PATENT SPECIFICATION (11) 1 417 006

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(21) Application No. 54381/72 (22) Filed 24 Nov. 1972 (19)
(31) Convention Application No. 2 158 334
(32) Filed 24 Nov. 1971 in
(33) Germany (DT)
(44) Complete Specification published 10 Dec. 1975
(51) INT. CL.[2] G03G 15/08
(52) Index at acceptance
G2H 1F 1Y 5D1X 5D1Y 5DY 5G2G4 5G2G5 5G2GY 5G2Y 5GY 5Y

(54) IMPROVEMENTS IN AND RELATING TO ELECTROSTATIC COPIERS

(71) We, AGFA-GEVAERT AKTIENGESELLSCHAFT, a body corporate recognised under German Law, of Leverkusen, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to electrostatic copiers and especially to cascade developing apparatus for use in electrostatic copiers. In previously proposed cascade developing apparatus, a toner/carrier mixture is conveyed from a supply tank by means of a conveyor device to a raised discharge point and thence pours over the photoconductive layer which is to be developed and which carries a latent electrostatic image, the electrostatic charging of the carrier/toner mixture necessary for the developing of the latent image being effected by means of triboelectrical effects occurring during the circulation of the mixture in the developing apparatus.

With this method, the carrier/toner mixture is charged by means of triboelectrical interactions between the individual particles and the surfaces of the developing apparatus which are in contact with the mixture. These varied interactions generally lead to the result that parts of the carrier/toner mixture receive a charge which is different from the average charge of the mixture as a whole.

However, for richly contrasted developing of the latent electrostatic image, that is to say, for adequate toner application in the ihage areas and complete removal of the toner powder adhering to the image-free areas as a result of adhesion forces, certain narrowly defined charge relationships between the latent image, the carrier particles and the toner powder are necessary.

The invention seeks to improve the homogeneity of the triboelectric charging of the toner/carrier mixture and thus make it possible to produce copies with a high degree of contrast and a clean background.

The invention provides a cascade developing apparatus for use in an electrostatic copier for conveying a toner/carrier mixture to an elevated discharge point from which it can pour onto a photoconductive layer carrying a latent electrostatic image to be developed, which comprises a supply vessel for a toner/carrier mixture, a conveyor provided with discrete receptacles and arranged, in operation, to convey toner/carrier mixture from the supply vessel to the elevated discharge point, a first guide surface arranged to deflect toner/carrier particles discharged at the elevated discharge point, and a second guide surface arranged to deflect back into the supply vessel those particles discharged from the elevated discharge point which are in excess of the particles required to develop an electrostatic image, surfaces of the apparatus which, in operation, contact the toner/carrier mixture and which experience relative movement with the particles of the toner/carrier mixture being electrically conductive and being earthed, and surfaces of the apparatus which, in operation, contact the toner/carrier mixture and which move relative to the first mentioned surfaces and with particles of the toner/carrier mixture being electrically non-conductive, the surfaces of the discrete receptacles being electrically non-conductive, and each of the discrete receptacles being made of an electrically conductive material provided with an electrically insulating coating.

Thus, with the arrangement of the invention, the particles at the boundary of the carrier/toner mixture that come into contact with the electrically conductive and earthed surfaces are discharged. As soon as they move back into the interior of the mixture, however, they regain charge by means of friction within the mixture. Hence, a greater homogeneity in the charges of the particles is achieved compared with apparatus in which the peripheral particles are additionally charged by the surfaces against which they are moved, as is the case when these surfaces are non-conductive, the additionally charged particles then moving back to the inside of the mixture without losing the additional charge. Such over-charging of

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carrier particles is avoided or reduced using the apparatus of the invention.

Therefore, the situation where, as a result of excessive charging, the carrier particles become almost completely clogged with toner and thus lose the ability to deliver up sufficient toner for the developing of the image and also to remove toner from the image-free areas of the drum, tends to be avoided when using the apparatus of the invention because the charge relationships, in this case, depend almost exclusively on the triboelectrical properties of the material pairing used for the carrier/toner mixture and are precisely defined. Copies which are rich in contrast, without a grey background, may thus be produced.

Advantageously, the inner surface of the supply tank is an electrically conductive earthed surface, and the first and second guide surfaces are also preferably electrically conductive earthed surfaces.

When the carrier particles have too little charge, they cannot either carry sufficient toner powder with them for maximum gradation, or remove the toner powder adhering to the uncharged areas of the latent image, so that insufficient charging of the carrier particles also leads to a grey background and inadequate contrast in the image. This problem is also alleviated using the apparatus of the invention, in that the surfaces which are relatively stationary in relation to the toner/carrier mixture and with which the mixture comes into contact, in particular, the surfaces of the discrete receptacles of the conveyor, are non-conductive. This prevents the draining away or neutralising of charges during long periods of transportation of the substantially homogeneously charged mixture.

Advantageously, the electrically conductive earthed surfaces are made of metal having a specific conductance of at least 10^{-5} ohm^{-1} cm^{-1}. The parts of the apparatus that have the said electrically conductive surfaces may be made throughout of metal which which a specific conductance of at least 10^{-5} ohm^{-1} cm^{-1}, or these parts may be provided with a galvanically applied coating. Advantageously, such coated parts are chrome-plated or nickel plated.

The parts of the apparatus that have the said electrically non-conductive surfaces may be made throughout of non-conductive material, for example, a plastics material. Preferably, however, all parts of the apparatus have the said electrically non-conductive surfaces are made of an electrically conductive material provided with an electrically insulating coating. Advantageously, the electrically insulating coating is a coating of laquer applied by the electrophoretic method.

The invention also provides an electrostatic copier which includes a cascade developing apparatus in accordance with the invention.

One form of cascade developing apparatus constructed in accordance with the invention will now be described, by way of example, with reference to the accompanying drawing, which is a side view partly in section.

Referring to the accompanying drawing, the carrier/toner 1 is contained in a supply tank 2 and is there electrostatically charged by means of relative movement between the particles of the mixture. A chain conveyor 3 transports the toner/carrier mixture to an elevated discharge point 4, where the containers 5 of the chain conveyor 3 are emptied and their contents are poured by way of a guide plate 6 onto the surface 7 of a drum 8 which carries the charge image which is to be developed. The toner/carrier mixture is sprinkled over the surface 7 of the drum 8, inks it in a known manner to correspond to the charge image, and the part of the mixture that does not adhere to the surface 7 returns by way of a collecting plate 9 to the supply tank 2.

The charging influences of surfaces of the developing apparatus with which the particles of the carrier/toner mixture come into contact are controlled by means of the measures described hereinafter and by means of particular properties of the surfaces in question.

The surface of the supply tank 2 and the guide plates 6 and 9 are electrically conductive and are connected to the chassis 10 of the apparatus. The positive effect on the uniformity of the charge distributions in the carrier/toner mixture can be explained in that the particles coming into contact with the surfaces are in fact discharged but, as soon as they re-enter the mass of particles, are charged again. Since the particles which are transported are in any case charged again on the way between this discharging surface and the chain conveyor pick-up area, owing to the distance over which they have to pass within the mixture, a uniform charge distribution is possible within the mass of developer taken from the supply tank 2 by the chain conveyor 3.

The surfaces of the chain conveyor containers 5 are non-conductive, there being substantially no frictional engagement between the toner/carrier mixture and these surfaces, the filling and emptying of the containers having a negligible effect. Thus the particles of the homogeneously charged carrier/toner mixture which touch the walls of the conveyor containers cannot be influenced by discharging or by neutralisation of charges.

The guide plate 6 and the collecting plate 9 are made conductive and are connected

to the chassis 10. Thus, as with the wall of the supply tank 2, no further charging of parts of the toner/carrier mixture by means of triboelectrical interaction with the surface of the guide plates 6 and 9 can occur. The slight discharging which occurs has proved to be less damaging than uncontrolled charging.

The toner/carrier mixture consists of carrier particles or balls made of glass with coating and toner powder made of polystyrol, polyvinylbutyral and pigment.

The walls of the supply tank 2, the guide plates 6 and 9, are made of metal having a specific surface conductance of approximately 10^{-5} Ohm^{-1}. Instead, they may be made, for example, of brass or steel, and the conductive surfaces may be formed by a galvanically applied layer of chrome or nickel.

The containers 5 of the chain conveyor 3 are made of brass or steel, with the surface insulated by means of a coating of lacquer. The lacquer coating is applied by the electrophoretic method and thus offers good mechanical and insulation properties.

The apparatus described may be modified in various ways. For example, a special device to mix carrier and toner could be provided, the electrically conductive properties of the surfaces of such a mixing device being chosen so as to minimise over-charging or under-charging of the particles of the toner/carrier mixture.

WHAT WE CLAIM IS:—

1. A cascade developing apparatus for use in an electrostatic copier for conveying a toner/carrier mixture to an elevated discharge point from which it can pour onto a photoconductive layer carrying a latent electrostatic image to be developed, which comprises a supply vessel for a toner/carrier mixture, a conveyor provided with discrete receptacles and arranged, in operation, to convey toner/carrier mixture from the supply vessel to the elevated discharge point, a first guide surface arranged to deflect toner/carrier particles discharged at the elevated discharge point, and a second guide surface arranged to deflect back into the supply vessel those particles discharged from the elevated discharge point which are in excess of the particles required to develop an electrostatic image, surfaces of the apparatus which, in operation, contact the toner/carrier mixture and which experience relative movement with the particles of the toner/carrier mixture being electrically conductive and being earthed, and surfaces of the apparatus which, in operation, contact the toner/carrier mixture and which move relative to the first mentioned surfaces and with particles of the toner/carrier mixture being electrically non-conductive, the surfaces of the discrete receptacles being electrically non-conductive, and each of the discrete receptacles being made of an electrically conductive material provided with an electrically insulating coating.

2. A cascade developing apparatus as claimed in claim 1, wherein the inner surface of the supply tank is an electrically conductive earthed surface.

3. A cascade developing apparatus as claimed in claim 1 or claim 2, wherein the first and second guide surfaces are electrically conductive earthed surfaces.

4. A cascade developing apparatus as claimed in any one of claims 1 to 3, wherein the electrically conductive earthed surfaces are made of metal having a specific conductance of at least 10^{-5} ohm^{-1} cm^{-1}.

5. A cascade developing apparatus as claimed in claim 4, wherein the parts of the apparatus that have the said electrically conductive surfaces are made throughout of metal which has a specific conductance of at least 10^{-5} ohm^{-1} cm^{-1}.

6. A cascade developing apparatus as claimed in claim 4, wherein the electrically conductive surfaces are made of chrome or nickel.

7. A cascade developing apparatus as claimed in claim 6, wherein the parts of the apparatus that have the said electrically conductive surfaces are chrome-plated or nickel plated.

8. A cascade developing apparatus as claimed in any one of claims 1 to 7, wherein the conveyor is a chain conveyor.

9. A cascade deevloping apparatus as claimed in any one of claims 1 to 8, wherein all parts of the apparatus that have the said electrically non-conductive surfaces are made of an electrically conductive material provided with an electrically insulating coating.

10. A cascade develpoing apparatus as claimed in claim 9, wherein the electrically insulating coating is a coating of laquer appliced by the electrophoretic method.

11. A cascade developing apparatus for use in an electrostatic copier substantially as hereinbefore described with reference to, and as shown in, the accompanying drawing.

12. An electrostatic copier which includes a cascade developing apparatus as claimed in any one of claims 1 to 11.

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Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY,
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The toner/carrier mixture consists of carrier particles or balls made of glass with coating and toner powder made of polystyrol, polyvinylbutyral and pigment.

The walls of the supply tank 2, the guide plates 6 and 9, are made of metal having a specific surface conductance of approximately 10^{-5} Ohm^{-1}. Instead, they may be made, for example, of brass or steel, and the conductive surfaces may be formed by a galvanically applied layer of chrome or nickel.

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The apparatus described may be modified in various ways. For example, a special device to mix carrier and toner could be provided, the electrically conductive properties of the surfaces of such a mixing device being chosen so as to minimise over-charging or under-charging of the particles of the toner/carrier mixture.

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3. A cascade developing apparatus as claimed in claim 1 or claim 2, wherein the first and second guide surfaces are electrically conductive earthed surfaces.

4. A cascade developing apparatus as claimed in any one of claims 1 to 3, wherein the electrically conductive earthed surfaces are made of metal having a specific conductance of at least 10^{-5} ohm^{-1} cm^{-1}.

5. A cascade developing apparatus as claimed in claim 4, wherein the parts of the apparatus that have the said electrically conductive surfaces are made throughout of metal which has a specific conductance of at least 10^{-5} ohm^{-1} cm^{-1}.

6. A cascade developing apparatus as claimed in claim 4, wherein the electrically conductive surfaces are made of chrome or nickel.

7. A cascade developing apparatus as claimed in claim 6, wherein the parts of the apparatus that have the said electrically conductive surfaces are chrome-plated or nickel plated.

8. A cascade developing apparatus as claimed in any one of claims 1 to 7, wherein the conveyor is a chain conveyor.

9. A cascade deevloping apparatus as claimed in any one of claims 1 to 8, wherein all parts of the apparatus that have the said electrically non-conductive surfaces are made of an electrically conductive material provided with an electrically insulating coating.

10. A cascade develpoing apparatus as claimed in claim 9, wherein the electrically insulating coating is a coating of laquer appliced by the electrophoretic method.

11. A cascade developing apparatus for use in an electrostatic copier substantially as hereinbefore described with reference to, and as shown in, the accompanying drawing.

12. An electrostatic copier which includes a cascade developing apparatus as claimed in any one of claims 1 to 11.

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