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[54] **MEANS FOR RAPID DEVELOPMENT OF ELECTROSTATIC IMAGES**

[75] Inventor: **Robert J. Wright,** Tranmere, Australia

[73] Assignee: **Research Laboratories of Australia Pty. Limited,** Eastwood, Australia

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[30] **Foreign Application Priority Data**

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

[51] **Int. Cl.²** **G03G 13/10**

[58] **Field of Search** ..... 118/DIG. 23, 637, 360; 117/37 LE, 111 D; 96/1 LY; 355/10; 354/318

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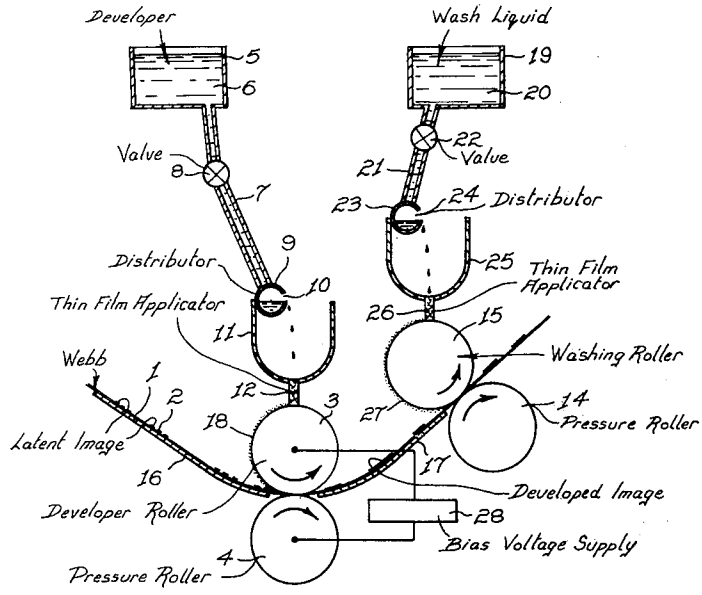
Primary Examiner—Morris Kaplan

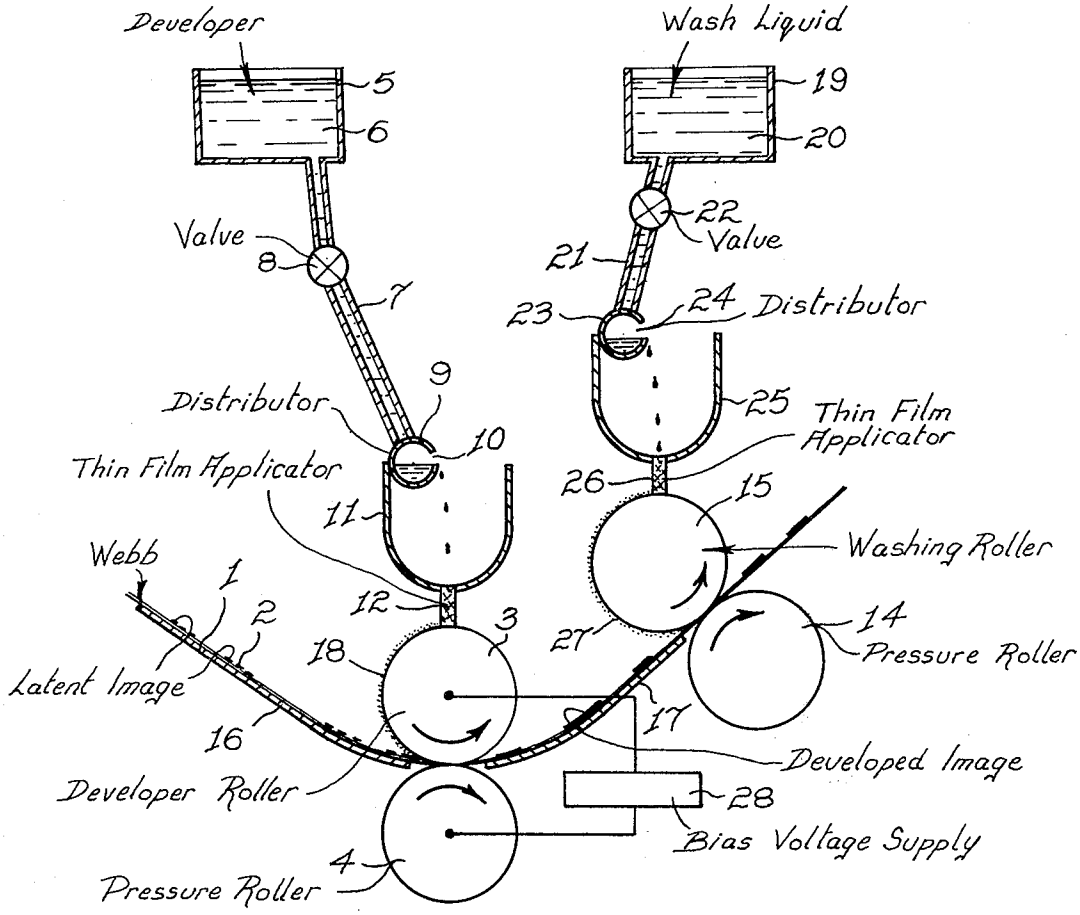
Attorney, Agent, or Firm—Kinzer, Plyr, Dorn & McEachran

[57] **ABSTRACT**

Electrostatic developing apparatus includes a developer-applicator electrode roller a porous element delivering liquid carrier and developer to the applicator. The element communicates with and through the bottom of a trough member. A vessel, receiving a controlled feed from a reservoir, has an overflow slot through which a drop-wise feed is effected to the trough and its porous element.

4 Claims, 1 Drawing Figure




Developer
5
6
Valve
8
7
Distributor
9
10
Thin Film Applicator
11
Webb
1
2
Latent Image
12
3
18
16
Developer Roller
4
Pressure Roller
Wash Liquid
19
20
22
Valve
21
23
24
Distributor
25
Thin Film Applicator
26
15
Washing Roller
27
14
Pressure Roller
17
Developed Image
28
Bias Voltage Supply

MEANS FOR RAPID DEVELOPMENT OF ELECTROSTATIC IMAGES

This is a division of application Ser. No. 343,244, filed Mar. 21, 1973.

This invention relates to the development of electrostatic latent images, and in particular relates to a means for the development of images on electrostatographic surfaces in continuous web form at high speeds.

BACKGROUND OF INVENTION

It is known to produce electrostatic latent images on various recording member surfaces, such latent images consisting of finite areas which are electrostatically charged, which areas are usually surrounded by more or less uncharged areas. Such electrostatic latent images are well known for instance in the art of photocopying, being produced in electrophotographic office copying machines and the like.

More recent processes involving the formation of electrostatic latent images, involving different principles of latent image formation, have been evolved and applied to signal recording print out. In these processes the recording member is a paper web or the like having coated on one side thereof a dielectric layer, which layer can be imaged in patterned form by the application thereto of discrete electrical pulses applied to selected writing styli in contact with said dielectric layer. In a still more recent process, as described by Cunningham et al in U.S. Pat. No. 3,579,330 a dielectric surface of a recording member may be imaged by patterned contact with a triboelectrically different surface.

In a co-pending patent application the present inventor has proposed a further imaging system which is superficially similar to that of Cunningham, although not triboelectric in nature, in which an electrostatic latent image is formed by contact deformation of a dielectric layer, such imaging being carried out at high speed if desired.

Generally prior art electrophotographic processes do not require image development to be carried out at high speed, most electrophotographic office copying machines operating at a speed of less than 60 ft./minute. However, signal recording and computer print out devices using dielectric recording members of the type already described may advantageously employ considerably higher developing speeds, such as 200–300 ft./minute, continuous operation.

Two general types of developing processes are used for the development of electrostatic latent images. In each process electroscopic marking particles are attracted to the latent electrostatic image, and may be fixed thereto or transferred to a receiving member surface. In the first type of developing process the electroscopic marking particles are in a dry state, whereas in the second type of developing process the electroscopic marking particles are suspended in an insulating carrier liquid. Each of dry and liquid dispersed developers and developing methods are well known in the prior art.

Prior art developing methods are generally satisfactory for the slower operating speeds associated with office copying machines and the like, but have certain disadvantages in relation to high speed electrostatic print out devices. Generally dry toner applicators are not suited to high speed developing, and thus liquid dispersed toners are usually employed in this application. The simplest liquid toner applicators require immersion of the recording member in a bath of liquid dispersed toner, followed by squeegee drying of the copy. In addition heating means are often provided to dry the copy to a greater extent. Such simple toner applicators are relatively slow in operation. Developing speed may be improved by the use of developing electrodes, which electrodes may be at ground potential or biased to any required potential of the required polarity. Thus the use of a grounded roller, completely or partially immersed in the toner bath allows the attainment of developing speeds of the order required. However such methods usually allow an excessive amount of carrier liquid to be removed from the toner suspension by the web being developed, this liquid ultimately being removed from the sheet by heating or natural evaporation, each of which releases solvent vapor into the atmosphere in excessive quantities.

SUMMARY OF INVENTION

We have now found that a developer applicator which allows image development at high speed with greatly reduced liquid consumption can be constructed utilising a thin film of liquid dispersed electroscopic marking particles carried on a conductive roller in contact with the surface being developed said conductive roller constituting a first liquid applicator. The roller may be at ground potential, or biased as desired depending on the latent image contrast, toner formulation, developing speed and the like. Alternatively the developing roller may be isolated from ground, in which instance it forms a virtual electrode.

Thus the present invention teaches an apparatus for the development of electrostatic latent images contained on the front surface of an electrostatographic recording member by the attraction of electroscopic marking particles thereto consisting of contacting said front surface of said recording member with the surface of a first liquid applicator member which functions as a developing electrode and as a carrier for said electroscopic marking particles dispersion, said first liquid applicator member having on its cylindrical surface a layer of liquid dispersed electroscopic marking particles, generally of a thickness within the range 1 micron to 5 microns, followed by contacting the developed front surface of said recording member with a second liquid applicator member having on its surface a film of clean carrier liquid of a thickness within the range 0.5 to 5 microns.

The distributing mechanism by which the liquid film is applied to the first liquid applicator surface is not critical provided the film is reasonably uniform over the length of the roller. Thus in accordance with one embodiment of this invention, an elastomeric blade is fitted in virtual contact with the first liquid applicator surface and the electroscopic particle suspension is drip fed to said elastomeric blade which acts as a distributor and leveller. The elastomeric blade may be of a non-porous nature positioned in relation to the first liquid applicator member to act as a doctor blade, or alternatively the blade may be in the form of a flexible open cell sponge to which liquid dispersed electroscopic marking particles are fed at a controlled rate to produce a layer of liquid dispersion of the desired thickness on the surface of the first liquid applicator member.

The developer film thickness on the first liquid applicator member is preferably maintained at a thickness with the range 1 – 5 microns to reduce solvent carry out

to a minimum, but may be increased if desired. Generally a minimum thickness of 1 micron has been found to be necessary to maintain toner particle mobility to a sufficient extent to allow image development, when using as liquid dispersed electroscopic marking particles a toner of the electrostatic office copier type dispersed in an aliphatic hydrocarbon carrier liquid in the proportions 20–50 ml toner concentrate per 1 litre of carrier liquid.

The use of such thin films of electroscopic marking particle dispersions at relatively high concentrations generally causes non-image or background toner deposition. This invention provides a method for the substantial removal of the so formed background deposit by the application of clean carrier liquid to a squeegee roller which contacts the developed image bearing surface, which film of clean liquid removes background deposition and displaces residual dispersed toner on the developed surface. The clean liquid film on the squeegee roller may be of the same order of thickness as the dispersed toner film on the developing roller, such as less than 5 microns, and preferably less than 2 microns to reduce liquid consumption to a minimum. The wetted squeegee roller constitutes a second liquid applicator member.

It will be seen that the herein described liquid toner applicator allows one side only of the recording member being developed to be contacted with liquid, and in addition the amount of liquid contacting said recording member surface being developed is controlled to reduce liquid carry out substantially below that which occurs when immersion developing techniques are used, or when liquid dispersed toner is allowed to flow over the surface being developed. Further it is believed that the maintaining of the developing roller in very close proximity with the surface being developed allows image development to occur at a very rapid rate. Thus the herein described toner applicator is capable of developing electrostatic latent images at a rapid rate using liquid dispersed toner and delivering developed copy in a substantially dry form.

The drawing illustrates the use of porous distributor blades to provide the liquid layers on each of the first and second liquid applicator members.

It will be realised that other members of liquid application to the surface of each of the first and second liquid applicator members may be used without departing from the spirit of the invention, provided such methods produce and maintain such films of liquid of the required thickness on each liquid applicator member. Consequently the configurations shown in the illustrations should be read in the sense of illustrating the principles of the invention and not in the restrictive sense.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing in detail, an electrostatographic recording member such as a paper web **1**, which may be of the electrographic or electrophotographic type has on the first surface thereof an electrostatic latent image **2**. The paper web **1** is constrained by guide member **16** to pass through the nip of a pair of rollers **3** and **4**. Roller **3** constitutes the first liquid applicator member and is of metal or other conductive material, thereby acting as a developing electrode. Roller **4** is positoned in virtual contact with roller **3**, and is preferably resilient to ensure contact of the paper web **1** with roller **3**. A reservoir **5**, containing liquid dispersed electroscopic marking particles **6**, is positioned above roller **3**, and the liquid dispersion **6** is allowed to flow through feed line **7**, regulated by regulator valve **8**, to distributor vessel **9**, distributor vessel **9** being substantailly similar in length to roller **4**. Liquid dispersion **6** flows through distributor **9**, and emerges through outlet holes or slot **10**, dropping into launder which constitutes a receiving trough **11**. Launder **11** is closed at its lower edge by an open cell compressed porous wiper blade **12** which contacts the surface of roller **3**. A pair of squeegee rollers **14** and **15** are positioned on the exit side of the nip between rollers **3** and **4** and paper guide **17** is provided to direct the developed paper web through the nip of squeegee rollers **14** and **15**. Squeegee roller **15** constitutes a second liquid applicator member, and a metered quantity of clean carrier liquid is fed to roller **15** to provide the necessary background cleaning liquid to contact the first surface of the recording member being developed. Clean carrier liquid **20** is contained in reservoir **19**, and flows through feed line **21**, regulated by regulator valve **22**, to distributor **23**, from which it emerges through outlet holes or slot **24**, dropping into launder **25**. Launder **25** is closed at its lower edge by open cell compressed porous wiper blade **26** which contacts the surface of roller **15**. In operation the rollers are rotated in the direction shown to cause the paper web to travel in the direction shown simultaneously with the regulation of regulator valve **8** to produce liquid dispersed toner film **18** on the surface of roller **3**, to develop the electrostatic latent image **2**, forming image deposit **13**. Simultaneously regulator valve **22** is adjusted to produce clean carrier liquid film **27** on the surface of roller **15** to remove unwanted background deposition from the developed first surface of the recording member. Development of the latent electrostatic image may be assisted if desired by the application of electrical bias using power supply **28**.

To further illustrate the function of this invention, reference will now be made to the following examples.

EXAMPLE 1

The developing apparatus shown in the drawing was used to develop an electrostatic latent image on a dielectric surface. The dispersion regulating valve was adjusted to produce a toner feed rate of 20 ml/minute and the roller rotational speed adjusted to cause the paper to travel through the apparatus at a linear speed of 200 ft/minute. The latent image was developed to an adequate density by the thin layer of dispersed toner on the developing roller, the thickness of this layer on the dispersed toner being approximately 1 micron. The regulator valve by which the clean carrier liquid was applied to the second liquid applicator member was also adjusted to a flow rate of 20 ml/minute.

EXAMPLE 2

Example 1 was repeated with the dispersed toner flow rate increased to 100 ml/minute, which produced a 5 micron layer of dispersed toner on the developing roller. The so produced developed image was of slightly higher density than that produced in Example 1, but the solvent carry out of the developed sheet was greater, however this excess solvent was substantially removed by the squeegee rollers, the liquid feed rate to the second applicator being 20 ml/minute, as in Example 1.

EXAMPLE 3

Example 1 was repeated but the roller speed was adjusted to produce a paper travel speed of 100 ft/minute. In this instance the dispersed toner layer on the developing roller was 2 micron thick, which gave adequate image density and solvent carry out of the order of 10 lbs/hour. Solvent carry out was reduced and a cleaner developed image obtained when clean carrier liquid was fed to the second liquid applicator member at a flow rate of 5 ml/minute, which produced a clean liquid film of 0.5 micron thickness on the surface of the second liquid applicator.

EXAMPLES 4–6

In each of the Examples 1–3, the liquid dispersed toner used was of the office copier type, dispersed in an iso-paraffinic carrier liquid in the proportions 20 ml toner concentrate per litre of carrier liquid. It was found that the toner concentration could be increased substantially without causing excessive background stain, and each of Examples 1–3 was repeated using the same toner at a concentration of 40 ml/litre, producing some increase in the density of the developed image deposit, without increasing significantly the background deposition thereon.

I claim:

1. Apparatus for electrostatic recording comprising a first set of vertically opposed rollers and a second set of vertically opposed rollers arranged in nip relation for feeding a paper web bearing an electrostatic latent image, means affording a pair of reservoirs positioned above the rollers, one reservoir for supplying to the upper roller in the first set developer liquid comprising electroscopic marking particles suspended in an insulating carrier liquid for developing the latent image, and one reservoir for supplying insulating carrier liquid to the upper roller in the second set, and two distributor means for transferring the liquids from each reservoir to the respective rollers in controlled thin-film form to conserve liquid while displacing background developer from the non-image background areas, each distributor means comprising:

a. a receiving trough positioned above the related upper roller and having a porous wiper blade communicating therewith and extending through the bottom thereof and into contact with the related upper roller to meter liquid thereto;

b. a distributor vessel operatively associated with the receiving trough for holding a supply of the liquid transferred from the related reservoir, said vessel having an overflow slot therein for substantial drop-wise distribution of liquid into said trough and thereby to the related wiper blade;

c. a conduit for transferring liquid by gravity flow from the reservoir to the related distributor vessel; and

d. an adjustable valve in said conduit to control the rate of transfer of liquid from the reservoir to said distributor vessel.

2. Apparatus according to claim **1** in which the upper roller in the first set is a metallic electrode and in which the lower roller in the first set is resilient to assure good contact with the web.

3. Apparatus for electrostatic recording comprising a set of vertically opposed rollers arranged in nip relation for feeding a paper web bearing an electrostatic latent image, means affording a reservoir for a liquid to be applied to the web, said reservoir being positioned above the rollers, and a distributor means for transferring liquid from the reservoir to the upper one of the rollers in a controlled thin-film form to avoid excessive wetting of the web, said distributor means comprising:

a. a receiving trough positioned above the related upper roller and having a porous wiper blade communicating therewith and extending through the bottom thereof and into contact with the upper roller to meter liquid thereto;

b. a distributor vessel operatively associated with the receiving trough for holding a supply of liquid transferred from the related reservoir, said vessel having an overflow slot therein for substantial drop-wise distribution of liquid into said trough and to the wiper blade;

c. a conduit for transferring liquid by gravity flow from the reservoir to the related distributor vessel; and

d. an adjustable valve in said conduit to control the rate of transfer of liquid from the reservoir to said distributor vessel.

4. Apparatus according to claim **3** in which the upper roller is a metallic electrode and in which the opposed roller is resilient.

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