United States Patent [19]

Plumadore

[11] **3,927,639**

[45] **Dec. 23, 1975**

[54] **APPARATUS FOR DEVELOPING AN ELECTROSTATIC LATENT IMAGE ON AN ELECTROPHOTOGRAPHIC FILM**

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[22] Filed: **Apr. 8, 1974**

[21] Appl. No.: **459,194**

[52] **U.S. Cl.** **118/637**; 118/DIG. 23; 427/15

[51] **Int. Cl.²** **B05B 5/02**

[58] **Field of Search** ..... 118/637, DIG. 23, 50, 58; 117/37 LE; 355/3 P

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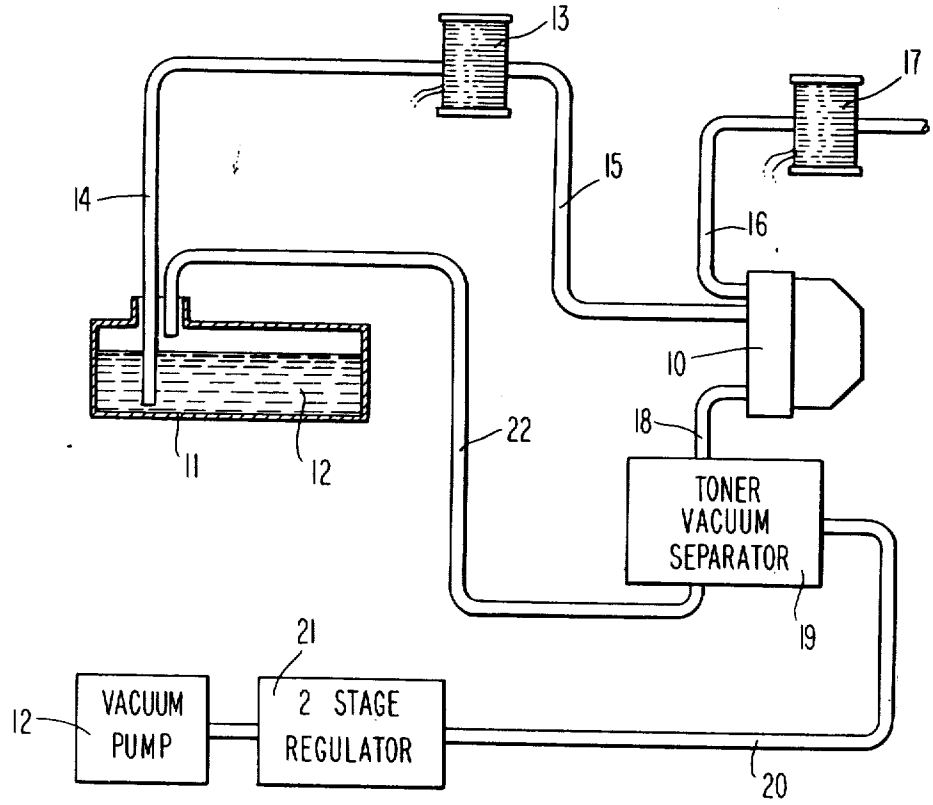
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Assistant Examiner—Steven Hawkins
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[57] **ABSTRACT**

Disclosed is a method and apparatus for developing an electrostatic latent image on an electrophotographic film through use of a special developing chamber forming a passageway through which electrostatically charged toner particles in a carrier liquid are conducted to contact the film and through use of special toner flow control means. The chamber has an opening bordered by a mask against which the film is placed to form a seal, an inlet and an outlet through which liquid toner and drying air enter and leave the chamber. In the preferred embodiment the apparatus further includes supply means for providing liquid toner to the chamber, a conduit leading from the toner supply means to the inlet of the developing chamber, a toner valve through which the conduit passes, a needle orifice connected to the conduit and positioned in the inlet of the chamber, means for supplying drying air through an air valve to the inlet of the chamber, vacuum means connected to the outlet of the chamber for drawing the liquid toner and air through the chamber, and means for opening and closing alternately the toner valve and the air valve to alternately draw liquid toner and drying air through the chamber. In the preferred embodiment a porous material is located in the chamber passageway for absorbing sufficient liquid toner to remain wet during the drying step and avoid permanent toner deposition in the passageway.

6 Claims, 2 Drawing Figures



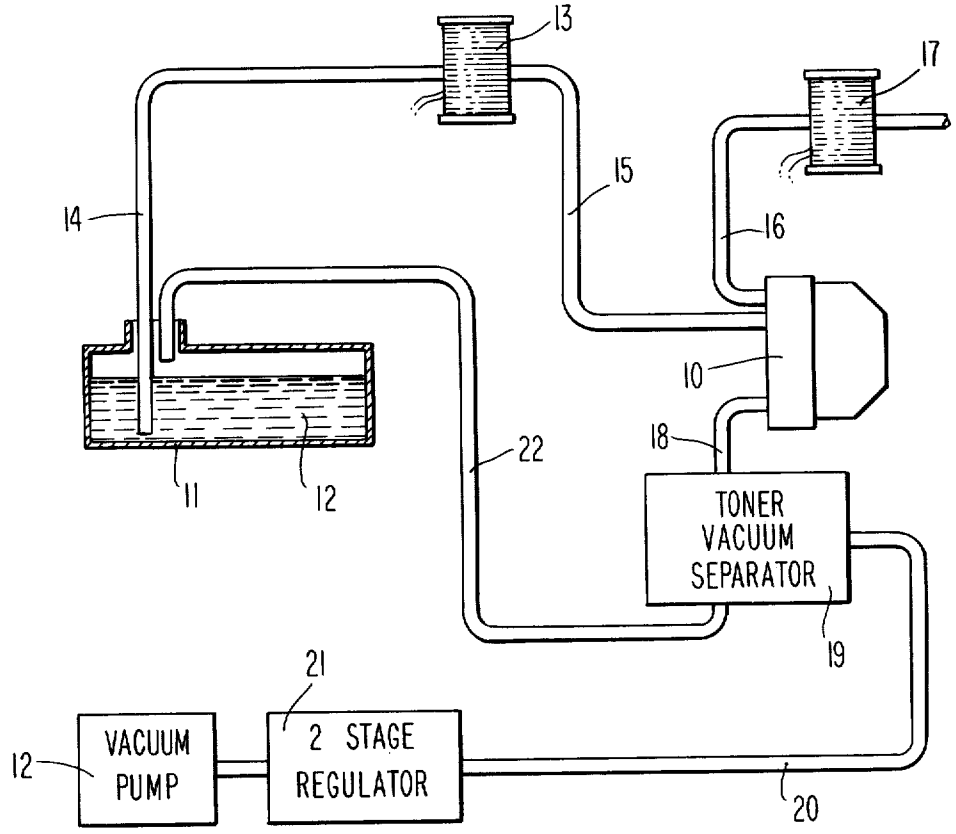

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TONER
VACUUM
SEPARATOR
19
21
VACUUM
PUMP
2 STAGE
REGULATOR
12
20

Fig. 1

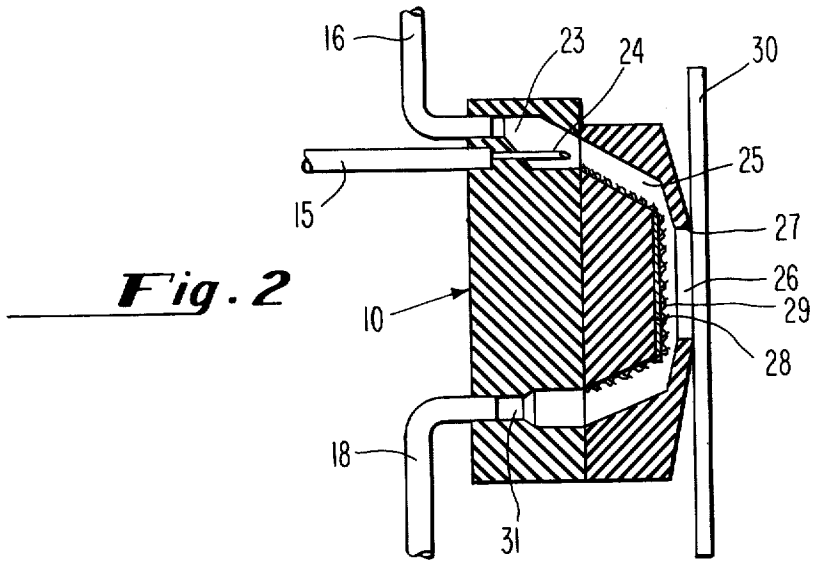

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Fig. 2

APPARATUS FOR DEVELOPING AN ELECTROSTATIC LATENT IMAGE ON AN ELECTROPHOTOGRAPHIC FILM

RELATED APPLICATIONS

The present invention is described, but not claimed in commonly assigned co-pending application U.S. Ser. No. 459,195 entitled METHOD AND APPARATUS FOR DEVELOPING AN ELECTROSTATIC LATENT IMAGE ON AN ELECTROPHOTOGRAPHIC FILM, filed in the name of Frank C. Gross on the same day as the present application. The disclosure of any portion of the present invention in that application was derived from the present applicant.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to electrophotography and more particularly to improvements in developing an image on an electrophotographic element.

2. Description of the Prior Art

In electrophotography, it is common to apply a uniform electrostatic charge to the surface of a photoconductive layer. The charge is then selectively dissipated in a pattern by exposing the surface to a light image. The resulting pattern of charges produces an electrostatic latent image on the photoconductive layer, which is rendered visible by applying to it electrostatically charged toner particles which adhere to the surface of the photoconductive layer by electrostatic attraction. A permanent visible image can be obtained by using toner particles which can be heat fused to the photoconductive layer and subjecting them to a heat application step.

In the conventional developing method using liquid developer or toner, which is a liquid carrier for finely divided electrostatic toner particles such as carbon particles, the image-exposed film is dipped in the liquid toner to produce a visible image corresponding to the latent image thereon. While this method of developing is satisfactory for some types of systems and film, it is not satisfactory for the type of system in which imaging and developing takes place automatically within a single apparatus. For example, in a preferred type of microphotographic copying machine, data from successive documents is sequentially recorded on individual frames of a multi-frame microfiche. Because it is desirable to image and develop each frame quickly before repeating the process for the next frame, the process for developing the images must be one which can be carried out quickly and conveniently to a microfiche fixed within a holder within the reproduction apparatus. Additionally, the developing system must be capable of quickly applying the correct amount of developer, or toner particles (which are preferably suspended in a liquid carrier), to the imaged area of the film and removing the toner particles from the film without permitting leakage of the toner particles into the interior of the reproduction apparatus. The system must also be capable of quickly evaporating any of the toner carrier liquid remaining on the film to immobilize the toner particles remaining on the film and prevent smearing of the toned imaged.

Therefore, it is an object of the invention to provide a method and apparatus for quickly applying a measured quantity of liquid toner to an imaged area of a film without permitting leakage of the liquid toner beyond the imaged area of the film. A further object of the invention is to quickly evaporate residual toner carrier liquid remaining on the film after toning. And a further object of the invention is to provide a method and apparatus for accomplishing the above objects while the film is held in a carrier within a microphotographic reproduction apparatus.

SUMMARY OF THE INVENTION

These and other objects are accomplished by the method and apparatus of the invention, which includes a developing chamber forming a passageway through which electrostatically charged toner particles in a carrier liquid are conducted to the imaged area of an electrostatically charged film. The passageway has an opening bordered by a mask against which the film is placed, and the developing chamber further includes an inlet through which liquid toner and drying air enter the chamber and an outlet through which liquid toner and drying air leave the chamber. The apparatus of the invention further includes supply means for providing liquid toner to the chamber, toner flow control means for permitting a predetermined quantity of liquid toner to flow through the developing chamber at predetermined times, air supply means for supplying drying air to the inlet of the chamber, and vacuum means connected to the outlet of the chamber for drawing the liquid toner and air through the chamber. The vacuum means creates a subatmospheric pressure within the chamber to prevent leakage of toner particles from the chamber around the film. The toner flow control means and the air supply means are provided by a conduit leading from the toner supply means to the inlet of the developing chamber, a toner valve through which the conduit passes, a needle orifice in the inlet of the developing chamber and connected to the conduit and through which the liquid toner is drawn by the vacuum means into the developing chamber when the toner valve is opened, an air valve through which passes the drying air which enters the developing chamber through the inlet, and means for opening and closing alternately the toner valve and the air valve for predetermined periods of time.

In its preferred form, the invention includes control means operably connected to the vacuum means for providing a high vacuum level and a low vacuum level, the low vacuum level being used to draw the liquid toner through the developing chamber, and the high vacuum level being used to draw the drying air through the chamber. The preferred embodiment of the apparatus further includes a development electrode forming one wall of the chamber passageway in a position close to the opening through which the toner particles contact the film. And the preferred embodiment also includes a porous material, preferably a finely woven cloth, in the passageway, preferably over the electrode. The porous material is saturated with liquid toner during passage of the toner particles through the chamber and remains wet during the drying step to prevent permanent deposition of toner particles on the electrode.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic view of the developing apparatus of the invention.

FIG. 2 is an enlarged cross-sectional view of the developing chamber illustrated in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1 and 2, the preferred embodiment of the invention is disclosed and includes toner reservoir 11 containing liquid toner 12, and from which toner fluid is drawn through conduit 14, through solenoid valve 13 and line 15 into the inlet 23 of developing chamber 10 by way of orifice needle 24. The liquid toner 12 is drawn through chamber passageway 25, through the developing chamber outlet 31, and into the toner vacuum separator 19 by way of conduit 18. Toner vacuum separator 19 is a conventional liquid/gas separator and is connected by way of conduit 20 to vacuum pump 12 through two-stage regulator 21. Leading from the bottom of toner vacuum separator 19 is toner return line 22, which conducts the toner fluid back into the toner reservoir 11 for recirculation. Drying air is conducted through solenoid valve 17 and conduit 16 into developing chamber inlet 23.

Developing chamber 10 includes an opening 26 communicating with the chamber passageway 25 and formed by rectangularly shaped mask means 27. The frame of the microfiche 30 to be toned is placed against opening 26 to form a seal with mask means 27. Of course, the photoconductive layer of the microfiche 30 is faced inwardly into the developing chamber 10. One wall of the chamber passageway 25 is formed by development electrode 28 positioned opposite the opening 26 and very close to the opening to create a strong electric field between the electrode 28 and the microfiche 30 and to force the liquid toner 12 flowing through the chamber passageway 25 against the microfiche 30. The development electrode is provided by a very thin electrically conductive plate, and functions in a manner well known to those skilled in the art. Covering the development electrode 28 is a finely woven material 29, such as silk, which is porous so that it can be saturated by the toner fluid during the toning process. The material 29 is preferably nonelectrically conductive and retains enough of the liquid toner to remain wet during the drying step which will be described subsequently. In this way, permanent deposition of toner particles upon the development electrode 28 is prevented. The material also can cover other portions of the passageway 25 walls such as is illustrated, in FIG. 2 to prevent permanent deposition of toner on them.

The operation of the preferred form of the invention will now be described. As soon as an imaged frame of a microfiche 30 is placed against opening 26 in the developing chamber 10, the vacuum pump 12 applies a low-level vacuum, controlled by a two-stage regulator 21, through conduit 20, toner vacuum separator 19, conduit 18, developing chamber 10, needle orifice 24, conduit 15, solenoid valve 13, and conduit 14 to draw toner particles 12 through the chamber passageway 25 of the developing chamber 10. During this operation, the toner solenoid valve 13 is opened, and the air solenoid valve 17 is closed to prevent drying air from being pulled through the conduit 16. The needle orifice 24 is sized to meter the liquid toner 12 through at a predetermined rate and is small enough to prevent liquid toner 12 from flowing out when toner valve 13 is closed.

A conventional timer closes solenoid valve 13 when the desired quantity of toner fluid 12 has been pulled through the developing chamber 10. Immediately upon closing of toner solenoid valve 13, air solenoid valve 17 opens, permitting drying air to be drawn through conduit 16 into the chamber passageway 25. At the same time the two-stage regulator 21 is switched to the high-vacuum level stage to draw air through at a fast rate. The drying air is drawn through at a fast rate to assure quick evaporation of residual toner carrier liquid remaining on the microfiche 30, as well as drawing air in from any opening which might exist between the microfiche 30 and the mask means 35, thereby preventing toner fluid from flowing along the microfiche beyond the frame being toned or into the interior of the reproduction apparatus.

Pulling the liquid toner 12 through the passageway 25 by vacuum means creates a pressure within the passageway 25 that is lower than the pressure of the outside air and draws air through any opening inadvertently or purposely formed between mask means 27 and the microfiche 30, thereby forming an air seal to prevent the liquid toner 12 from leaking from the developing chamber 10. In a preferred embodiment, the drying step also includes separating the microfiche 30 slightly from the mask means 27 to draw additional drying air into the developing chamber 10 from around the frame being developed for more efficient drying, particularly at the edges of the frame being developed.

The special toner flow control means is very advantageous in reducing the portion of the system upstream of the passageway opening 26 through which both liquid toner and drying air flow. Thus, during the drying step of that upstream portion, only the upper portion of passageway 25 need have the liquid toner removed by the drying air between each process cycle. During drying, the liquid toner remains in the needle orifice because of capillary forces. As a result, the drying air picks up less liquid toner and more effectively dries.

What is claimed is:

1. In an apparatus for developing an electrostatic latent image on an electrophotographic film, comprising:

a developing chamber forming a passageway through which electrostatically charged toner particles in a carrier liquid are conducted to contact the film, the chamber having an opening bordered by a mask against which the film is placed to form a seal, an inlet through which toner particles and air enter the chamber, and an outlet through which toner particles and air leave the chamber;

toner supply means for providing liquid toner to be passed through the chamber;

toner flow control means for permitting a predetermined quantity of liquid toner to flow through the developing chamber at predetermined times;

air supply means for supplying drying air to the inlet of the chamber; and

vacuum means connected to the outlet of the chamber for drawing the liquid toner and the air through the chamber, the vacuum means creating subatmospheric pressure within the chamber to prevent leakage of liquid toner from the chamber around the film;

the improvement in the apparatus wherein the toner flow control means and the air supply means are provided by:

a conduit leading from the toner supply means to the inlet of the developing chamber;

a toner valve through which the conduit passes;

an orifice connected to the conduit and positioned in the inlet of the developing chamber, the orifice sized to permit liquid toner to be drawn by the

vacuum means into the developing chamber only when the toner valve is opened;

an air valve through which passes the drying air which enters the developing chamber through the inlet; and

means for opening and closing alternately the toner valve and the air valve for predetermined periods of time.

2. Apparatus according to claim **1** further including control means attached to the vacuum means for providing a high vacuum and a low vacuum, the low vacuum being used to draw the liquid toner through the developing chamber, and the high vacuum being used to draw drying air through the chamber.

3. Apparatus according to claim **1**, wherein the developing chamber includes a development electrode forming one wall of the passageway for conducting the liquid toner through the developing chamber and being positioned close to the opening through which the toner particles contact the film.

4. Apparatus according to claim **3**, including a porous material positioned over the electrode, the porous material being made of a nonelectrically conductive material and capable of absorbing sufficient liquid toner to remain wet while the drying air is passed through the developing chamber.

5. In an apparatus for developing an electrostatic latent image on an electrophotographic film, comprising;

a developing chamber forming a passageway through which electrostatically charged toner particles in a carrier liquid are conducted to contact the film, the chamber having an opening bordered by a mask against which the film is placed to form a seal, an inlet through which liquid toner and air enter the chamber, and an outlet through which liquid toner and air leave the chamber,

toner supply means for providing liquid toner to be passed through the chamber;

toner flow control means for permitting a predetermined quantity of liquid toner to flow through the developing chamber at predetermined times;

air supply means for supplying drying air to the inlet of the chamber; and

vacuum means connected to the outlet of the chamber for drawing the liquid toner and the air through the chamber, the vacuum means creating subatmospheric pressure within the chamber to prevent leakage of liquid toner from the chamber around the film;

the improvement wherein the developing chamber includes a porous material covering portions of the passageway walls, the porous material being capable of absorbing sufficient liquid toner to remain wet while drying air is passed through the developing chamber.

6. Apparatus according to claim **5**, wherein the chamber has a development electrode forming one wall of the passageway and positioned close to the opening through which the liquid toner contacts the film, and the porous material covers the electrode.

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