March 19, 1963 F. H FRANTZ ET AL 3,081,737

XEROGRAPHIC APPARATUS FOR APPLYING FERROMAGNETIC POWDER

Filed March 1, 1961 3 Sheets-Sheet 1

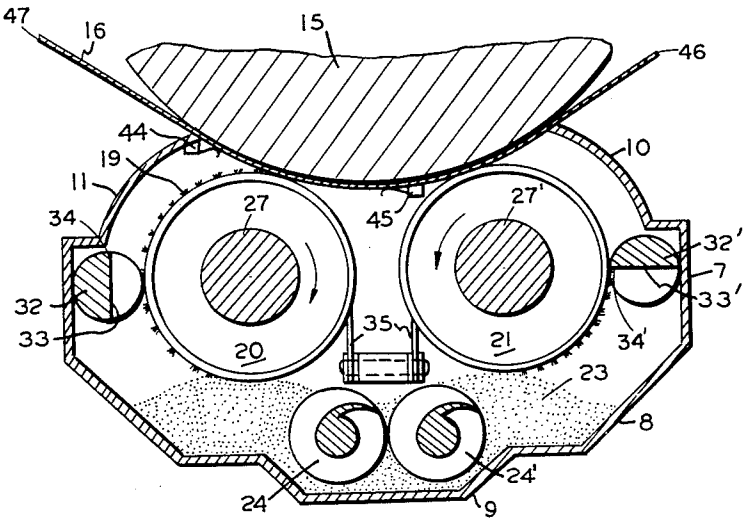


FIG. 1

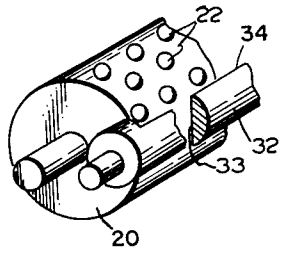


FIG. 3

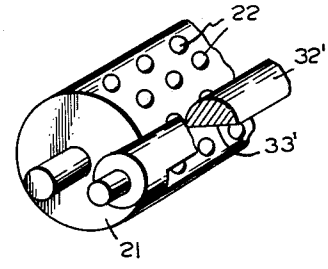


FIG. 4

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XEROGRAPHIC APPARATUS FOR APPLYING FERROMAGNETIC POWDER

Filed March 1, 1961 3 Sheets-Sheet 2

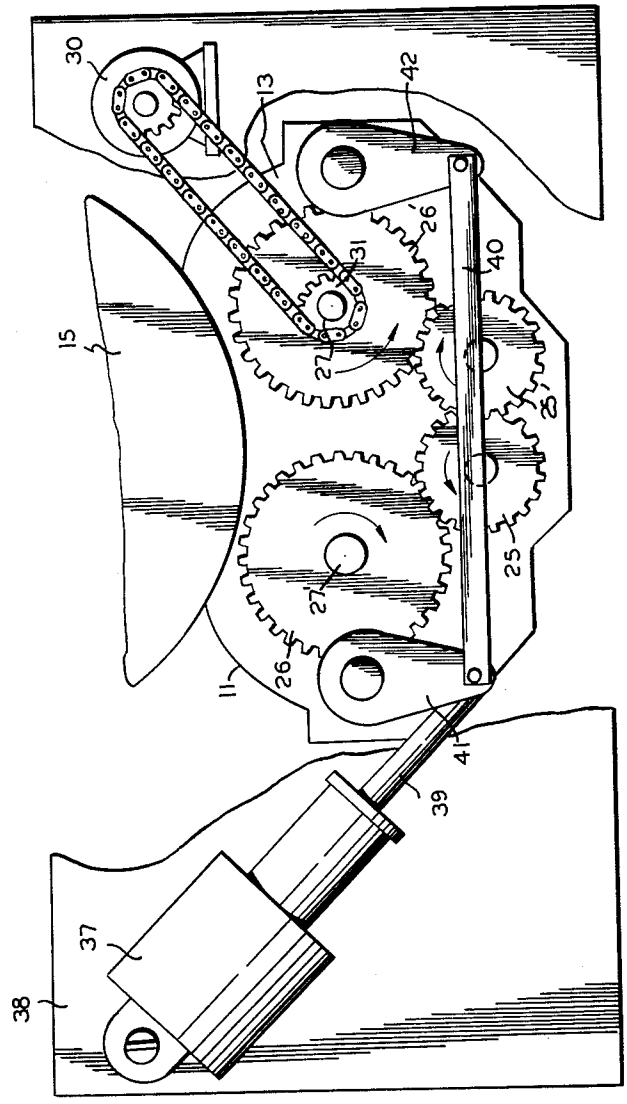


FIG.2

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XEROGRAPHIC APPARATUS FOR APPLYING FERROMAGNETIC POWDER

Filed March 1, 1961 3 Sheets-Sheet 3

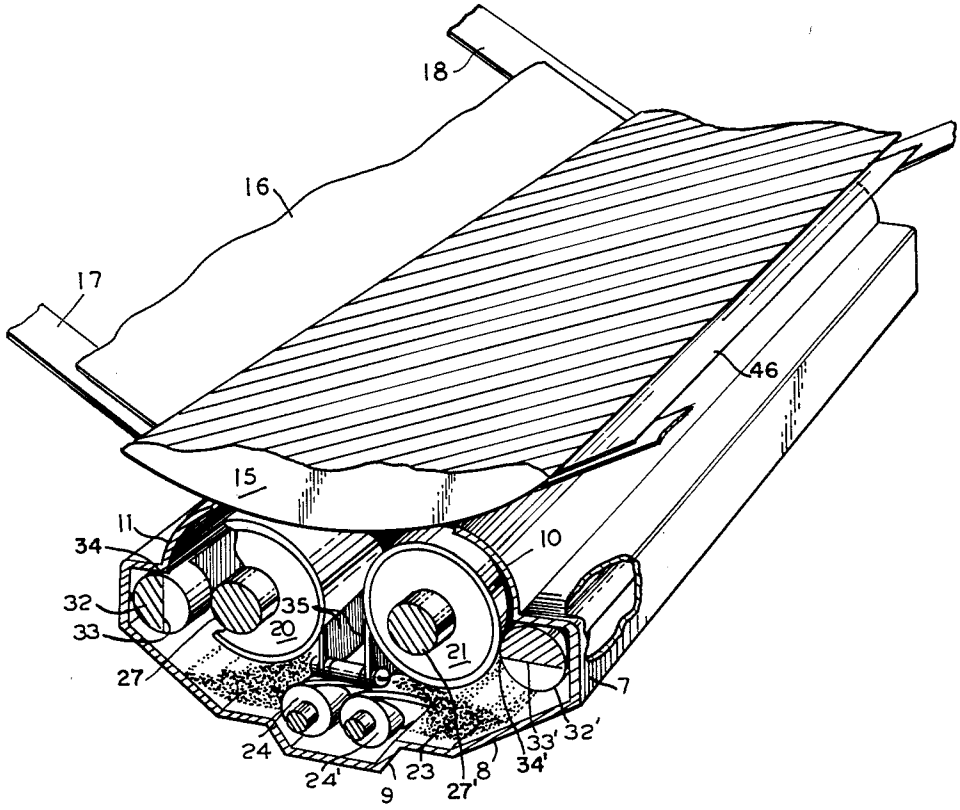


FIG.5

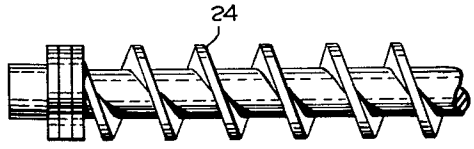


FIG.6

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XEROGRAPHIC APPARATUS FOR APPLYING FERROMAGNETIC POWDER

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6 Claims. (Cl. 118—637)

This invention relates to the art of electrophotography and, more particularly, to the development of the latent image caried on an electrostatically charged sheet. Specifically, the invention pertains to improvements in the apparatus for applying developing powder to such sheets.

Electrophotography, also termed xerography, as exemplified in the patent to Carlson, USP 2, 297,691, is well known in the art, and various modifications have been made in apparatus utilizing this process. In one form, the paper itself has a coating of a photoconductive material which, after an electrostatic charge, may be exposed to light in contact with any original whereby a latent electrostatic image is produced. This image may be developed by applying a powder which adheres to the electrostatically charged portions representing the image. The developing powder is generally of a ferromagnetic material containing a coloring or toner substance for rendering the image visible. A thermoplastic substance may also be incorporated so that the toner may be fused to the base by heat in order to produce a permanent image.

Various types of devices have been developed in connection with electrophotographic apparatus for applying the developing powder to the charged and exposed sheet. In general, difficulty has been experienced in these devices with the uniformity of application of the ferromagnetic powder over the area of the sheet to be covered, and also with the even distribution of the toner and carrier material. It has also been a problem to prevent the formation of powder clusters which interfere with the handling of the material.

It is the primary object of this invention to provide an apparatus which is capable of uniform application of the developing powder and which is simple in construction and operation.

It is a particular feature of the apparatus in accordance with the invention that in utilizing electromagnetic brushes in the form of cylinders, it provides control of the powder deposit and subsequent application thereof in accordance with the position of the sheet with respect to the brushes.

Other objects and features will be apparent from the following description of the invention, pointed out in particularity in the appended claims, and taken in connection with the accompanying drawings, in which:

FIG. 1 is a front elevational view in cross section of the developing powder applicator;

FIG. 2 is a rear view thereof;

FIG. 3 is a detail view showing the powder supply gate in open position;

FIG. 4 is a similar detail view showing the gate in closed position;

FIG. 5 is a perspective view of the apparatus partially in cross section; and

FIG. 6 is a view of a helical agitating rod.

Referring to the figures as seen in FIGS. 1, 2 and 5, the apparatus consists of an elongated casing **7**, having a bottom portion **8**, formed with a downwardly extending recess **9** and side cover portions **10** and **11**. The front cover is not shown in FIGS. 1 and 5 in order to see the various working elements of the toner mechanism. In the back view shown in FIG. 2, the cover **13** is in place

through which various shafts and gears extend, the operation of which will be referred to later.

The side covers **10** and **11** do not form a complete closure so that a rotating drum **15**, which carries the electrostatically charged sheet **16**, may be placed in close proximity to the powder applicator mechanism within the casing **7**. The drum **15** is shown, by way of example, as a means for carrying the charged sheet **16** over the powder applicator assembly. It is generally a part of a reproducing or duplicating apparatus, which may include in addition an exposure unit and charging unit, with which the present invention is not concerned.

Various means may be utilized for holding the sheet **16** over the periphery over the drum **15**. For example, a pair of belts as indicated by reference characters **17** and **18**.

Within the casing **7**, and journalled in the front and back covers thereof, are placed two cylinders **20** and **21** of non-magnetic material, such as brass or aluminum, the surface of each is studded with small magnetic cores **22**, distributed over the entire area of the cylinder and closely spaced so that each forms individual magnets which attract the ferromagnetic powder **23** and form radially extending bristles **19**. The bottom of casing **7** is filled with finely divided ferromagnetic material, such as iron powder **23**, which is intermixed with suitable toner substance, as is well known in the electrophotographic art. The powder **23** is continuously agitated by a pair of agitator rods **24** and **24'** which have a helical configuration and are located in the recessed portion **9**. The agitator rods are inetrcoupled by intermeshing gears **25** and **25'** as seen in FIG. 2. The gear **25** also meshes with gear **26** affixed to the shaft **27'** of the cylinder **21** and the gear **25'**, meshes with the gear **26'** of the shaft **27** of the cylinder **20**. In this manner, a complete drive assembly is obtained for the rotating elements within the casing **7**. This assembly may be driven by a motor **30** coupled to the pinion **31** on the shaft **27'**. As seen by the intercoupling of the rotating elements, the cylinders **20** and **21**, as well as the helical agitator rods **24** and **24'**, rotate in opposite directions. The ferromagnetic substance **23** is picked up by the closely spaced magnetic cores **22** and dense bristles **19** are formed over the surface of cylinders **20** and **21**.

In accordance with the invention, means are provided for controlling the effective powder deposit on the rotating cylinders **20** and **21**; namely, the application of this powder to the traveling sheet **16**. It has been observed that a more uniform distribution of the powders is obtained on the surface of the copy material if the first application is in the direction of the travel of the sheet **16** and the second application in the opposite direction. This is related to a given size of the copy material; for example, a letter-size reproduction and the effective powder deposit on the surface of the cylinders **20** and **21** is controlled by the extent of travel of a given size of the copy material over the drum **15**.

As seen in the detail views in FIGS. 3 and 4, a rotary gate **32** and **32'** is provided for the cylinders **20** and **21**, respectively. The gates **32** and **32'** are in the form of an undercut shaft placed parallel to the cylinder surface. In one position, the undercut, or flat side **33** or **33'**, is facing the cylinder and thus allows free passage of the bristles **19**, whereas in the other position, as seen in FIGS. 1 and 4, the gate **32'** is turned so that the edge **34'** nearly contacts the cylinder surface and thus scrapes off the powder bristles **19**. The control of the respective rotation of the gates **32** and **32'** may be effected in any desired manner. By way of example, a solenoid **37** is shown in FIG. 2 pivotally supported on the side of the casing **38**. The shaft **39** of the solenoid **37** is interconnected with

lever arm **40** and cranks **41** and **42** of the gates **32** and **32'**, respectively. A pair of closely spaced fixed scrapers **35** provided in the bottom of the casing to remove residual magnetic material from the surface of the cylinders.

The energizing of the solenoid **37** may be effected from any conventional circuit, not shown here, which is controlled by microswitches **44** and **45** schematically shown in FIG. 1, so placed that the leading edge of the copy material **16** will actuate these switches and hold them in actuated position as long as there is a copy sheet on the surface of the drum at the point between tangency of the drum with the cylinders **20** and **21**. The gates operate in tandem so that when solenoid **37** is actuated, the gate **32** is closed and the gate **32'** is open and vice versa.

In the operation, the motor **30** is energized by a switch mechanism, not shown, prior to the insertion of the copy material. The rotating assembly sets in motion the cylinders **20** and **21**, as well as the agitators **24** and **24'**. This solenoid is in such a position that the gate **32** is opened and **32'** is closed. The sheet **16** entering the toner unit actuates the microswitch **44**, which in turn, energizes the solenoid **37**, closing the gate **32** and opening the gate **32'**. As the sheet **16** is passed between the microswitches **44** and **45**, the amount of developing powder material in the form of bristles accumulated over the roller **20** prior to the closing of the gate **32**, is thus applied to the surface of the sheet **16**. When the leading edge **46** of the sheet **16** closes the microswitch **45**, the solenoid **37** is actuated again closing the gate **32'** and thus the powder accumulated over the surface of the cylinder **21** is applied over the surface of the traveling sheet **16**. The trailing edge **47** of the sheet **16** opens the microswitch **45** reestablishing the condition existing at the start of the operation. It is also practical to utilize the microswitch **45** to shut off the motor **30**, so that the entire apparatus is at a standstill until a sheet of paper is inserted under the drum to start the operation.

In the above manner, developing powder is applied to the surface of a charged sheet material from a magnetic brush which rotates in the direction of the travel of the paper for a certain period of time and then, from another brush rotating in the opposite direction of the travel of the paper. Both of these applications deposit a controlled amount, inasmuch as the amount of powder deposit on each cylinder is determined in alternate sequence in accordance with the extent of travel of the charged sheet over the magnetic brushes.

What is claimed is:

1. In an apparatus for applying a ferromagnetic powder for developing of a latent image on an electrostatically charged sheet, an elongated casing having a bottom portion adapted to hold finely divided ferromagnetic material, means for continuously agitating said material, a pair of adjacently placed cylinders in said casing having distributed on the surface thereon spaced magnetic cores adapted to attract discrete amounts of said powder and thereby forming bristles thereof extending radially from the surface of said cylinders, a rotating drum having means for supporting said charged sheet on the outer periphery thereof, said drum being arranged tangential to both said cylinders and in close proximity thereof for said bristles to contact the surface of said sheet, means for simultaneously rotating one of said cylinders in the direction of travel of said sheet and the other of said cylinders in the opposite direction thereto, and means associated with each of said cylinders for removing the powder deposit from said cylinders in alternate sequence in accordance with the extent of travel of said sheet over said cylinders.

2. Apparatus in accordance with claim 1 wherein said means for continuously agitating said material comprises a pair of shafts having laterally extending helical convolutions journaled in said housing and geared for simultaneous rotation in opposite directions.

3. In an apparatus for applying a ferromagnetic powder for developing of a latent image on an electrostatically charged sheet, an elongated casing having a bottom portion adapted to hold finely divided ferromagnetic material, means for continuously agitating said material, a pair of adjacently placed cylinders in said casing having distributed on the surface thereon spaced magnetic cores adapted to attract discrete amounts of said powder and thereby forming bristles thereof extending radially from the surface of said cylinders, a rotating drum having means for supporting said charged sheet on the outer periphery thereof, said drum being arranged tangential to both said cylinders and in close proximity thereof for said bristles to contact the surface of said sheet, means for simultaneouly rotating one of said cylinders in the direction of travel of said sheet and the other of said cylinders in the opposite direction thereto, gate means associated with each of said cylinders for removing upon closure the powder deposit from the active surface thereof and means for closing one of said gates and simultaneously opening the other of said gates in alternate sequence during passage of said sheet over said cylinders.

4. In an apparatus for applying a ferromagnetic powder for developing of a latent image on an electrostatically charged sheet, an elongated casing having a bottom portion adapted to hold finely divided ferromagnetic material, means for continuously agitating said material, a pair of adjacently placed cylinders in said casing having distributed on the surface thereon spaced magnetic cores adapted to attract discrete amounts of said powder and thereby forming bristles thereof extending radially from the surface of said cylinders, a rotating drum having means for supporting said charged sheet on the outer periphery thereof, said drum being arranged tangential to both said cylinders and in close proximity thereof for said bristles to contact the surface of said sheet, means for rotating one of said cylinders in the direction of travel of said sheet and simultaneously rotating the other of said cylinders in the opposite direction, a pair of rotatable gate means each associated with one of said cylinders and each having a scraping edge adapted to engage the periphery of the associated cylinder for removing the powder adhering to the surface thereof, means for simultaneously rotating said gate means in accordance with the extent of travel of said sheet over said cylinders, the scraping edges of said pair of gate means being displaced for alternate engagement with the associated cylinder surface.

5. In an apparatus for applying a ferromagnetic powder for developing of a latent image on an electrostatically charged sheet, an elongated casing having a bottom portion adapted to hold finely divided ferromagnetic material, means for continuously agitating said material, a pair of adjacently placed cylinders having distributed on the surface thereon spaced magnetic cores adapted to attract discrete amounts of said powder and thereby forming bristles thereof extending radially from the surface of said cylinders, a rotating drum having means for supporting said charged sheet on the outer periphery thereof, said drum being arranged tangential to both said cylinders and in close proximity thereof for said bristles to contact the surface of said sheet, means for rotating one of said cylinders in the direction of travel of said sheet and simultaneously rotating the other of said cylinders in the opposite direction, a pair of rotatable gate means each associated with one of said cylinders and each having a scraping edge adapted to engage the periphery of the associated cylinder for removing the powder adhering to the surface thereof, means for simultaneously rotating said gate means in accordance with the extent of travel of said sheet over said cylinders, the scraping edges of said pair of gate means being displaced for alternate engagement with the associated cylinder surface, and control means actuated by the leading edge of said sheet for initiating the actuation of said rotating means.

6. Apparatus for applying toner powder to a sheet of paper as recited in claim 5 wherein said control means comprises spaced microswitches positioned within the casing in the path of movement of said paper.

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