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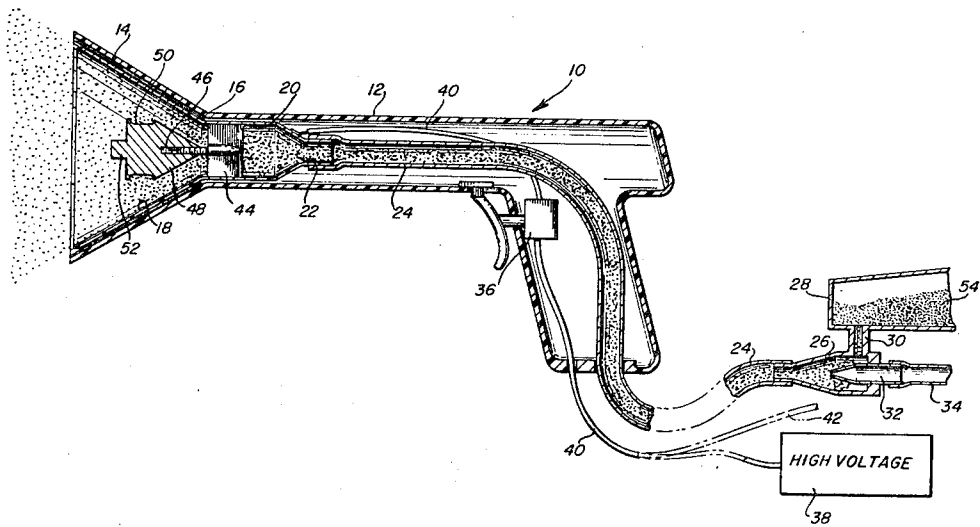
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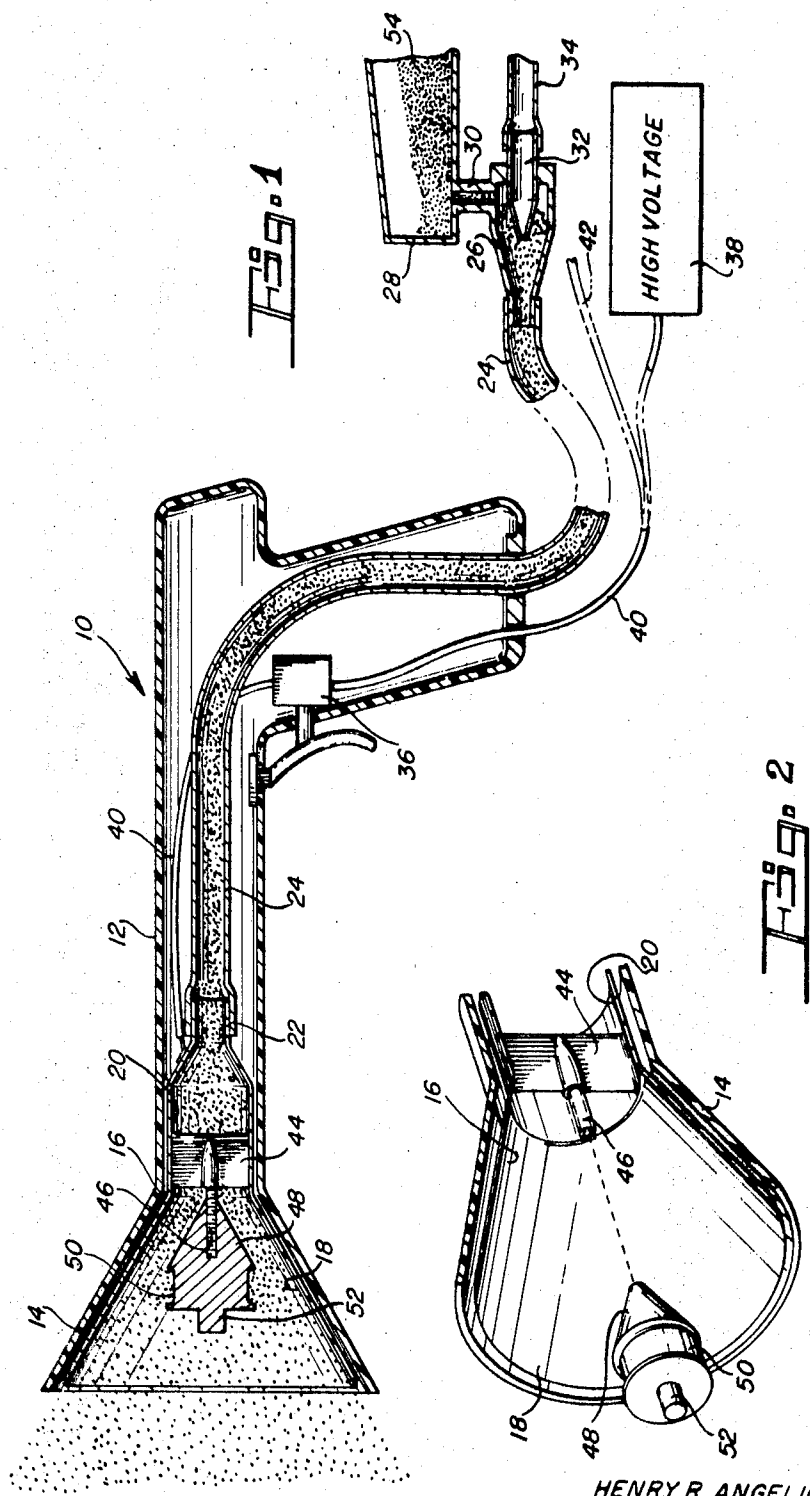
[54] **NOZZLE AND APPARATUS FOR ELECTROSTATIC
POWDER SPRAYING**
9 Claims, 2 Drawing Figs.

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ABSTRACT: A nozzle for an electrostatic powder spray apparatus has a plug member which is generally circular in cross section mounted axially within a generally circular passage therethrough so as to provide an annular flow path therebetween. Adjacent its outlet end the plug member has a circumferential groove which serves to radially divert the powder particles that pass through the annular flow path.





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NOZZLE AND APPARATUS FOR ELECTROSTATIC POWDER SPRAYING

BACKGROUND OF THE INVENTION

It is well known that articles can be coated with particulate materials by electrically charging the particles with a given polarity and exposing an article charged with an effective opposite polarity to a cloud or spray thereof. The article may be exposed by passing it over or through a fluidized bed of the particles, or the particles may be projected toward the article by using a spray gun especially adapted for that purpose. Two factors are of paramount importance if coating by the latter technique is to be effective: firstly, it is desirable to charge the particles as effectively as possible to most efficiently coat the article and utilize the power and powder consumed; secondly, the spray of powder particles issuing from the nozzle should be in a desirable configuration. Although the desired configuration of the spray may vary for some applications, frequently a generally solid cone, as opposed to a thin conical shell, is preferred since it provides a high degree of uniformity in the powder deposit. Many designs have been proposed for spray guns and nozzles but, so far as is known, none of the devices heretofore developed are capable of both charging particles in a highly efficient manner and also of dispensing the particles in a generally solid configuration. This is thought to be due to the fact that efficient charging normally demands that the particle be present in the charging zone in the form of a relatively thin sheet.

In addition to the foregoing, the conventional types of powder-spraying apparatus usually rely upon a system for distributing the powder to the spray gun which utilizes a venturi-type device inserted in a fluidized bed of the powder. A pressurized stream of gas is passed through the venturi device, and the particles are sucked into the stream from the fluidized bed by the well-known venturi principle. This type of system is somewhat disadvantageous because it requires relatively high pressures through the venturi, and also because there is a tendency for a powder surging to occur each time the spray device is actuated. The latter effect is primarily due to the accumulation of powder within the system, either because it has not all been discharged or because additional quantities enter the system after the flow of gas has been terminated. Although attempts have been made to alleviate the problem by activating and deactivating the fluidizing apparatus while maintaining a continuous flow of gas, such a mode of operation is far from ideal for a number of reasons. For example, time is wasted each time the cloud of particles has to build up and settle, and the continuing stream of gas tends to blow deposited particles from the workpiece.

Accordingly, it is an object of the present invention to provide a novel nozzle for electrostatic powder spraying which is simple and economical to manufacture, and which efficiently charges powder particles and at the same time produces a highly desirably configured spray thereof.

A more specific object is to provide such a nozzle which is capable of producing a spray of charged particles in a generally solid cone-shaped configuration.

It is also an object of the invention to provide apparatus for electrostatically spraying powder, which apparatus operates at relatively low pressures and in which problems of powder surging are virtually eliminated.

SUMMARY OF THE INVENTION

It has now been found that the foregoing and related objects are readily attained in electrostatic powder-spraying apparatus comprising a nozzle having a generally circular interior passage therethrough and inlet and outlet ends. Conduit means is connected to the inlet end of the nozzle for delivering a gas suspension of particles axially thereto, and charging means is provided along the flow path of the suspension for electrically charging the particles thereof. A plug member having a generally circular cross section is mounted axially in the passage of the nozzle in the flow path of

the suspension. The plug member is dimensioned and configured to seat within the nozzle passage with annular spacing between its circumferential surface and the sidewall of the nozzle defining the passage to provide an annular flow path for the suspension. The plug member has a groove extending circumferentially on its circumferential surface adjacent the outer end thereof to effect a radial diversion of the particles of the gas suspension passing over it.

In a preferred embodiment, the outlet end of the nozzle has an outwardly flared configuration and the plug member has a generally conical portion. The plug member is positioned with its smaller diameter end directed inwardly of the nozzle, with the circumferential groove adjacent the larger diameter end thereof, and it may be adjustably mounted in the nozzle for axial movement within the passage thereof to vary the dimensions of the annular flow path. The nozzle may also include a metallic insert along the passage through which the suspension of particles must pass, and this insert provides at least a portion of the charging means for the particles. In such an instance, the insert preferably has a portion which is generally conical in configuration, and the edge thereof at the outlet end is relatively sharp to enhance the effectiveness of particle charging.

Most desirably the gas suspension delivery means of the apparatus comprises a mixing chamber wherein the gas suspension is produced, feed means for providing powder to the mixing chamber, and a source of gas under pressure, the mixing chamber being independent of the feed means and located outwardly of it. Preferably, in such apparatus, the mixing chamber is positioned below the feed means so that the powder is provided thereto at least in part by gravitational flow. Alternatively, or in addition to the foregoing feature, the mixing chamber may be of a venturi type so that the powder is provided thereto at least in part by vacuum effects. It is particularly desirable that the feed means include an inclined vibratory trough down which the powder migrates from a supply thereof to the mixing chamber.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a fragmentary sectional view of electrostatic powder-spraying apparatus embodying the present invention with a diagrammatically illustrated high-voltage source; and

FIG. 2 is a perspective view in section to an enlarged scale of the nozzle portion of the gun shown in Fig. 1 with the plug member removed from the threaded stud on which it is normally mounted.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

Turning now in detail to the appended drawing, there is illustrated electrostatic powder-spraying apparatus including a spray gun generally designated by the numeral 10. The gun 10 has a hollow body 12 fabricated of a synthetic, electrically insulating resin with a flared nozzle portion 14 at the outlet end of the body 12. A hollow metal insert 16 is mounted within the body 12 at the flared nozzle portion 14, and includes a flared conical outer end portion 18, an intermediate cylindrical throat portion 20 and a nipple portion 22 at the inner end thereof providing a reduced diameter inlet thereto.

One end of a flexible hose or conduit 24 is secured over the nipple portion 22 of the hollow metal insert 16, and the opposite end thereof is connected to the outlet end of a venturi chamber 26 which is mounted directly below a vibrator pan or trough 28 and is connected thereto by a short tube or conduit 30. Mounted in the rear wall of the venturi chamber 26 in axial alignment with the outlet opening thereof is a gas nozzle 32, which is connected by a hose or conduit 34 to a source of gas under pressure (not illustrated).

The body 12 of the gun 10 has mounted therein a trigger switch mechanism 36 through which the high-voltage source 38 is connected to the metal insert 16 by a wire lead 40. Switch mechanism 36 also operates the gas source (not

shown) and the vibrator pan 28, and is connected to the control mechanisms therefore (not shown) by the branch 42 of conductor 40.

The throat portion 20 of the metal insert 16 has a conductive bracket 44 vertically mounted therein, which supports a threaded stud 46 extending axially outwardly into said flared nozzle portion 14. A metal plug member 48 with a conical inner end portion is threadably engaged on the outer end of the stud 46 and is dimensioned and configured to provide an annular flow passage between its circumferential surface and the corresponding sidewall of the flared end portion 18 of the hollow metal insert 16. The plug member 48 has a circumferential groove 50 in the side surface thereof adjacent its outer end and short stud 52 on its outer end surface by which the plug member 48 may be grasped to facilitate axial adjustments by turning it upon the threaded stud 46.

Operation of the apparatus is initiated by depressing the trigger of the trigger switch mechanism 36 which activates the control mechanisms (not shown) for the pressurized gas source (not shown) and the vibrator pan 28, and charges the metal insert 16 and, through the bracket 44, the plug member 48 with high voltage from the source 38 thereof. Powder 54 is fed into the vibrator pan 28 from a hopper (not shown), and vibration of the pan 28 distributes the powder 54 and aids its gravitational flow through the tube 30 and into the venturi chamber 26. A gas suspension of powder particles is produced in the venturi chamber 26 by the effect of the gas jet which issues from the nozzle 32. The gas pressure developed within the chamber 26 forces the suspension of particles through the hose 24, into the metal insert 16 and through the annular passage between the surfaces of the plug member 48 and the corresponding sidewall of the flared outer end portion 18 of the metal insert 16, whereby the particles acquire an electrical charge due to the high electrical potential existing thereat. The circumferential groove 50 in the plug member 48 imparts a radial movement to the particles in the gas stream, thus producing a generally solid conical cloud of particles at the outlet of the nozzle 32 and also enhancing the efficiency of the charging effect thereupon.

The design of the gun may be varied in many ways such as by altering the general configuration of the nozzle portion thereof. For example, rather than having a conical or flared configuration as is shown in the drawing, the nozzle portion of the gun may have a generally cylindrical or bell-shaped configuration. Although the nozzle portion of the body itself may be metallic and electrified to produce the desired charge on the particles, most desirably the gun includes a metal insert which cooperates with the plug member to serve that purpose. When such an insert is used, it will normally conform to the corresponding portion of the gun so that it seats closely therewithin, and most desirably it is of a relatively thin-walled construction with a relatively sharp edge at the outlet end thereof, since this feature has been found to enhance the efficiency of charging.

A most significant element of the present invention is the plug member or diverter which is mounted within the nozzle and which serves to improve the efficiency of charging and the flow characteristics of the suspended particles. In order to provide the full benefits of the invention, it is essential that the plug member have a circumferential configuration which conforms generally to the inner configuration of the corresponding portion of the nozzle (or insert if one is included), and that it be provided with a circumferential groove at its outlet end. To satisfy the former requirement, the plug member will usually have a generally conical inner end to seat in an appropriate manner within a generally cone-shaped nozzle (which will be the most common form used) and define an annular flow path between its circumferential surface and the nozzle inner surface.

Although the groove in the plug member may be fairly shallow, it should be relatively wide in comparison to the length of the plug member to create a significant effect upon the flow characteristics and discharge pattern of the powder.

Furthermore, the groove should be located quite near the outlet end of the plug member so that the directional effect which it has upon the path of the particles is not diminished significantly prior to discharge from the gun by structure located further downstream than the groove. The cross-sectional configuration of the groove may also deviate from that illustrated, such as by being generally semicircular, V-shaped or by having an irregular shape produced by combining linear and arcuate portions. The particular dimensions and relationships in the plug member will depend upon the construction and dimensions of the specific gun involved; however, typical dimensions for a plug of the design illustrated are about 1 $\frac{1}{2}$ inches long (excluding the stud on the outlet end portion) and about 1 inch in diameter at its outlet end portion, with the conical inner portion having a slope of about 27°. The circumferential groove therein may be about half an inch wide and about $\frac{3}{16}$ — $\frac{1}{4}$ inch deep. Such a plug may be used in a gun with a conical nozzle portion of the same slope, and may be positionable therein in such a manner that the thickness of the annular flow path defined between the plug and the nozzle portion inside wall is about $\frac{3}{16}$ — $\frac{1}{2}$ inch, measured normal to the surfaces. A gun having a body of polyvinyl chloride and an insert and plug member of aluminum, and constructed to the approximate dimensions previously suggested was found to produce excellent results while employing an air pressure of only 9 p.s.i.g..

Although the theory of the invention is not clearly understood, it is believed that the groove in the plug member imparts a radial deflection (either perpendicular to the axis of flow or at an acute angle thereto) to the particles, which enhances the intimacy and/or duration of contact with the charged elements of the gun, or at least enhances the influence of such elements upon the particles. Whereas adequate charging of the particles normally requires a thin flow path in the charging zone and thus necessitates higher pressures for a sufficient volume of discharge, the improved charging efficiency of the present nozzle design permits the flow path in the charging zone to be wider, and thus the nozzle operates best at significantly lower pressures and provides desirably high volumetric flow rates. The radial deflection of the particles also ultimately causes movement radially inwardly toward the axis of the flow, providing a uniform, generally solid pattern of particles issuing from the nozzle. The phrase "generally solid" as applied herein to the particle pattern is employed to differentiate from the thin-walled shell of particles that would tend to be produced with a regular plug member of the present type having no circumferential groove near its exit end. What is meant can best be understood by pointing out that with the present nozzle construction a generally disc-shaped area can be covered uniformly by directing the gun normal to a planar surface.

The plug member may be mounted within the nozzle portion of the gun by any suitable means and the means illustrated in the drawing is merely exemplary. Moreover, the plug member need not be adjustably mounted although this is very desirable as a means of achieving optimum results from the apparatus. Thus, the type of particle suspension, the gas pressure, the desired spray pattern, etc. may vary in given instances, and the ability to alter the dimensions of the annular flow path is a most desirable option for achieving the best results.

As regards construction of the gun, most desirably the body is made of a natural or a synthetic resin possessing good electrical insulating properties to protect against electrical discharge as a result of the high voltages employed. However, as has been mentioned previously, the nozzle portion at the end of the body may be metallic to eliminate the need for a hollow metallic insert. Conversely, the plug member may be nonmetallic, but charging efficiency will usually be best when both a metallic insert and a metallic plug member are used.

The electrical charge will normally be produced by connecting one or more metallic elements in the nozzle to a high-voltage source through a switch on the gun, such as the

trigger switch mechanism illustrated. Usually, it will be desirable to have the same switch control the delivery means so that the flow of particles occurs simultaneously with the activation of the charging elements. As regards the workpiece, it may be electrically grounded, charged with a polarity opposite to that on the particles, or left free of any electrical connections, so long as a sufficient electrical potential difference is established between the particles and workpiece to ensure adequate attraction therebetween.

The spray gun with the unique nozzle construction herein described may be employed with any feed mechanism by which a gas suspension of particles may be conveyed thereto, and it may be used with the conventional type of apparatus wherein a venturi-type device is mounted within a fluidized bed or cloud of powder. However, there are two principal drawbacks to such a system: first of all, proper operation requires that relatively high pressure (i.e., upwards of about 25 p.s.i.g.) be used; secondly, there is a strong tendency for powder to accumulate in the system, causing a surge or blast of powder at the initiation of each spraying operation.

On the other hand, the type of feed system depicted in the drawing operates well at low pressures and is therefore particularly well adapted for use with the present nozzle, which is uniquely suited for operation at relatively low pressures (e.g. of about 7—15 and preferably about 9—10 p.s.i.g.). In addition, the type of feed mechanism illustrated virtually eliminates the surging problem and, as a result, the most desirable embodiment of the invention utilizes the novel nozzle construction in combination with the feed mechanism of the type illustrated.

More particularly, rather than having the venturi-type device mounted for envelopment within a powder cloud or fluidized bed of particles, the powder is fed from external feed means into the venturi device (preferably by the gravitational vibratory type of feeder suggested in the drawing) and the suspension of particles is formed therein by injecting gas under pressure towards the exit end. The design of the mixing chamber may vary considerably from that illustrated and, in fact, need not necessarily employ the venturi principle although at least partial reliance upon vacuum effects for feeding the powder is most desirable. Also, it should be appreciated that the phrase "venturi-type device" or "venturi-type mixing chamber" as employed herein is intended to encompass all appropriate devices having a constricted gas flow portion exiting to an enlarged zone, whereby a vacuum is created as a result of the pressure drop.

Although any of the powders which are conventionally employed for electrostatic spray coating may be employed in accordance with the present invention, synthetic thermoplastic resins are preferred. Exemplary materials of the latter type include the vinylidene polymers (e.g., polystyrene and polyvinyl chloride), the olefin polymers (e.g., polyethylene, polypropylene and copolymers thereof), cellulose esters (cellulose acetates and butyrates), the polyamides (e.g., nylons) etc. Normally, the thermoplastic particles are fused into a unified structure by heating the deposit on the workpiece, and this may be done either by spraying the particles upon a preheated surface or by subsequently heating the workpiece after the coating of particles has been produced. However, the apparatus of the present invention may be used in virtually any application in which it is desired to produce a spray of electrostatically charged particles and is not limited by any particular

application or type of powder that may be employed therein.

Thus, it can be seen that the present invention provides a novel nozzle construction for electrostatic powder spraying which is simple and economical to manufacture and which efficiently charges powder particles while at the same time producing a highly desirably configured spray thereof. Moreover, the present invention provides a nozzle construction which produces a spray of charged particles in generally solid cone-shaped configuration. The invention provides apparatus for electrostatically spraying a powder which is operable at relatively low pressures and virtually eliminates problems of powder surging

I claim:

1. Electrostatic powder-spraying apparatus comprising a nozzle having a generally circular interior passage therethrough and inlet and outlet ends; conduit means connected to the inlet end of said nozzle for delivering a gas suspension of particles thereto; charging means along the flow path of the suspension for electrically charging the particles thereof; and a plug member having a generally circular cross section mounted axially in said passage of said nozzle, said plug member being dimensioned and configured to seat within said passage with annular spacing between the circumferential surface of said plug member and the sidewall of said nozzle defining said passage to provide an annular flow path for the suspension, said plug member having in said surface a groove extending circumferentially about said plug member adjacent the outer end thereof to effect a radial diversion of the gas suspension passing thereover.

2. The apparatus of claim 1 wherein the outlet end of said nozzle has an outwardly flared configuration, and wherein said plug member has a generally conical portion and is positioned with the smaller diameter end thereof directed inwardly of said nozzle passage, said circumferential groove being adjacent the larger diameter end of said plug member.

3. The apparatus of claim 2 wherein said plug member is adjustably mounted in said nozzle for axial movement within said passage to vary the dimensions of said annular flow path.

4. The apparatus of claim 1 wherein said nozzle includes a metallic insert along said passage through which the suspension of particles must pass, said insert providing at least a portion of said charging means for the particles.

5. The apparatus of claim 4 wherein said insert has a portion generally conical in configuration, and wherein the edge at the outlet end thereof is relatively sharp to enhance the effectiveness of particle charging.

6. The apparatus of claim 1 wherein said gas suspension delivery means comprises a mixing chamber wherein said gas suspension is produced, feed means for providing powder to said mixing chamber, and a source of gas under pressure connected to said mixing chamber, said mixing chamber being independent of said feed means and located outwardly thereof.

7. The apparatus of claim 6 wherein said mixing chamber is positioned below said feed means so that the powder is provided thereto at least in part by gravitational flow.

8. The apparatus of claim 6 wherein said mixing chamber is of a venturi type so that the powder is provided thereto at least in part by vacuum effects.

9. The apparatus of claim 7 wherein said feed means includes an inclined vibratory trough down which the powder migrates from a supply thereof to said mixing chamber.