March 11, 1969 R. R. ULARY 3,431,890

APPARATUS FOR REPLENISHING DEVELOPER IN AN ELECTROPHOTOGRAPHIC SYSTEM

Filed Sept. 28, 1967

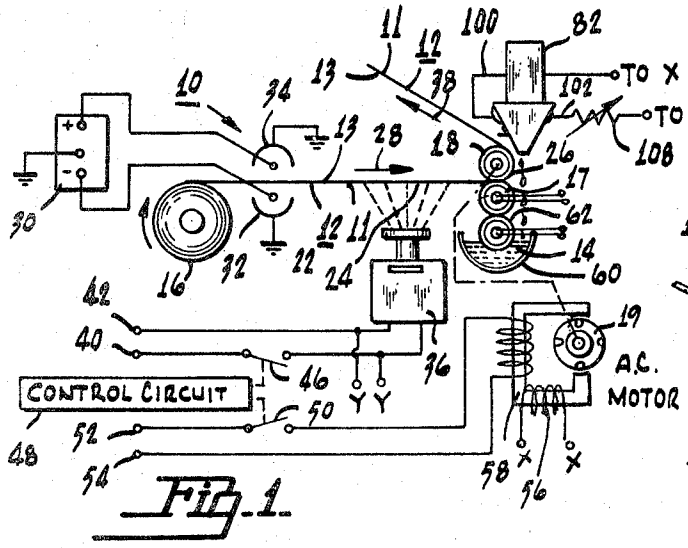


Fig. 1.

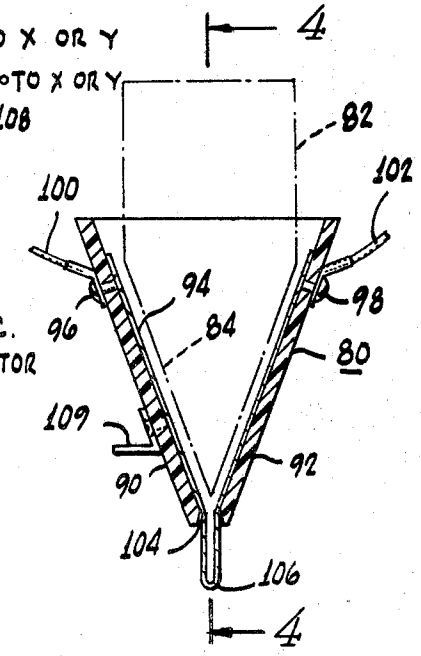


Fig. 3.

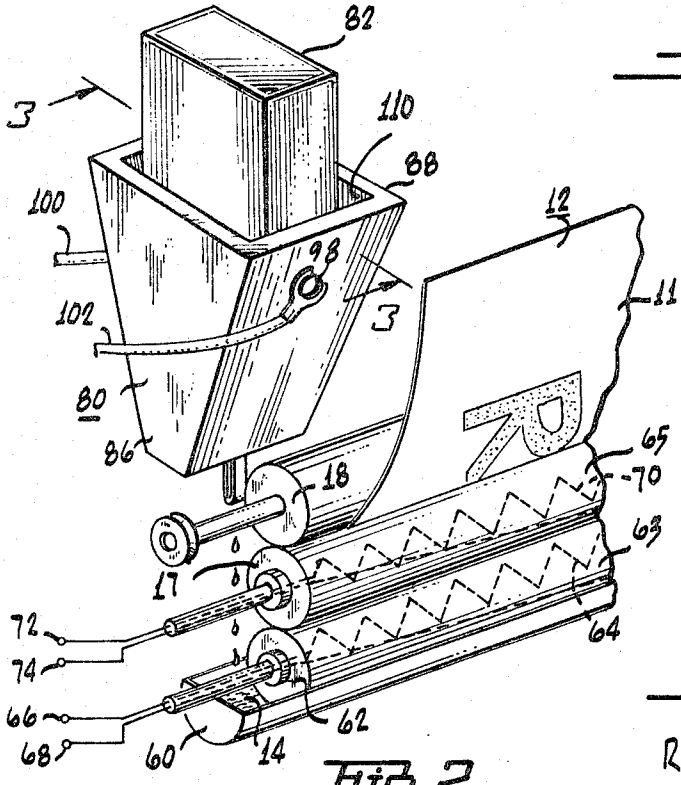


Fig. 2.

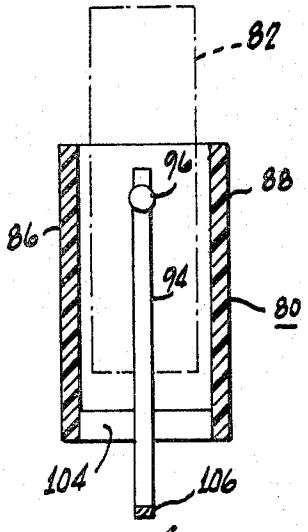


Fig. 4.

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APPARATUS FOR REPLENISHING DEVELOPER IN AN ELECTROPHOTOGRAPHIC SYSTEM

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Int. Cl. G03g 15/10; B05b 5/02; B05c 11/10

ABSTRACT OF THE DISCLOSURE

Apparatus for replenishing principal developer, originally present in an electrophotographic system in the form of a solid meltable body, comprises a container for holding solid meltable replenisher developer. Heating means within the container are energized periodically to melt small portions of the replenisher developer as the principal developer is consumed. The container is formed with a lower opening and disposed so that the small portions of molten replenisher developer can fall through the lower opening onto the principal developer to replenish the latter periodically.

Background of invention

This invention relates generally to apparatus for replenishing developer material in an electrophotographic system. More particularly the invention relates to improved apparatus for periodically replenishing principal developer, originally present as a solid meltable body, in an electrophotographic system. The improved apparatus is particularly applicable to electrophotographic systems employing solid (hot-melt) developers of the electroscopic type described in U.S. Patent No. 3,079,272, issued to H. G. Greig, on Feb. 26, 1963, for Method of Developing an Electrostatic Image.

By the term "hot-melt developer," as used herein, is meant a developer that is solid at normal room temperature and that comprises finely-divided electroscopic toner particles dispersed in an electrically-insulating thermoplastic carrier material having a melting point substantially within a range of, e.g., from 50° C. to 200° C.

In electrophotographic systems wherein hot-melt developer is used in a molten state to develop a charge pattern on an insulating surface, it has been found desirable to replenish the developer periodically as it is consumed in the developing process. For the optimum and reproducible development of charge patterns, it has been found desirable to maintain the hot-melt developer at a substantially constant quantity or level. Unless the quantity of hot-melt developer, however, is continuously monitored and corrected in such electrophotographic systems, the quantity of developer material can vary from excessive to exhausted, thereby affecting the quality of development and the optimum operation of the apparatus involved.

Summary of the invention

Briefly stated, the improved replenishing apparatus comprises means for adding replenisher hot-melt developer to principal hot-melt developer originally provided as a solid body in apparatus for developing an electrostatic image on an insulating surface. The improved replenishing apparatus comprises a container for solid replenisher hot-melt developer. Heating means within the container are energized periodically to melt portions of the replenisher hot-melt developer as the principal hot-melt developer is consumed during the developing process.

The container is disposed so that an opening therein permits quantities of molten replenisher hot-melt developer to be added automatically and periodically to the principal hot-melt developer.

In a preferred embodiment of the improved replenishing apparatus, the heating means are energized at least once during the formation of each image on the insulating surface so that a small quantity of replenisher hot-melt developer can be added to the principal hot-melt developer to compensate the latter for the quantity of hot-melt developer consumed in the development of the image.

Brief description of the drawing

FIG. 1 is a schematic drawing of automatic apparatus for developing an electrostatic image on an insulating surface, utilizing the improved replenishing apparatus for adding replenisher hot-melt developer periodically to principal hot-melt developer;

FIG. 2 is an enlarged, fragmentary, perspective view of a portion of the apparatus shown in FIG. 1, illustrating details of the replenisher hot-melt developer means and the principal hot-melt developer means;

FIG. 3 is a cross-section of the container of FIG. 2 for replenisher hot-melt developer, taken along a vertical plane parallel to, and adjacent, a side of the container, and viewed in the direction indicated by the arrows 3 in FIG. 2, the hot-melt developer being shown in phantom, and

FIG. 4 is a cross-sectional view of the container for the replenisher hot-melt developer, taken along the line 4—4 in FIG. 3, the replenisher hot-melt developer being shown in phantom.

Description of a preferred embodiment

Referring, now, particularly to FIG. 1 of the drawing, there is shown apparatus **10** for developing electrostatic latent images (or charge patterns) on a photoconductive insulating surface **11** of an electrophotographic recording medium **12** by (principal) hot-melt developer **14**. The recording medium **12** comprises a web of relatively electrically conductive backing paper **13**, having thereon the insulating surface **11** of a photoconductive material, such as zinc oxide.

The recording medium **12** is pulled from a supply roll **16** by an idler roller **17** and a driven roller **18**, driven by a motor **19** coupled to the roller **18** by any suitable means. The recording medium **12** is thus pulled past a charging station **22**, an exposure station **24**, and a developing station **26** of the apparatus **10**, in the direction of the arrow **28**. With the exception of the use of the hot-melt developer **14**, the method of developing electrostatic images by the apparatus **10** is described in an article, "Electrofax," Direct Electrophotographic Printing on Paper, by C. J. Young and H. G. Greig, RCA Review, December 1954, vol. XV, No. 4.

The recording medium **12** is charged at the charging station **22** with a suitable electrostatic charge from a suitable unidirectional power supply **30**. The power supply **30** is capable of providing about ±6000 volts with respect to a reference potential, such as ground. The photoconductive insulating surface **11**, if zinc oxide, is usually charged uniformly negatively, as from a corona discharge device **32**, and the paper backing is charged uniformly positively, as from a corona discharge device **34**. The electrostatic charging operation is performed in the absence of light.

The uniformly-charged photoconductive insulating surface **11** of the recording medium **12** is exposed with a light image, as from a projection of light through a photographic slide in a photographic enlarger **36**, to discharge the uniform negative electrostatic charge selec-

tively, in accordance with the amplitude of light from the projected image. Thus, there is formed a latent electrostatic image on the photoconductive insulating surface **11**.

At the developing station **26**, the latent electrostatic image is developed by the principal hot-melt developer **14**, in a manner to be described hereinafter in detail. The electrostatic image developed by the hot-melt developer **14** is substantially self-fixing so that no additional fixing or glossing operations are necessary. The developed image on the recording medium **12** now moves in the direction of the arrow **38** and may be cut from the web by any suitable means, as desired.

The projector **36** is energized from a source of suitable electrical energy connected to a pair of terminals **42** and **40**. The terminal **40** is connected to the projector **36** through a normally open switch **46**. The switch **46** is actuated at an appropriate time, and for a suitable duration, by a control circuit **48**, in a manner well known in the art of automatic electrophotographic systems of which the apparatus **10** is one. A pair of terminals YY is connected to the terminals **42** and **44**, respectively, through the switch **46** for the purpose hereinafter appearing.

The motor **19** is energized, through a switch **50**, from a source of suitable electrical energy applied to a pair of terminals **52** and **54**. The switch **50** is also actuated by the control circuit **48** to control the movement of the recording medium **12** as desired in the apparatus **10**. A winding **56** around a field pole piece **58** of the motor **19** has a pair of terminals XX for the purpose hereinafter appearing.

The hot-melt developer **14** is a solid at room temperature. When heated to melting and applied in the molten form to a (latent) electrostatic image on the recording medium **12**, the developer **14** functions substantially as a liquid developer and the electrostatic image is developed to a visible image and substantially fixed. The hot-melt developer **14** comprises a mixture of (1) a low melting carrier material which upon heating becomes quite fluid and which is electrically-insulating in character, and (2) a dispersed phase in the carrier material of finely-divided toner particles. The hot-melt developer **14** has a melting point preferably between 50° C. and 200° C. and a viscosity not in excess of about 500 centipoises at a temperature within that range. The toner particles may comprise liquid droplets or solids, but they should be substantially insoluble in the carrier material, and, when dispersed therein, should have an electrical characteristic such that it takes on an electrical charge. A number of examples of suitable hot-melt developers are described in detail in the aforementioned U.S. Patent 3,079,272.

A typical hot-melt developer, for example comprises paraffin wax (melting point 55° C. to 79° C.) and carbon black. Finely-divided carbon black is dispersed in the melt of the wax in proportions of up to 5 parts by weight of carbon black and 95 parts by weight of wax. The mixture is continuously stirred until a uniform dispersion is obtained. The mixture is then allowed to cool to form a solid block or cake developer. Such a developer, when remelted and applied to a surface bearing an electrostatic image, will develop that image as a result of the electrophoretic deposition of carbon black particles in the charged areas of the image. This hot-melt developer will, during development, provide a smooth glossy finish on the photoconductive insulating surface **11**.

Referring, now, paticularly to FIG. 2, the principal hot-melt developer **14** is shown in a container or trough **60**. A hollow idler roller **62** is disposed to rotate about its axis so that its peripheral surface **63** extends into the trough **60**. A stationary electrical heating element **64** is disposed within the hollow roller **62** and is connected to a pair of electrical terminals **66** and **68** for energization from a suitable source of electrical energy to a temperature above that at which the principal hot-melt developer **14** melts. The peripheral surface **63** of roller **62** is in frictional contact with the peripheral surface **65** of the roller **17**.

The roller **17** is also hollow and has a stationary electrical heating element **70** disposed therein. The heating element **70** is energized from a suitable source of electrical energy connected to a pair of terminals **72** and **74**. Energizing the heating elements **64** and **70** causes at least a portion of the principal hot-melt developer **14** to melt in the trough **60** and to wet the surface **63** of the roller **62**. The molten hot-melt developer **14**, which also wets the surface **65** of the roller **17** by contact with the roller **62**, is maintained in a liquid state on the heated rollers **62** and **17** as the rollers are rotated by the driven roller **18**. The liquified hot-melt developer **14** is applied to the photoconductive insulating surface **11** of the recording medium **12**, at the developing station **26**, to develop the latent electrostatic image as the recording medium **12** is moved in the direction of the arrows **28** and **38**.

During the developing operation for each latent electrostatic image, a small portion of the principal hot-melt developer **14** is consumed and the quantity, as well as the level, of the hot-melt developer **14** in the trough **60** consequently tends to decrease. The improved apparatus **10** comprises means to maintain the quantity, and the level, of hot-melt developer **14** in the trough **60** substantially constant. To this end, there is provided a container **80**, preferably of heat resistant, electrically insulating, plastic material, for holding a block or cake **82** of replenisher hot-melt developer. The composition of the replenisher hot-melt developer **82** is substantially similar to that of the principal hot-melt developer **14**.

In the embodiment shown in FIGS. 2, 3, and 4, the container **80** is substantially wedge-shaped for receiving therein a complementary wedge-shaped portion **84** of the block **82** of replenisher hot-melt developer. The container **80** has a pair of opposite, parallel sides **86** and **88**, and a pair of opposite, downwardly and inwardly sloping sides **90** and **92**, as shown in FIG. 3.

A heating element **94**, such as a strip of Nichrome wire, is disposed within the container **80** along the inner surfaces of the sides **90** and **92**. One end of the heating element **94** is fastened to the inner surface of the side **90** by a rivet or screw **96**, and the other end of the heating element **94** is fastened to the inner surface of the side **92** by a rivet or screw **98**. The rivets or screws **96** and **98** provide electrical contact means for electrical connectors **100** and **102**, respectively, as shown in FIG. 3, for energizing the heating element **94** periodically in a manner hereinafter to be described.

The container **80** is formed with a relatively small lower opening **104** between the lower edges of the sides **90** and **92**. A bight portion **106** of the heating element **94**, intermediate the ends thereof, preferably extends through the lower opening **104** of the container **80** to provide an intense concentration of heat for melting relatively small portions of the cake of replenisher hot-melt developer **82** and for directing the molten small portions to a desired target, the trough **60**.

The conductors **100** and **102** may be connected to either the terminal XX, respectively, of the winding **56** or to the terminals YY, respectively, in parallel with connections to the projector **36**, to energize the heating element **94** periodically. A variable resistor **108** (FIG. 1) may be inserted in series between the conductor **102** and either one of the terminals X or Y, if needed, for controlling the current through the heating element **94**, thereby regulating its temperature to a desired value.

The container **80** is disposed above the trough **60** by any suitable means, as by a bracket **109** (FIG. 3) fixed to the side **90** and to a suitable part (not shown) of the apparatus **10**, so that replenisher hot-melt developer **82**, when molten, can flow through the lower opening **104** and fall into the trough **60** to replenish the principal hot-melt developer **14** as the latter is consumed.

In operation, the block or cake **82** of replenisher hot-

melt developer **82** is inserted through a large upper opening **110** of the wedge-shaped container **80** with the wedge-shaped portion **84** of the cake in a complementary position to the wedge-shaped contour of the container **80**, as shown in phantom in FIGS. 3 and 4. Let it be assumed that the conductors **100** and **102** are connected to the terminals YY, in parallel with the conductors to the projector **36**. Consequently, the heating element **94** is energized every time the switch **46** is closed to expose the charged photoconductive insulating surface **11** of the recording medium **12** with a light image. This energization raises the temperature of the heating element **94** which in turn melts a small portion of the replenisher hot-melt developer **82** adjacent to the heating element **94**. Because of the sloping, wedge-shaped contours of the sides **90** and **92** of the container **80**, the molten small portion of the replenisher hot-melt developer **92** falls through the lower opening **104** onto the principal hot-melt developer **14** in the trough **60**. Also, as the block or cake of solid replenisher hot-melt developer **82** is consumed, it is advanced automatically, by gravity, into the container **80** so that a portion of it is always adjacent the heating element **94**.

Since the photoconductive insulating surface **11** of the recording medium **12** is exposed each time it is desired to copy an image with the apparatus **10**, the heating element **94** is energized each time the projector **36** is energized, thereby melting a small portion of the replenisher hot-melt developer **82** each time the recording element **12** is exposed with a light image. The portion **106** of the heating element **94** that protrudes through the opening **104** provides an intense concentration of heat and also directs the molten replenisher hot-melt developer **84** to the trough **60**. By controlling the current to the heating element **94** to a desired value, as by adjusting the variable resistor **108**, it is possible to add a small quantity of replenisher hot-melt developer **82** to the principal hot-melt developer **14** that is substantially the quantity of principal hot-melt developer **14** consumed by the development of a typical electrostatic latent image at the developing station **26** during the development process. In this manner, it is possible to maintain the quantity, and thus the level, of the principal hot-melt developer **14** in the trough **60** substantially constant during operation of the apparatus **10** for the development of a plurality of electrostatic images.

Instead of being connected to the terminals YY, the conductors **100** and **102** can be connected to the terminals XX, respectively, of the coil **56**. The variable resistor **108** is also connected in series with the conductor **102** for adjusting the current through the heating element **94**. When energized from the coil **56**, the heating element **94** is heated every time the motor **19** is energized, that is, every time it is necessary to move the recording element **12** in the process of making a visible copy of an image projected from the projector **36**. Regardless of whether the heating element **94** is energized from the terminals XX or YY, however, it is apparent that the heating element **94** is energized periodically, that is, every time an image is produced on the recording medium **12**.

Thus, there has ben shown and described an improved apparatus for replenishing principal hot-melt developer with replenisher hot-melt developer in an automatic electrophotographic system as the principal hot-melt developer is consumed. While the replenisher hot-melt developer has been shown and described as a block or cake, it can also be in other solid forms, such as solid granules, for example. Also, the heating element within the container for the replenisher hot-melt developer may be energized intermittently or continuously from other components in the electrophotographic system than from those described.

What is claimed is:

1. In apparatus for developing an electrostatic image on an insulating surface, wherein principal developer is a solid body comprising finely-divided electroscopic toner particles dispersed in an electrically-insulating thermoplastic carrier material having a melting point substantially within a range from 50° C. to 200° C., wherein said solid body is heated to melt at least a portion thereof, and wherein said molten portion is applied to said insulating surface to produce thereon a visible image with said toner particles, the improvement comprising:

a container for a quantity of meltable solid replenisher developer, said container having an upper opening, for receiving said replenisher developer, and a lower opening,

heating means cooperatively associated with said container for heating said container,

means connected to said heating means to energize said heating means and to melt at least a small portion of said replenisher developer, and means to dispose said container above said principal developer, whereby said molten portion of replenisher developer may emerge through said lower opening for addition to said principal developer.

2. In apparatus for developing an electrostatic image as defined in claim **1**, said apparatus comprises:

a plurality of components adapted to be energized selectively from a source of electrical energy, and

said means connected to said heating means comprises means connected in circuit to at least one of said components to be energized simultaneously therewith.

3. In apparatus for developing an electrostatic image as defined in claim **2**, said one component is an electric motor.

4. In apparatus for developing an electrostatic image as defined in claim **2**, said one component is a light-image projector.

5. In apparatus for developing an electrostatic image as defined in claim **1**, at least a lower portion of the interior of said container is wedge-shaped, and said replenisher developer comprises at least a lower portion that is wedge-shaped and adapted to conform to said interior of said wedge-shaped container, whereby said replenisher developer may be advanced by gravity into said container as portions of said replenisher developer are melted.

6. In apparatus for developing an electrostatic image as defined in claim **1**, said heating means comprises a heating element, and a portion of said heating element extends through said lower opening of said container, whereby to direct said replenisher developer, when molten, in a desired direction.

7. In apparatus for developing an electrostatic image as defined in claim **1**, said apparatus is substantially automatic and comprises a trough for said principal developer, and heatable roller means disposed partially within said trough to melt said principal developer and to apply said principal developer, when molten, to said insulating surface to develop said electrostatic image.

8. In apparatus for developing an electrostatic image on an insulating surface of a recording medium, wherein said apparatus comprises a trough for principal hot-melt developer, a roller disposed within said trough, means to heat said principal hot-melt developer to melt it, and means to apply said molten principal hot-melt developer to said electrostatic image to develop it, the improvement comprising:

replenishing means for replenishing said principal hot-melt developer as it is consumed, said replenishing means comprising

a container for replenisher hot-melt developer,

means to melt at least a portion of said replenisher hot-melt developer in said container, and

means to add said melted portion to said principal hot-melt developer, whereby to replenish said principal hot-melt developer.

9. In apparatus for developing an electrostatic image as defined in claim **8**,

said apparatus is substantially automatic and com-

prises a plurality of components adapted to be energized from a source of electrical energy, and

said means to melt a portion of said replenisher hot-melt developer comprises a heating element disposed within said container and connected in circuit with at least one of said components for simultaneous energization therewith.

10. In apparatus for developing an electrostatic image as defined in claim **8**,

said means to heat said principal hot-melt developer comprises a heating element disposed within said roller,

said means to apply said molten principal hot-melt developer to said electrostatic image comprise a second roller, in rolling contact with said first-mentioned roller, and means including a third roller disposed to move said recording medium between it and said second roller, and

said container comprises a lower opening therein, whereby molten replenisher hot-melt developer may emerge therethrough for addition to said principal hot-melt developer.

11. In apparatus for developing an electrostatic image as defined in claim **8**,

said container is wedge-shaped, having a relatively large upper opening for receiving solid replenisher hot-melt developer, and a relatively smaller lower opening through which molten replenisher hot-melt developer may emerge for addition to said principal hot-melt developer.

12. In apparatus for developing an electrostatic image as defined in claim **11**, said solid replenisher hot-melt developer comprises at least a portion that is wedge-shaped and substantially conforms to the contour of the interior of said container, whereby said replenisher hot-melt developer is advanced by gravity into said container as it is melted.

13. In apparatus for developing an electrostatic image as defined in claim **8**,

said container has a lower opening therein,

said means to melt at least a portion of said replenisher hot-melt developer comprises a heating element disposed within said container, and

said means to add said portion to said principal hot-melt developer comprises means to dispose said container above said trough so that said portion of replenisher hot-melt developer, when molten, may fall through said lower opening for addition to said principal hot-melt developer.

14. In apparatus for developing an electrostatic image as defined in claim **13**,

said heating element in said container has a portion which protrudes through said lower opening of said container, whereby to direct said molten portion of replenisher hot-melt developer to said trough.

15. Apparatus for feeding a hot-melt developer to a recording medium, in an electrostatic printing process, said apparatus comprising:

(a) a first container from which hot-melt developer is applied to said recording medium,

(b) first heating means for melting developer material disposed in said first container,

(c) a second container disposed above said first container and including an opening at the bottom thereof through which developer material in said second container may be discharged into said first container to replenish the developer in said first container consumed by application to said recording medium, and

(d) second heating means for melting developer material disposed in said second container.

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