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(54) Adjustable flat pattern powder spray gun.

(57) An electrostatic spray gun for spraying solid particulate powder materials entrained in a gas medium in a flat pattern including an electrically non-conductive housing and a nozzle to which is rotatably mounted an orifice restricting element with a pair of edges which move across the nozzle orifice as the element is rotated to adjustably restrict the orifice and thereby vary the width of the flat powder spray pattern.

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ADJUSTABLE FLAT PATTERN POWDER SPRAY GUN

This invention relates to electrostatic powder spray systems and more particularly to powder spray guns for use in such systems.

Electrostatic powder spray systems operate on the principle of transporting a finely divided powder, generally on the order of 150 mesh, to a spray gun or spray head while the powder is entrained in an air or gaseous stream. The air entrained powder is transferred from the nozzle of the gun to a target article or substrate by an electrostatic charge applied to the powder and an effectively opposite charge on the substrate. Once applied to the substrate, the powder is generally heated and melted so as to adhere the powder to the substrate as a film when the molten powder subsequently cools.

A characteristic of nearly all electrostatic powder spray applications is that less than half of all the sprayed powder adheres to the target article or substrate. The oversprayed powder thus must generally be collected, cleaned, and recycled in order for a powder spray system to operate efficiently and economically. Generally, the cost of collecting and recycling the powder is substantially greater than the cost of initially applying the powder. Consequently, it is very important to the economy of powder spray systems that as high a percentage as possible of the initial sprayed powder be adhered to the target article or substrate so that a minimum of the sprayed powder need by recycled or lost if the powder is not to be recycled.

The efficiency or percentage of sprayed powder which adheres to the target is a function of many variables, including the size and density of the sprayed powder, the velocity of the air stream in which the powder is ejected from the spray gun, the charge applied to the powder, and the configuration of the powder spray pattern.

It is difficult with existing powder spray guns to convert from one powder spray pattern to another because each application requires a different combination of spray nozzle characteristics to optimize the percentage of sprayed powder adhered to the substrate. Presently existing powder spray guns do not lend themselves to rapid adjustment of all of these variables and often require replacement of one gun with another or the replacement of one spray nozzle with another in order to change from one spray pattern to another or in order to maintain an optimum spray pattern when other variables affecting the pattern are changed.

It has therefore been one objective of this invention to provide an improved powder spray gun which lends itself to rapid and inexpensive adjustment of the spray pattern or conversion from one spray pattern to another without substitution of the nozzle or gun.

In any given electrostatic powder spray system, the number of applications in which the amount of oversprayed powder can be optimally minimized is dependent on the variety and number of nozzles available to define the spray pattern and to focus the powder spray. It is therefore still another objective of this invention to provide an electrostatic powder spray gun which has a nozzle adjustable continuously to vary the powder spray pattern or continuously vary the focus of the powder spray over a given range.

These objectives are achieved by, a powder spray gun in accordance with the invention in which the nozzle is adjustable so as to change the geometry of the nozzle orifice to control the pattern of powder spray. The adjustability of the nozzle is achieved by providing a nozzle having a fixed orifice in relation to which is adjustably positioned a sleeve or other orifice restricting element with a pair of edges which can be simultaneously moved across the nozzle orifice as the element is rotated to vary the effective boundary of the nozzle opening to shape the pattern and focus the powder spray.

Electrostatic powder spray guns often employ flat spray nozzles producing flat fan patterns. Minimizing the amount of overspray has heretofore required selection of a nozzle which produces a pattern with a width only sufficient to encompass the work. In many applications, the fan pattern is achieved through the use of a slotted nozzle with the width of the slot determining the width of the fan pattern. With a powder spray gun which has a nozzle adjustable to vary the dimensions of the nozzle slot which determines the pattern width, the width of the fan spray pattern is also varied.

An advantage of the present invention is that it provides a powder spray gun which, with a single nozzle, will direct powder spray patterns with widths which vary over a wide range. In one embodiment, the spray pattern is continuously adjustable to any width over a 9 to 1 range.

The primary advantage of a gun in accordance with the invention is the ease with which it facilitates adjustment of the powder spray pattern of an electrostatic powder gun without change of the gun nozzle.

The invention will now be further described by way of example with reference to the accompanying drawings in which:

Figure 1 is a side view of one embodiment of an electrostatic powder spray incorporating the invention of this application.

Figure 2 is a cross-sectional view through the discharge end of the gun shown in Figure 1.

Figure 3 is a front view of the nozzle of the gun shown in Figures 1 and 2 with the nozzle adjusted for maximum pattern width.

Figure 4 is a front view of the nozzle of the gun shown in Figures 1 and 2 with the nozzle adjusted for minimum patter width.

The powder spray gun of this invention is intended for use as a part of a powder spray system, such as that disclosed in United States Patent No. 4,245,551. Within such a system, air entrained powder is supplied to a powder spray gun through a supply hose while simultaneously, a very high voltage electrical charge is supplied to the gun from a source of electrical power. The electrostatic spray gun is operative to dispense the air entrained powder in a predetermined pattern while simultaneously applying a charge to the powder. The electrical charge then is operative to transport the powder from the nozzle of the gun to a target article or substrate which is of an opposite charge from that applied to the powder by the gun. Generally, a negative charge is applied to the powder by the electrostatic spray gun and the target article or substrate to which the powder is to be applied is grounded so that the powder is attracted to the article and adheres thereto as a consequence of the charge on the powder.

Referring first to Figure 1, there is illustrated an embodiment of a powder spray gun 10 incorporating the invention of this application. This powder spray gun comprises a housing 11 upon which there is mounted a nozzle 12 and an electrode support 13. The housing 11 comprises a pair of spaced mounting blocks 14 and 15 between which there are supported a pair of tubes 16 and 17. The uppermost one of these tubes is a resistor support tube 16 and the lowermost tube is a powder transport tube 17. Components 14, 16 and 17 are electrically nonconductive, while component 15 is electrically conductive to provide conductance to ground.

The forwardmost one of the mounting blocks 14 has a lower through-bore 20 therein which may be threaded and an upper blind recess 21 as is illustrated more fully in Figure 2. The blind recess 21 is threaded as indicated at 22. Intersecting this blind recess 21 there is an angled threaded bore 23. The electrode support 13 is threaded into the bore 23 and the forward threaded end 24 of the resistor support tube 16 is threaded into the threaded section 22 of the recess 21. The threaded forward end 25 of the powder transport tube 17 is threaded into and through the threaded bore 20 of the mounting block 14 so that the forwardmost end 25 of the powder transport tube 17 extends forwardly beyond the front face 26 of the mounting block 14. The nozzle 12, which is a conventional slotted nozzle, is threaded onto this forwardmost end 25 of the powder transport tube 17. The powder transport tube 17 is locked to the mounting block 14 by a jam nut 27 threaded over the rearwardmost threaded portion of the threaded forward end 25 of the powder transport tube 17.

The rear mounting block 15 is provided with a pair of through-bores 30, 31. The powder transport tube 17 extends through the lowermost one of these through-bores. The uppermost bore 31 is threaded for reception of the threaded rear end of the resistor support tube 16 and for reception of the threaded forward end 33 of a cable adapter 34. The rear end of the cable adapter 34 is also threaded for connection to a conventional electrical shielded cable (not shown).

Extending transversely through the rear mounting block 13 there is a transverse bore 36. This transverse bore 36 is intersected by a threaded bore 37 within which there is a set screw 38. The transverse bore 36 enables the rear mounting block 15 and thus the gun 10 to be secured to a mounting rod and fixed thereon by the set screw 38 as is conventional in this art.

Mounted internally of the resistor support tube 16 there is an electrical resistor 40. At the rear, this resistor 40 is connected via an electrically conductive spring 41 to an insulated electrical cable 42 contained internally of a conventional shielded cable (not shown) adapted to be connected to the cable adapter 34.

The forward end of the resistor 40 is electrically connected to a smaller resistor 44 contained internally of the electrically non-conductive casing the electrode support 13. This small resistor 44 is connected via a conventional connector 45 to the forward end of the large resistor 40. At its forward end, the small resistor 44 is attached to the powder charging electrode 46 which extends forwardly beyond the forward end of the casing of electrode support 13. In electrostatic powder spray guns, the illustrated placement of the electrode is only one of many. Such electrodes are, for example, also alternatively disposed within the nozzle of the gun. When an electrically shielded cable (not shown) is connected to the cable adapter 34, electrical contact is established between the conductor contained within the electrical insulated cable 42 of the shielded cable (not shown) and the electrode 46 via the spring 41, the resistor 40, the connector 45, and the small resistor 44.

When a source of air entrained powder, such as a conventional powder feed hopper, is connected via a hose (not shown) to the rearward end 48 of the powder transport tube 17, air entrained powder may be transported through the tube and ejected from an orifice 49 in the forward end of the nozzle 12. In the illustrated embodiment, the nozzle 12 is a conventional slotted nozzle which is a type which will more fully benefit by this invention. However, any type of powder spray nozzle may be utilized in the practice of this invention as long as the width of the spray pattern is determined by the effective position of the boundary of the nozzle orifice. The powder ejected from the nozzle orifice 49 is electrically charged during the course of passage through an electrostatic field created by the electrode 46. That powder then adheres to an effectively oppositely charged substrate (not shown) toward which the powder is ejected.

The nozzle 12 has an outer surface which includes a cylindrical portion 52, a truncated conical portion 53 forward of the cylindrical portion 52, and a circular planar end portion 54, the axes of the three portions being the same. The orifice 49 of the nozzle 12 is an elongated rectangular slot centered on the diagonal of the circular end 54 of the nozzle 12, and extending onto and terminating on the conical portion 53 of the surface of the nozzle 12. In typical operation, the powder sprayed from a nozzle of this type would be effected in a wide fan pattern, the width of the pattern being determined by the position of the slot ends 55.

It is important to the efficient use of a powder spray gun that the pattern of the powder ejected from the nozzle of the gun be sufficiently wide to encompass the entire work to be coated, but no wider than necessary to do so. Due to a substitution of workpieces of different sizes, or due to some other change of parameters, it may become necessary to widen or narrow the spray pattern to maintain the optimum efficiency in coating the work piece.

To accomplish this result, the illustrated embodiment of the invention is provided with a sleeve 61 rotatably attached to the outer surface of the nozzle 12. The sleeve 61 includes a cylindrical portion 62 which fits in close conformity with the cylindrical portion 52 of the outer surface of the nozzle 12, and a truncated conical portion 63 which fits in close conformity with the conical portion 53 of the outer surface of the nozzle 12. The forward edge 64 of the sleeve 61, which is the smaller end of the conical portion 63 of the sleeve 61, is in the plane of the circular end 53 of the nozzle 12.

The rotatably mounted sleeve 61 is dimensioned so as to be retained on the nozzle 12 by friction. An O-ring seal 66 is set in an annular groove 67 in the cylindrical portion 52 of the outer surface of the nozzle 12.

Referring to Figure 3, the sleeve 61 is shown positioned on the nozzle 12. In the forward end of the sleeve 61 is a hole 72 which is shaped so that the sleeve partially blocks the orifice 49 of the nozzle 12 to differing degrees depending on the angular position of the sleeve 61 on the nozzle 12.

The shape of the hole 72 is best described with reference to Figure 3. In the illustrated embodiment, the hole is defined by three superimposed shapes. One is a circle defined by the forward edge 64 of the sleeve 61. The second is a diametrically positioned rectangular slot 73 centered on and bisecting the circle 64, and of the same dimensions as the maximum cross-section of the orifice 49. The third shape is a pair of identical segments 75 of an elliptical curve defined by the section of the conical surface 63 intersected by a plane. These curves join the slot ends 76 with the circular edges 64 in opposite quadrants of the sleeve 61 to form continuously curved edges in those quadrants. On any diagonal, opposite edges of the hole 72 are at the same radius from the center of the hole. This radius is continuously decreasing moving along the curves 75 from the slot ends 76 to a point in tangential juncture with the circular edge 64. The edge of the hole 72 which crosses the orifice 49 thus defines the effective end boundary of the orifice 49, and the width of the nozzle slot.

In Figure 3, the sleeve 61 is shown in a position where the effective orifice of the nozzle 12 is wide open, with the ends 76 of the hole aligning with the ends 55 of the orifice 49. When the sleeve is in the position shown in Figure 4, the circular edge 64 forms the effective edge of the slot 73 defining the narrowest setting of the orifice 49. In the embodiment shown, the shape of the hole is such that as the sleeve 61 is rotated clockwise through ninety degrees, from the position shown in Figure 3 to the position shown in Figure 4, the effective width of the nozzle orifice 49 is continuously decreased from a maximum to a minimum width to produce a correspondingly wide to narrow fan pattern of the ejected powder spray. As a result, in a typical application, a flat fan pattern of powder spray is produced which is capable of being infinitely adjustable from, for example, a maximum of eighteen inches to a minimum of two inches without change of the nozzle.

Claims

1. An electrostatic spray gun for spraying solid particulate powder materials comprising: a powder transport tube supported by the gun housing, and having a nozzle connected to its outlet end the nozzle having an orifice through which powder from the transport tube may be ejected onto a substrate in a pattern, the width of the pattern being determined by the boundary of the orifice, characterised in that an orifice restricting element is rotatably mounted on the nozzle with a pair of edges simultaneously movable across the nozzle orifice so as to change opposite sides of the effective boundary of the orifice to change the pattern width.

2. A powder spray gun as claimed in Claim 1 wherein the orifice restricting element is a sleeve rotatably attached to the nozzle.

3. A powder spray gun as claimed in Claim 2 wherein the sleeve has an opening therein with an edge adjacent the orifice, the opening being configured so that its opposing edges move across the orifice as the sleeve is rotated with respect to the nozzle so as to change the effective boundary of the nozzle orifice.

4. A powder spray gun as claimed in Claim 1 wherein: the nozzle is a slotted nozzle and wherein the nozzle orifice is elongated to produce a fan shaped powder spray pattern the width of which is determined by location of the ends of the slot, the orifice restricting element being rotatable to a first position at which the orifice is opened so that the ends thereof define the maximum width of the slot and of the powder spray pattern ejected therefrom, and to a second position at which the orifice is narrowed so that the ends thereof define the minimum width of the slot and of the powder spray pattern, the location of the ends of the slot being determined by the position of the edges of the element.

5. A powder spray gun as claimed in Claim 4, wherein the edge of the opening includes a section continuously contoured so that the width of the slot is continuously adjustable between the positions of maximum and minimum width whereby the width of the pattern ejected from the nozzle is continuously adjustable between maximum and minimum width.

6. A powder spray gun as claimed in Claim 5, wherein: in the first position, the boundary of the opening of the orifice restricting element surrounds the slot so that the boundary of the slot determines the effective boundary of the nozzle orifice, in the second position, the edge of the sleeve opening determines the effective boundary of the orifice which determines the pattern width, and wherein the edge is contoured so as to continuously narrow the slot as the element is rotated from the first to the second positions whereby the width of the pattern continuously narrows as the sleeve is moved from the first toward the second positions.

7. An electrostatic spray gun as claimed in any preceding claim wherein the orifice restricting element has a curved surface and wherein each of the edges is defined by the intersection of a plane with the curved surface.

8. An electrostatic spray gun as claimed in Claim 7 wherein the surface is a cone having an axis which coincides with the axis of the nozzle and wherein each of the edges defines an elliptical curve.

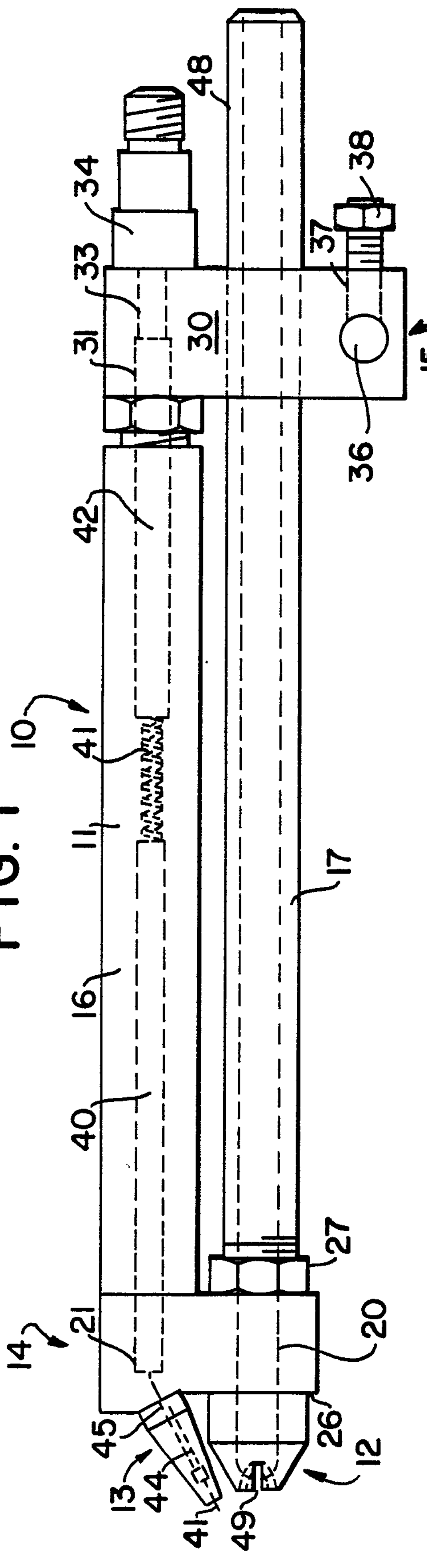

FIG. 1

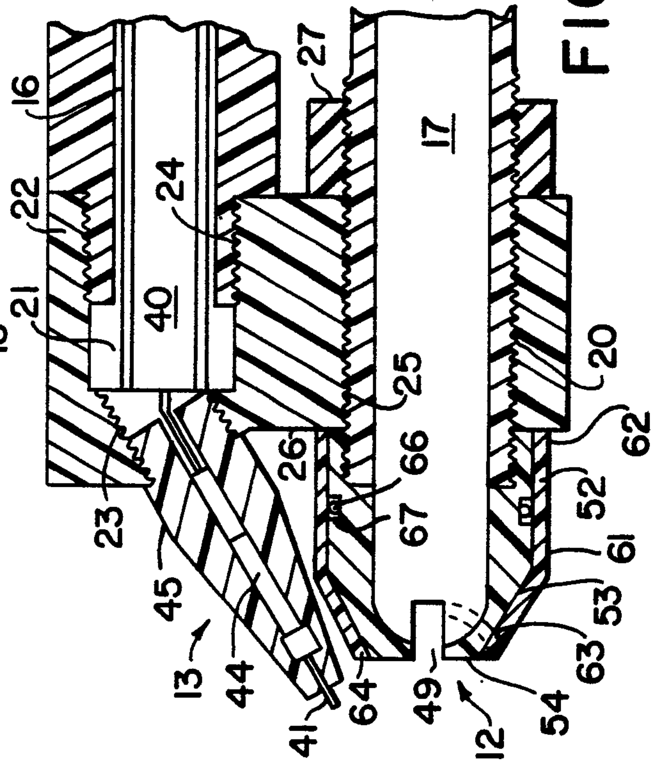

FIG. 2

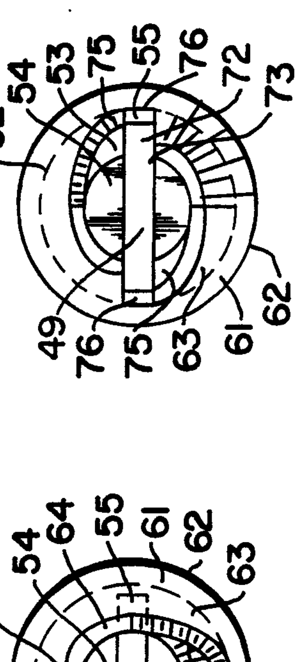

FIG. 3

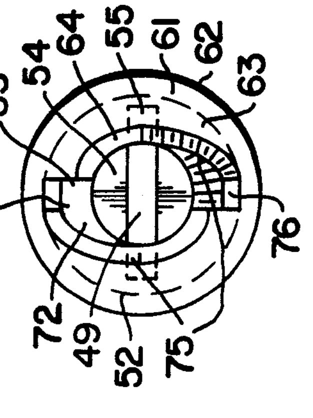

FIG. 4