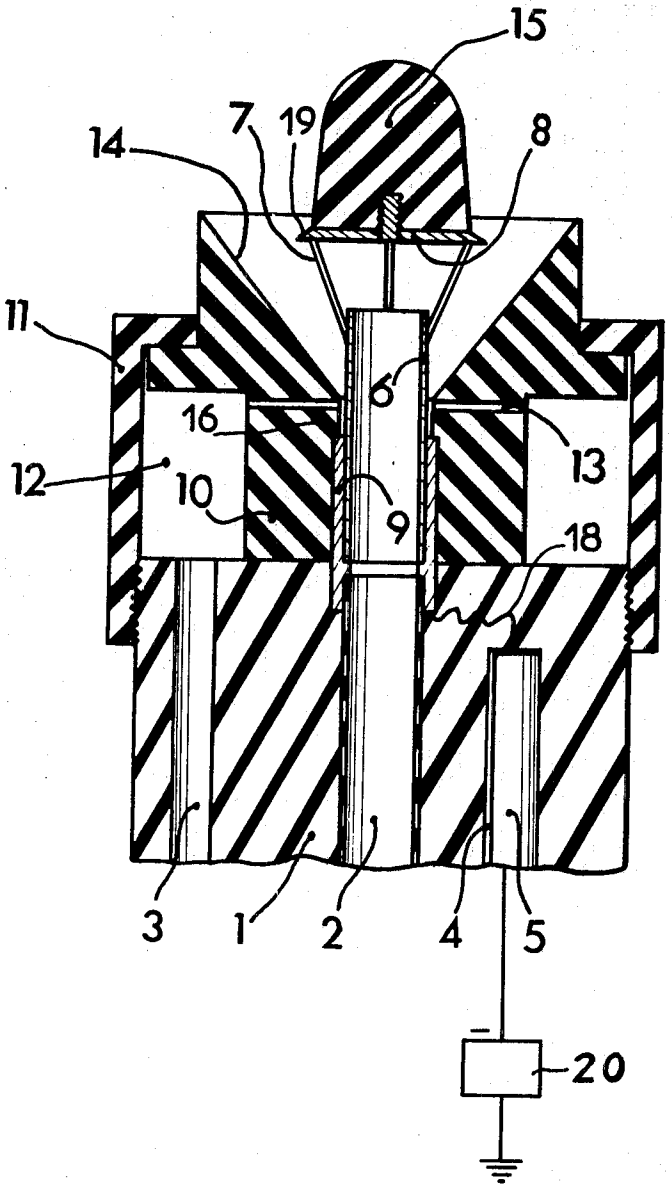
ABSTRACT: A nozzle assembly having an axial duct through which powder suspended in a low-pressure airstream is discharged, to impinge on a baffle plate which extends in a plane perpendicular to the path of the stream. Simultaneously, high-pressure air is delivered into an annular chamber and is formed into a whirling conically diverging vortex of gas adjacent the baffle plate. The particles of powder are deflected by the plate into the vortex and are entrained thereby. A high DC Voltage is applied to the plate to electrostatically charge the particles as they are deflected.

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APPARATUS FOR DISPERSING AND ELECTRICALLY CHARGING SUBSTANCES IN DISCRETE PARTICULATE FORM

This invention relates to apparatus for discharging electrically charged particles of finely divided solid materials such as powder, flakes, flock, grains and the like.

Apparatus of the type to which the present invention is directed, while of general application, is particularly well suited for use in the electrostatic coating of objects with powder, plastic or other coating compositions. As is well known, in such processes the object to be coated is connected to a potential which differs considerably from the potential with which the particles are charged, whereby the charged particles follow the lines of force of the electric field and are effectively and reliably deposited over the surfaces of the object. Usually, the object is at ground potential, while the particles are charged to a high DC potential.

In U.S. Pat. No. 3,248,606, granted Apr. 26, 1966, to R. P. Fraser, there is disclosed highly advantageous apparatus for the general purpose just stated. The disclosed apparatus includes an axial conduit for delivering a first stream of gas containing suspended particles of coating material to a generally cylindrical vortex chamber. A further stream of gas is delivered tangentially into the chamber to entrain the particles and discharge them in the form of a whirling, diverging vortex sheet along the inner surface of a diverging outlet nozzle communicating with the chamber. The outlet nozzle is electrically connected to a high DC voltage source for electrostatically charging the particles.

Among the numerous advantages of prior apparatus of the foregoing type is the fact that the particles are constrained by the centrifugal force of the vortex to flow closely adjacent the diverging outlet nozzle surface. The particles are effectively charged by this surface without the need for providing a narrow outlet passage which would be prone to clogging.

Further, because of the whirling motion of the particles their axial component of velocity can be kept desirably low, while at the same time the absolute linear velocity is desirably high. The low axial velocity component is advantageous because it renders the charged particles more readily responsive to the action of the electric field, while the high absolute velocity is desirable in order to ensure the requisite stable suspension of the particles in the air stream with an adequate discharge rate.

It is an object of the present invention to provide apparatus of the specified type, which will possess similar advantages as the prior apparatus described above, to an even higher degree.

A more specific object of the invention is to provide such apparatus in which the axial velocity component of the discharged particles is maintained at a minimum.

Another object of the invention is to provide modified and highly effective means for electrostatically charging substantially all of the particles which are discharged by the apparatus.

Still another object of the invention is to provide a continuous process for applying a smooth and uniform coating to the articles in a rapid and straightforward manner.

According to several important embodiments of this invention, there is provided apparatus for discharging electrically charged particles of divided solid material which comprises means for creating a generally axial stream of gas having the particles suspended in it and for directing the stream along a predetermined path, a baffle plate disposed in the path of the stream so as to deflect the same into a generally radial outflowing sheet, means creating a whirling vortex sheet of gas surrounding the stream so as to be impinged on by the outflowing sheet, and to entrain said particles, and means connected to a high DC voltage source for electrostatically charging the particles.

In a preferred embodiment, the high voltage source is connected to the baffle plate, such that an electrostatic charge is applied to the particles substantially as they are deflected by the plate.

An exemplary embodiment of the invention is described below with reference to the accompanying drawing, which is an enlarged view in axial section of the end part of electrostatic discharge apparatus according to the invention.

Referring to the drawing, the apparatus includes a body **1** which comprises the forward section of a hand held electrostatic spray gun. The body **1** is made of insulating material and has an axial conduit **2** which extends along a predetermined path and is connected to a source (not shown) of air at relatively low pressure. Suspended within the source of air is a mass of powder particles, flock or similar solid particles to be electrostatically deposited by means of the apparatus. Also formed in the body **1** is a side longitudinal conduit **3** connected to a source of air at higher pressure. A third conduit **4** is formed longitudinally in the body **1**, and this latter conduit contains a conductor **5** which is connected to the negative terminal of a source **20** of high DC voltage such as an electrostatic generator.

Supported in abutting relation with the flat end face of the body **1** is an outer nozzle member **10**. The member **10** is of insulating material and is held in place by a flanged screw cap **11**, also of insulating material. The member **10** includes a central aperture coaxial with the axial duct **2** and a conically flared inner outlet surface **14** extending outward from the central opening in contiguous relationship therewith. The member **10** is formed to define an annular air chamber **12** with the inner wall surface of the cap **11**.

An inner nozzle **6** is provided in the form of a metal tube member which is fitted in the central opening of the outer nozzle member **10**. The nozzle **6** protrudes from the central opening into the conical space formed by the surface **14** for a part of the axial length of the surface. In the illustrated example, the portion of the nozzle **6** within the central opening is press fitted in a sleeve member **9**. The sleeve **9** is also made of electrically conductive material and projects some distance into the body **1**, where it is electrically connected by a wire **18** to the conductor **5**.

The central opening of the outer member **10** is shaped and dimensioned to define a narrow annular chamber **16** between its cylindrical wall surface and the outer wall surface of the tube member **6**. The chamber **16** is connected with the air chamber **12** by passages **13** which are directed so as to connect tangentially at their inner ends with the chamber **16**.

Projecting from adjacent the outer end of the tube member **6** are metallic spider arms **7**. These arms diverge and support at their outer ends a disc-shaped baffle plate **8** which is made of conductive or semiconductive material. The plate **8** is axially positioned somewhat short of the outer edge of the flared outlet surface **14** and includes a sharp circumferential edge **19** which is radially spaced by an annular gap from this surface. Secured to the outer face of the baffle **8** is a protruding fair-shaped nose member **15** of dielectric material.

In operation, a relatively low pressure axial gas stream containing particles of divided solid material is directed along the path defined by the conduit **2** and is discharged from the tubular nozzle **6**. The discharged particles impinge on the substantially flat planar surface of the baffle plate **8** and are thereby converted into a flat, radially outflowing sheet. Concurrently, a high-pressure airstream is delivered through the conduit **3** into the pressure chamber **12** and enters the annular interstice **16** by way of the tangential passages **13**. The passages **13** create a vortex sheet which issues along the flared outlet surface **14**, being forced outwardly into close proximity with the surface by centrifugal force. Shortly before the vortex leaves the outer end of the surface **14**, it is impinged on from within by the flat sheet of particle-laden air deflected from the baffle **8**. The particles at this time have all been fully charged to the desired electrostatic potential by the action of the baffle, which serves as a high voltage electrode.

There issues from the apparatus a conically diverging stream of air (or other gas) laden with the particles to be deposited. The discharged particles are revolving about the axis of the stream at a high absolute velocity but with a very

low axial velocity component. Substantially all of the particles are electrostatically charged to a high DC potential.

The faired nose **15** serves to insure against the formation of a suction region beyond the baffle **8**. Any such region, if present, would be liable to disturb the vortex stream and thus impair the operation of the apparatus with optimum efficiency.

In an illustrative spray gun constructed in accordance with the invention, the apparatus had the following characteristics; inner diameter of tubular nozzle **6**, 6 mm.; inner diameter of outlet surface **14** at its narrow end, 10 mm.; inner diameter of outlet surface **14** at its outlet end, 42 mm.; axial length of outlet surface **14**, 28 mm.; axial length of nozzle **6** projecting into the outlet surface, 10 mm.; axial spacing from end of nozzle **6** to proximate face of baffle plate **8**, 10 mm.; diameter of baffle plate **8**, 26 mm.; diameter of interstice **16**, 10 mm. There were **4** tangential passages **13** each 2 mm. in diameter. The supply conductor **5** was connected to the negative terminal of an electrostatic generator the output voltage of which may be varied from 30 to 90 kv. The concentration of powder in the airstream delivered to the axial duct **2** was about 10 grammes/litre of air reduced to standard conditions.

Although substantially any type of particulate material may be utilized in connection with the invention, particularly good results are obtained in cases in which the powder has comparatively good insulation properties. In some embodiments, the volume resistivity of the powder preferably is greater than about 100,000 ohm-centimeters. With this arrangement, the possibility of substantial current flow between the powder and an article being coated is maintained at a minimum, and the electrostatic adhesion between the article and the powder serves to affirmatively maintain the powder on the coated surfaces.

Representative powders that have exhibited particular utility as coating materials include a wide variety of thermoplastic resins, such as polyethylene, polypropylene, nylon, vinyl chloride, the cellulosics, acrylics, etc., various thermosetting resins, *e.g.*, the epoxies, several phenolic type resins and many of the silicones, for example, and various inorganic powders. Examples of suitable powders of this latter class include talc, various vitreous materials, metallic oxides and phosphors.

Of course, it will be understood that the foregoing coating materials are but illustrative, and numerous other materials may be employed without departing from the spirit or scope of the invention.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described, or portions thereof, it being recognized that various modifications are possible within the scope of the invention.

I claim:

1. Apparatus for discharging electrically charged particles of divided solid material, said apparatus comprising:

particle delivery means for directing a gas stream containing particles of divided solid material along an axial path;

baffle means disposed in the path of said stream for deflecting the axially moving particles in directions perpendicular to said path;

means in juxtaposition with said baffle means for producing a whirling vortex of gas adjacent to but spaced from the axially moving particles, said particle delivery means including a discharge portion interposed between the whirling vortex and the axially moving particles for preventing entrainment of said particles by said vortex prior to the deflection of said particles by said baffle means, said particles thereafter being deflected from said baffle means to said vortex and being entrained thereby;

a source of high DC voltage; and

means connected to said source for applying an electrostatic charge to said particles.

2. Apparatus for discharging electrically charged particles of divided solid material, said apparatus comprising:

particle delivery means for directing a gas stream containing particles of divided solid material along a predetermined path;

baffle means disposed in the path of said stream for deflecting said particles in directions transverse to said path, to produce a generally radial outflowing sheet of particles;

means cooperating with the stream directing means for producing a whirling vortex of gas surrounding said baffle means in spaced relationship therewith, said particles being deflected from said baffle means to said vortex and being entrained thereby;

a source of high DC voltage; and

means connected to said source for applying an electrostatic charge to said particles.

3. Apparatus of the character set forth in claim **2**, said baffle means comprising a substantially flat plate extending in a plane perpendicular to said flow path.

4. Apparatus for discharging electrically charged particles of divided solid material, said apparatus comprising:

particle delivery means for directing a first gas stream containing particles of divided solid material along a predetermined path;

baffle means disposed in the path of said first stream for deflecting said particles in directions perpendicular to said path;

means cooperating with the stream directing means for receiving a second gas stream and for producing a whirling vortex of gas from said second stream adjacent to but spaced from the baffle means, said particles being deflected from said baffle means to said vortex and being entrained thereby;

a source of high DC voltage; and

means for electrically connecting said source to said baffle means, to apply an electrostatic charge to said particles substantially as they are deflected from said path.

5. Apparatus of the character set forth in claim **4**, in which the pressure of the first gas stream containing said particles is substantially less than the pressure of said second gas stream.

6. Apparatus for discharging electrically charged particles of divided solid material, said apparatus comprising:

nozzle means having a powder delivery portion for directing a gas stream containing particles of divided solid material in an axial direction along a predetermined path;

means including a baffle plate disposed in the path of said stream for deflecting said particles in directions transverse to said path, to produce a generally radial outflowing sheet of particles;

discharge means in spaced juxtaposed relationship with said baffle plate for producing a whirling vortex of gas adjacent to but spaced from said baffle plate, the powder delivery portion of said nozzle means being interposed between the whirling vortex and the axially moving particles for preventing entrainment of said particles by said vortex prior to the deflection of said particles by said baffle means, said discharge means including a cylindrical chamber surrounding the nozzle means and a plurality of passages opening tangentially into said chamber;

a source of high DC voltage; and

means for electrically connecting said source to said baffle means to apply an electrostatic charge to said particles.

7. Apparatus of the character set forth in claim **6**, said discharge means having a conically flared surface contiguous with the cylindrical wall of said chamber.

8. Apparatus of the character set forth in claim **7**, said nozzle means including a discharge end extending through said cylindrical chamber and protruding therefrom into the conical space formed by said flared surface, said discharge end being disposed intermediate the smaller and larger ends of said flared surface.

9. Apparatus of the character set forth in claim **8**, including means connected to the discharge end of said nozzle means for supporting said baffle plate in rigid, fixed relationship with said end.

10. Apparatus for discharging electrically charged particles of divided solid material, said apparatus comprising:

nozzle means having a powder delivery portion for directing a gas stream containing particles of divided solid material along a predetermined path;

means including an electrically conductive baffle plate disposed in the path of said stream for deflecting said particles in directions transverse to said path, to produce a generally radial outflowing sheet of particles;

discharge means cooperating with said nozzle means for producing a whirling vortex of gas adjacent to but spaced from said baffle plate, the powder delivery portion of said nozzle means being interposed between the whirling vortex and the axially moving particles for preventing entrainment of said particles by said vortex prior to the deflection of said particles by said baffle means, said discharge means including a first annular chamber surrounding the nozzle means, a second annular chamber surrounding said first chamber and a plurality of tangential passages interconnecting said chambers;

a source of high DC voltage; and

means for electrically connecting said source to said baffle plate, to apply an electrostatic charge to said particles substantially as they are deflected from said path.

11. Apparatus for discharging electrically charged particles of divided solid material, said apparatus comprising:

nozzle means having a powder delivery portion for directing a gas stream containing particles of a divided solid material in an axial direction along a predetermined path;

means including a baffle plate disposed in a plane perpendicular to the path of said stream for deflecting said particles in directions transverse to said path, to produce a generally radial outflowing sheet of particles;

discharge means cooperating with said nozzle means for producing a whirling vortex of gas surrounding said sheet, the transversely deflected particles impinging on said vortex and being entrained thereby, said discharge means including a cylindrical vortex chamber, a plurality of passages opening tangentially into said chamber and a conically flared surface contiguous with the cylindrical wall of said chamber, said chamber and said surface being coaxial with the path of said stream;

a tubular member communicating with said nozzle means for receiving the gas stream containing said particles, said tubular member extending through said cylindrical chamber and protruding therefrom into the conical space formed by said flared surface;

mounting means connected to the protruding end of said tubular member for supporting said baffle plate in rigid, fixed relationship with said end, said baffle plate being located within said conical space intermediate the smaller and larger ends of said flared surface;

a source of high DC voltage; and

means connected to said source for applying an electrostatic charge to said particles.

12. Apparatus of the character set forth in claim 11, said baffle plate, said mounting means and said tubular member each being of electrically conductive material and being connected to said voltage source, said particles contacting said baffle plate to charge the particles substantially as they are deflected from said path.

13. Apparatus of the character set forth in claim 11, including a faired nose member projecting from said baffle plate in the direction of discharge of said particles.

14. Apparatus for discharging electrically charged particles of divided solid material, said apparatus comprising:

nozzle means having a powder delivery portion for directing a first gas stream containing particles of divided solid material along an axial path;

baffle means disposed in the path of said first stream for deflecting said solid particles in directions perpendicular to said path;

means for maintaining said baffle means in rigid, fixed relationship with said nozzle means;

means cooperating with said nozzle means for receiving a second gas stream and for producing a whirling vortex of gas from said second stream adjacent to but spaced from the axially moving particles, said particles being deflected by said baffle means into said vortex and being entrained thereby;

a source of high DC voltage; and

means for electrically connecting said source to said baffle means, to apply an electrostatic charge to said particles substantially as they are deflected from said path.

15. Apparatus for discharging electrically charged particles of divided solid material, said apparatus comprising:

nozzle means having a powder delivery portion for directing a first gas stream containing particles of a divided solid material in an axial direction along a predetermined path;

means including a baffle plate disposed in a plane perpendicular to the path of said stream for deflecting said solid particles in directions transverse to said path, to produce a generally radial outflowing sheet of particles;

discharge means cooperating with said nozzle means for receiving a second gas stream and for producing a whirling vortex of gas from said second stream around the outflowing sheet of solid particles, said particles being deflected by said baffle plate into said vortex and being entrained thereby, said discharge means including a tubular member communicating with said nozzle means, a first annular chamber surrounding said tubular member, a second annular chamber surrounding said first chamber, a plurality of tangential passages interconnecting said chambers and a conically flared surface having a circular opening adjacent its smaller end in contiguous relationship with and of a diameter equal to that of the outer cylindrical wall of said first chamber, said tubular member extending through said first cylindrical chamber and protruding therefrom into the conical space formed by said flared surface with its protruding end disposed intermediate the smaller and larger ends of said surface;

mounting means connected to the protruding end of said tubular member for supporting said baffle plate in rigid, fixed relationship with said protruding end, said baffle plate being located within said conical space intermediate the smaller and larger ends of said flared surface;

a source of high DC voltage; and

means connected to said source for applying an electrostatic charge to said particles.