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POWDER DUSTING DEVICE FOR ELECTROPHOTOGRAPHY

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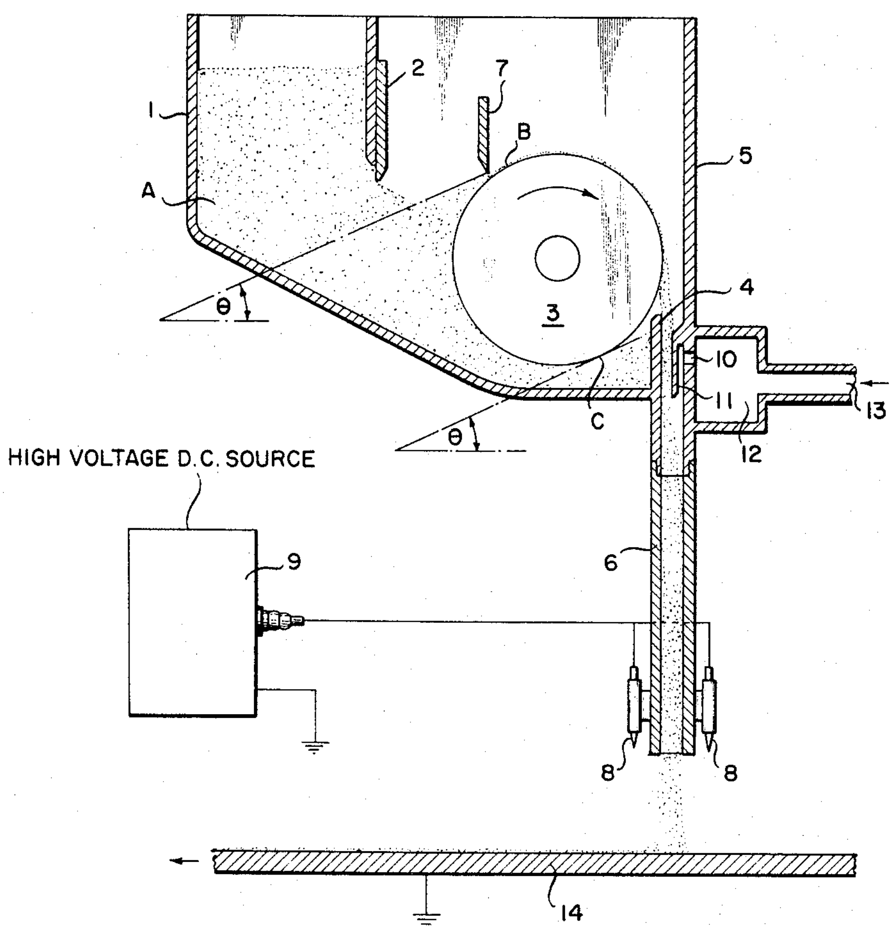

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POWDER DUSTING DEVICE FOR ELECTROPHOTOGRAPHY

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ABSTRACT OF THE DISCLOSURE

A powder dusting device for electrophotography comprising: a hopper, a reservoir interconnected to an exit of said hopper, a hopper gate disposed at the interconnection between said hopper and said reservoir, for controlling the level of a photoconductive powder delivered from the exit of the hopper to the reservoir, a rotating roller having a powder supply side disposed within the reservoir so that said supply side is dipped in the powder, thereby carrying a layer of powder forward over its outer surface, a doctor plate positioned with a gap between the lower end of the doctor plate and the surface of the roller on the powder supply side of the roller in order to control the amount of powder being carried over on the roller surface, a duct arranged below the top of the rotating roller on the side opposite the powder supply side to receive powder which falls under the influence of gravity from the surface of the roller as said roller rotates, an air supply conduit provided at the upper end of the duct, and corona discharge means provided at the lower end of said duct, whereby said powder is charged and uniformly dusted as a solid-gas sol onto an image carrier being moved at a constant speed and at a fixed distance below the outlet of said duct.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to a device for dusting photoconductive powder over an image carrier in the electrophotography art.

Description of the prior art

The details of electrophotography using photoconductive powder are disclosed in the specification of Japanese Patent No. 422,242 (Publication No. 22,645/1963). The point which is particularly important in industrializing this process is that the layer of photoconductive powder dusted over the image carrier should be tight and uniform, and a proper quantity of powder dusted per unit area should be maintained in order to hold an adequate and uniform electrostatic charge.

In order to avoid irregularities in the developed picture, it is necessary that the layer of powder should be uniform and the quantity of dusted powder should be even. Further, it has been experimentally verified that the tightness of powder layer affects the sharpness of the picture obtained and, if the powder layer lacks tightness, the resulting picture lacks clarity, as compared to a tight powder layer, even if the same photoconductive powder is used and the same amount is dusted. Also, the tightness of the powder layer is related to the electric charge carried by each unit quantity of the dusted powder, and the tighter such a layer is, the greater is the electrostatic charge so held, and the better the picture obtained. Moreover, the layer of photoconductive powder which is tight and has a greater electrostatic charge is characterized by the fact that decay in the electrostatic potential of such a layer in the dark is considerably less than that of the same powder

that is not tight. This brings about a great advantage in such processes of photographic treatment, since the time from charging up to development is decreased.

The quantity of dusted powder per unit area affects the electrostatic charge or surface potential per unit area of the image carrier. It is believed that the surface potential does not have as great an effect upon picture quality as the electrostatic charge held by the dusted powder per unit area and the uniformity of the electrostatic charge. With respect to surface potential, the quantity of dusted powder is not an important factor. However, if too much powder is dusted, the residual potential after exposure to light augments superlinearly, and the fog increases, causing the apparent photosensitivity of the powder layer to decrease. As a result, it becomes impossible to obtain a highly contrasted picture. Conversely, if too little powder is dusted, not only does the maximum density of the picture decrease, but the difference in the electrostatic force of attraction to the image carrier between the exposed and unexposed portions of the powder layer decreases sharply, thus making developing operations very difficult.

As discussed, the quantity of electrostatic charge held by the powder layer should be adequate and uniform. Devices utilized in this connection vary the quantity of electrostatic charge held per unit quantity of dusted powder according to the method of charging. As regards how to charge the photoconductive powder, the following two methods have been considered: the first involves charging the powder after dusting it over the image carrier. For example, the powder may be dusted over the carrier using a vibrating sieve, a pneumatic sprinkler or the like, and then charged by utilizing a corona discharge method or the like. This method is generally known in electrophotography as the Carlson Method. The second method of charging the powder involves charging the powder as it is dusted, or before it is dusted, over the image carrier. For example, the method which is known as the electrostatic powder coating method utilizes this sequence.

An experiment made by the inventors has proven that the latter of these two methods better meets the conditions required in powder dusting devices applicable to the field of electrophotography using photoconductive powder.

Devices for electrostatic powder coating which are commercially utilized include the r.e.p. gun made by the Japan Runsburg Company, and similar articles made by the Sames Company of France, the Hursant Company of Great Britain and others. In cases where, for instance, the r.e.p. gun of the Japan Runsburg Company is used for dusting photoconductive powder over the image carrier, good results may be obtained on a laboratory basis. Although this is the case on a laboratory basis, application of this electrostatic powder coating device to an actual electrophotographic apparatus using photoconductive powder would give rise to a number of problems. The first problem is that where a copying apparatus utilizing photoconductive powder is required for business or industrial use, an electrostatic coating device such as mentioned above is not practical because it requires a large space in order to dust the powder. In addition, large incidental devices such as a compressor and a super high-tension electric source are also required.

In the case of application of photoconductive powder to the technique that is known as the electrophotographic marking method, it would be impossible to achieve the desired performance unless an economically prohibitive number of such electrostatic powder coating devices were installed. This would be required by the size of the material which is to be marked, e.g., the maximum marking size of 4 m. x 16 m. applicable in the model EPM–416 electrophotographic marking device (manufactured by the Fuji Shashin Film Kabushiki Kaisha, a company of

Japan) and the economically practical marking speed, e.g., the marking speed of 9 m./min. (36 m.^{2}/min. for a width of 4 m.) applicable in said device.

Summary of the invention

The present invention is intended to provide a powder dusting device for electrophotography which satisfies the above-mentioned requirements, and is applicable mainly to electrophotographic apparatus such as electrophotographic marking apparatus using photoconductive powder in large quantities and at high speeds.

According to the invention, there is provided a powder dusting device for electrophotography, comprising: a hopper, a reservoir interconnected to an exit side of said hopper; a hopper gate for controlling the level of a photoconductive powder delivered from the exit of the hopper to the reservoir; a rotating roller having a powder supply side disposed within the reservoir so that said powder supply side is dipped in the powder, thereby carrying a layer of powder forward over its outer surface; a doctor plate positioned with a gap between the lower end of the doctor plate and the surface of the roller on the powder supply side of the roller to control the amount of powder being carried over on the roller upper surface; a duct arranged below the top of the rotating roller on the side opposite of the powder supply side to receive the powder which falls under gravity from the surface of the roller as said roller rotates; an air supply nozzle provided at the upper end of the duct; and corona discharge means provided at the lower end of said duct, whereby said powder is charged and uniformly dusted as a solid-gas sol onto an image carrier being moved at a constant speed and at fixed distance below the outlet of said duct.

Description of the drawing

The attached drawing shows a schematic diagram of a vertical side cross-section of a powder dusting device for use in electrophotography in accordance with this invention.

Description of the preferred embodiments

In the drawing, the numeral **1** denotes a hopper wall; **2** a hopper gate; **3** a roller capable of rotating in the direction of the arrow about its central axis; **4** a wall having a fixed space between it and the main wall **5** of the device to define an opening into which the photoconductive powder A falls; **6** a duct wide enough for the powder dusting breadth (perpendicular to the plane of the drawing) which consists of insulating walls provided below the above-mentioned opening; **7** a doctor plate which regulates the quantity of the powder carried to the roller rotating in the direction of the arrow; **8, 8** a pair of electrodes for corona discharge; **9** a D.C. high voltage source; **10** a hole row or slit provided in the main wall **5** of the device; **11** a guide plate provided on the main wall **5** of the device, arranged in the opening formed by the main wall **5** of the device and the wall **4** and opening downward just in front of the above-mentioned hole row or slit **10** with a narrow space between the plate **11** and the wall **5**; **12** a pressure equalizing chamber connected with an air conduit **13**; and **14** the image carrier over which the powder is to be dusted. B and C are the respective positions determined by the repose angle θ of photo-conductive powder A and the roller **3**, and represent the boundary lines between the upper surface of the layer of the powder A and the cylindrical surface of the roller **3**.

In operation, the photoconductive powder A is put into the hopper **1** until it fills the powder reservoir formed by the bottom of the hopper **1**, the wall **4** and the main wall **5** of the device. The height of the surface of the powder layer delivered out of the hopper **1** is maintained constant by the hopper gate **2**. As the roller **3** is turned in the direction of the arrow shown in the drawing, the powder A is moved along the outer surface of the roller **3** by virtue of the friction between the powder and the outer surface of the roller **3**, and is carried as a layer from the boundary line B to the right (in the drawing) over the upper surface of the roller. At this time, the upper surface of the powder A in the powder reservoir, inclined at the repose angle θ of the powder A, is in contact with the upper surface of the roller **3**. On the powder supply side of the roller **3** there is provided a doctor plate **7**, which is attached to the main wall **5** of the device. A space between the lower end of the plate and the outer surface of the roller is provided in order to regulate the quantity of powder carried by the roller **3**, and thereby insure that a uniform quantity of powder is dusted. The carried powder leaves the surface of the roller **3** on the opposite side to that of the powder supply, and thereafter passes through the opening formed between the wall **4** and the main wall **5** of the device and then through the duct **6**, to be dusted down upon the upper surface of the image carrier which is proceeding forward in the direction indicated by the arrow in the drawing. Any powder sticking or adhering to the surface of the roller **3** is brought back into the aforementioned layer of powder through the space between the surface of the roller **3** and the upper end of the wall **4**. A current of air which is fed from a pneumatic source, such as a compressor or blower, through the air conduit **13** is adjusted in the pressure equalizing chamber **12** to a uniform pressure in the direction of the axis of rotation of the roller **3**. It is then driven into the duct **6** through a hole row or slit **10**, and out of the downwardly open air nozzle which is composed of the guide plate **11** and the main wall **5** of the device. In the duct **6** the air is mixed with the powder, and this mixture passes the lower end of the duct in the state of solid-gas sol. The photoconductive powder is electrostatically charged by the corona discharge occurring on the lower end of the duct **6**, and then is dusted uniformly over the image carrier **14** and is attached to the latter electrostatically. A high voltage is provided to the corona discharge electrodes **8** from the high-voltage electrode of D.C. high-tension source **14** which has one end grounded.

In this invention, since the surface of the photo-conductive powder layer is kept inclined at a repose angle θ as it touches the upper surface of the rotating roller **3**, good results can be obtained because it becomes possible to dust a smaller quantity of powder uniformly than when using a device which regulates the dusted quantity of powder by means of a doctor plate **7** alone without making use of the repose angle θ. With devices wherein the repose angle θ is not utilized, the powder is supplied to the upper surface of the roller **3** by merely utilizing the powder pressure, and the powder is dusted in quantities which are too large, and without uniformity.

Generally, in cases where the fluidity of the photoconductive powder A is adequate, it is possible to carry the powder forward in uniform quantities in the direction of the axis of rotation of roller **3** even if no doctor plate is installed in position. It is difficult however, for every kind of powder to have a desirable fluidity and, with the rotation of the roller **3**, the position B where the powder surface comes in touch with the roller **3** may constantly change so much that the thickness of the powder layer will become irregular. According to this invention, however, it is always possible to have the powder uniformly dusted by providing the doctor plate **7** which is just a slit away from the surface of the roller **3** slightly below the contact position B. This prevents changes in the powder layer thickness from affecting the contact position B.

In cases where air is not blown out of the nozzle to mix with the photoconductive powder, if the powder is such as is ordinarily used, e.g., with a specific gravity of 1.5, an average particle diameter of 70μ, a particle diameter distribution of 30–120μ, the final rate of spontaneous falling due to the resistance of air will be about 0.3–0.5 m./sec.

Therefore, although the powder stream may be uniform in the duct 6, it will produce considerable turbulence when it falls 50–60 mm. after leaving the duct, and thus uniform dusting is made very difficult. When operating the corona discharge electrodes 8, the powder stream is disturbed by the corona wind originating from the electrodes, and this makes a uniform dusting impossible. For this reason, it becomes necessary to give the powder stream enough momentum for it to be able to withstand the influence of the corona wind or the air outside the duct. This is the reason why air is mixed with the powder stream in the middle portion of the duct in this invention.

It has been experimentally found that a practical velocity for the air to be mixed is about 1–10 m./sec. at the lower end of the duct 6. If the wind velocity is too low, the powder stream will be disturbed by the strong influence of the corona wind and thereby the thickness of the dusted powder layer will become irregular in the direction of the axis of rotation of the roller 3. Conversely, if the wind velocity is too high, the powder stream will not be adequately charged owing to the shortened period of time during which the powder is exposed to the ions produced from the corona discharge electrodes, and because of the lowered electrostatic force of attraction to the image carrier 14, part of the supplied powder will be blown away by the wind without attraction to the image carrier 14.

As for the corona discharge electrodes, those of various forms such as arrayed needles, saw teeth, knife edges, plates, small-diameter wires, etc. may be used. It is desirable that they produce uniform discharges in the direction of the axis of rotation of the roller 3. Where the distance between the electrodes and the image carrier is comparatively large, it is difficult to obtain uniform discharges by using electrodes other than those shaped like arrayed needles, or those shaped like large-pitch saw teeth. The voltage to be applied to the corona discharge electrodes depends upon the electrode structure, the distance between the electrodes and the image carrier, but ordinarily the voltage is approximately 4 kv.–100 kv. The polarity of the applied voltage is determined by the electrical characteristics of semiconductors contained in the photoconductive powder used, and when zinc oxide, cadmium sulphide and the like is used (as is usually the case) it is desirable that the polarity be negative.

In the drawing, the corona discharge electrodes are shown provided one on each side of the duct 6, making a total of two, but this does not necessarily mean that two of them are necessary. One alone on one side will suffice.

A few examples of various embodiments of the powder dusting device of this invention are given as follows:

EXAMPLE 1

As the roller 3, a 60 mm. O.D. hard vinyl chloride pipe whose surface was painted with Dotite E–3 electroconductive paint manufactured by Fujikura Kasei K.K. (an electroconductive paint with an electroconductive carbon black suspended in a water-based vinyl emulsion) was utilized. The hopper gate 2 was so set that its pointed end might be positioned 35 mm. horizontally, and 10 mm. vertically (upward) away from the center of the roller. Further, the duct 6, which was made of hard vinyl chloride, was provided so as to measure 10 mm. across its inner space and 250 mm. in length. Close to the pointed end of the duct arrayed needle electrodes were provided having record needles (for SP) arrayed at an interval of 10 mm. in the direction of the axis of rotation of the roller 3. An air blowing mechanism (such as is illustrated in the drawing) was provided near the upper end of the duct. With the roller rotating at a rate of 120 r.p.m., the lower end of the duct 80 mm. distant from the image carrier, the image carrier being fed forward at the rate of 100 mm./sec., a wind velocity of 4 m./sec. at the lower end of the duct, and a voltage of 80 kv. (minus) applied to the corona discharge electrodes 8, a photoconductive powder

A, which had a specific gravity of 1.54, an average diameter of 70μ, a particle diameter range of 30–120μ, and which comprised a transparent resin nucleus and a zinc oxide binder type photosensitive layer was dusted, with the following result: quantity dusted was 100 g./m.^{2}, the irregularity of dusting was $\pm 10\%$, and a surface potential of 450 v. was realized. Upon exposure and development of the image carrier, there resulted a sharp and uniform picture.

EXAMPLE 2

The roller 3 was a 100 mm. O.D. brass cylinder whose surface was lathe-finished to a roughness of about 6–S. The hopper gate 2 was provided so that its pointed end might be positioned 25 mm. horizontally, and 30 mm. vertically (upward) from the center of the roller 3. Further, the doctor plate 7 was installed with an interstice of 0.5 mm. between it and the roller so that its pointed end might be placed in the position determined by the angle of 55° which is formed between two planes intersecting with each other at the axis of rotation of the roller, one plane being horizontal and the other passing through the pointed end of the doctor plate 7. The layout of the device in other respects was the same as that in case of Example 1. With the roller 3 rotating at the rate of 35 r.p.m., the lower end of the duct 60 mm. distant from the image carrier, the image carrier being fed forward at the rate of 100 mm./sec., a wind velocity of 3 m./sec. at the lower end of the duct, and a voltage of 75 kv. (minus) applied to the corona discharge electrodes, the same photoconductive powder A as was used in Example 1 was dusted, with the following result: quantity dusted was 80 g./m.^{2}, the irregularity of dusting was $\pm 5\%$, and a surface potential of 370 v. was realized. Upon exposure and development of the image carrier there resulted a sharp and uniform picture.

In the explanations of the aforementioned examples the irregularity of dusting represents the maximum value of deviation from the average value of the samples each having an area of 50 mm. square with respect to the average dusted quantity of powder.

If a baffle plate (not illustrated) having a descending gradient toward the wall 4 is provided across the main wall 5 of the device and the wall 4 on each side in the direction of dusting breadth (perpendicular to the plane of the drawing) of the duct 6, the powder A does not fall into the duct 6 where the baffle plates stand, but is returned into the powder layer past the interstice between the wall 4 and the roller 3, and thereby it becomes possible to adjust the dusting breadth. This fact is taken advantage of in case the breadth of the image carrier is different from piece to piece when the electrophotographic marking method is used.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A powder dusting device for electrophotography, comprising: a hopper, a reservoir interconnected to an exit of said hopper, a hopper gate disposed at the interconnection between said hopper and said reservoir for controlling the level of a photoconductive powder delivered from the exit of the hopper to the reservoir, a rotating roller having a powder supply side disposed within the reservoir so that said supply side is dipped in the powder, thereby carrying a layer of powder forward over its outer surface, a doctor plate positioned with a gap between the lower end of the doctor plate and the surface of the roller on the powder supply side of the roller in order to control the amount of powder being carried over on the roller surface, a duct arranged below the top of the rotating roller on the side opposite the powder supply

side to receive powder which falls under gravity from the surface of the roller as roller rotates, an air supply conduit provided at the upper end of the duct, and corona discharge means provided at the lower end of said duct, whereby said powder is charged and uniformly dusted as a solid-gas sol onto an image carrier being moved at a constant speed and at fixed distance below the outlet of said duct.

2. Apparatus as in claim **1** wherein: pressure equalizing means are provided between said air supply conduit and said duct.

3. Apparatus as in claim **1** wherein: a guide plate is provided in said duct at the entrance of said air supply conduit.

4. Apparatus as in claim **1** wherein: said duct is arranged so as to protrude above the bottom of said hopper on the side of said roller opposite the powder supply, whereby any powder remaining on said roller which does not fall onto the duct is dropped into the area bounded by the said roller and the protruding portion of said duct.

5. An apparatus as in claim **4** wherein: said hopper gate is provided so that as said powder is delivered from the hopper to the surface of the roller said powder is maintained at an acute angle as said powder is contacted by the roller.

6. An apparatus as in claim **5** wherein: said powder which is carried beyond said protruding portion of said duct is maintained at an acute angle as said powder is contacted by the roller.

7. Apparatus as in claim **1** wherein: said air supply conduit is selected so as to enable said solid-gas sol to attain an exit velocity of from about 1–10 m./sec.

8. Apparatus as in claim **1** wherein: said corona discharge means are electrodes.

9. Apparatus as in claim **8** wherein said electrodes are arranged so as to produce a uniform discharge in the direction of the axis of rotation of said roller.

10. Apparatus as in claim **1** wherein the corona discharge means are powered by a D.C. high voltage source.

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