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Fukushima et al.

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[54] **ELECTRO-PHOTOGRAPHIC APPARATUS**

[75] Inventors: **Osamu Fukushima; Masamichi Sato; Seiji Matsumoto,** all of Asaka, Japan

[73] Assignee: **Rank Xerox, Ltd.,** London, England

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Related U.S. Application Data

[62] Division of Ser. No. 234,287, March 13, 1972, Pat. No. 3,816,114.

[52] **U.S. Cl.** ..... **118/637,** 96/1 LY, 117/37 LE, 355/10, 118/DIG. 23

[51] **Int. Cl.** **G03g 15/10**

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

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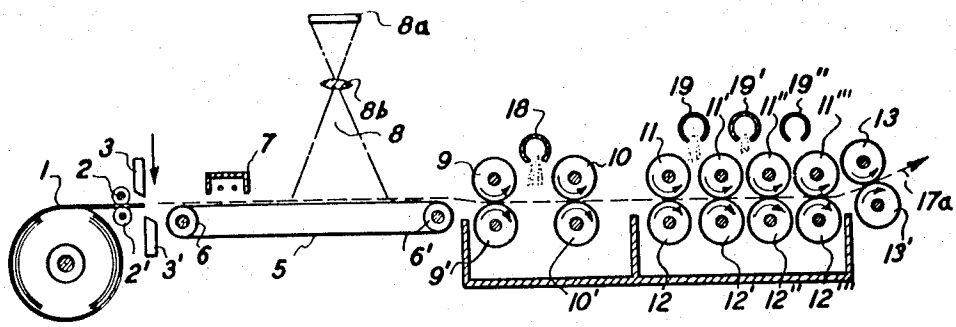
Primary Examiner—Mervin Stein
Assistant Examiner—Douglas A. Salser

[57] **ABSTRACT**

Development of an electrostatic latent image on an image carrier with liquid electrophoretic developer and utilizing a closely spaced development electrode, is facilitated by embossing the side edges of the carrier with embossments that project above the image surface of the carrier. These embossments are used to establish and maintain a fixed spacing between the electrode and the image surface.

6 Claims, 7 Drawing Figures



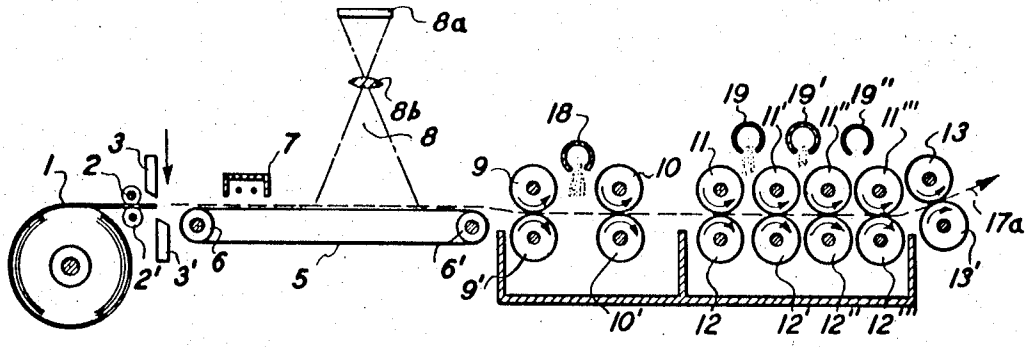


FIG. 1

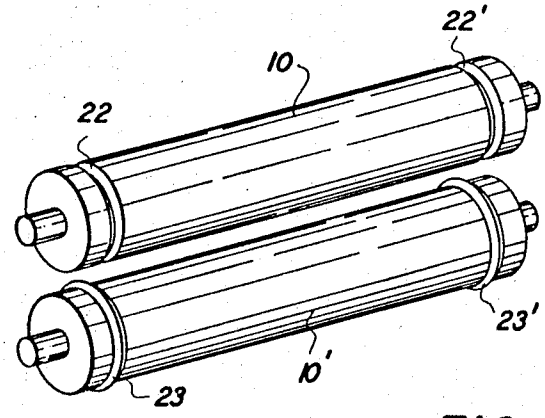


FIG. 2

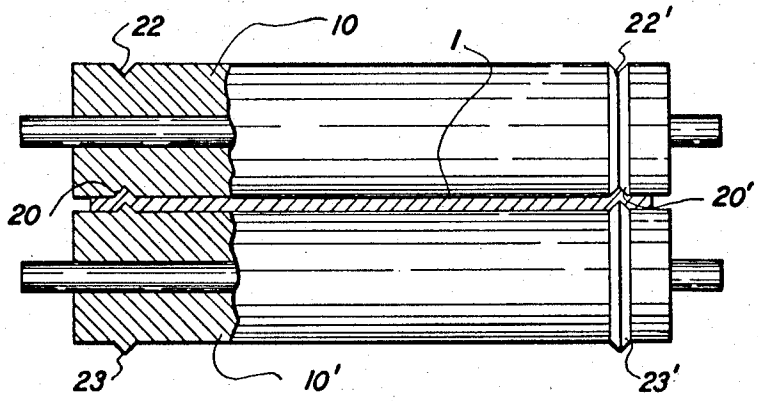


FIG. 3

FIG. 4

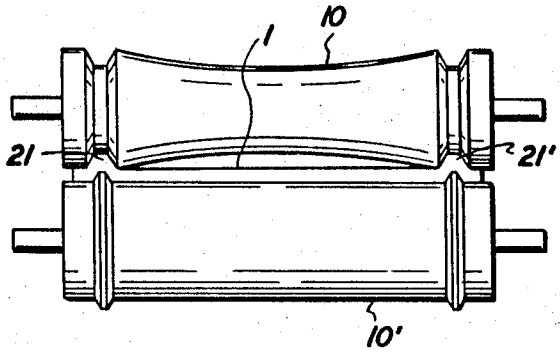


FIG. 5

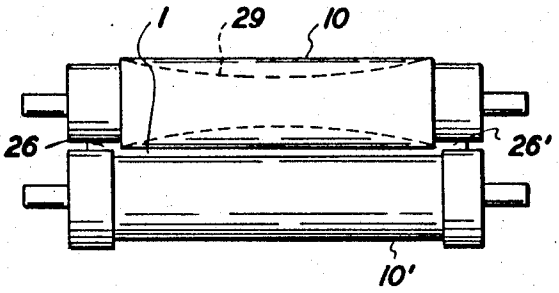


FIG. 6

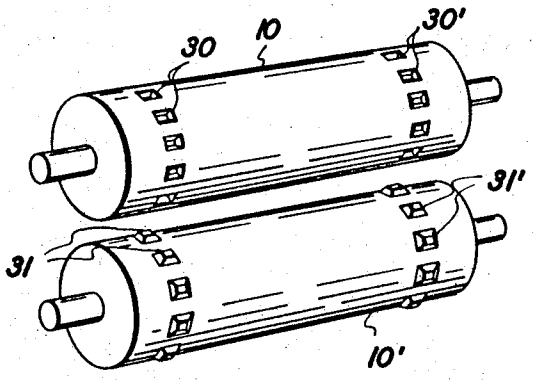
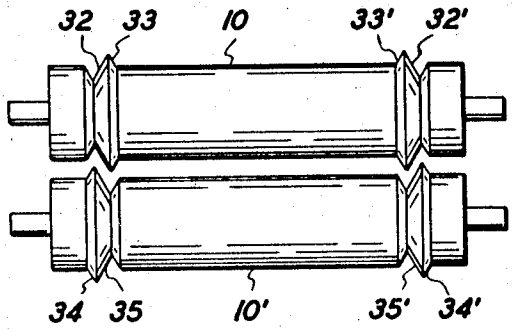


FIG. 7



ELECTRO-PHOTOGRAPHIC APPARATUS

This is a continuation, division, of application Ser. No. 234,287, filed Mar. 13, 1972, now U.S. Pat. No. 3,816,114.

INTRODUCTION AND BRIEF DESCRIPTION OF INVENTION

The present invention relates to the development of electrostatic latent images, and more particularly to the development of such images by the use of liquid electrophoretic developers, such as those comprising a suspension of minute colored toner particles in an electrically insulating liquid vehicle.

The process of developing electrostatic latent images by immersing the image surface of an electrostatic image carrier in a liquid electrophoretic developer solution, is well known. There are also a number of well known methods for obtaining electrostatic latent images. One such method is to apply a uniform electrostatic charge over a photoconductive electrically insulating surface layer carried on a conductive paper backing. The charged surface is then exposed to an optical image, which causes the charge to be dissipated or discharged in the light struck areas in accordance with the intensity of the light impinging thereon, leaving an electrostatic latent image of the applied optical image on the surface of the photoconductive layer.

In the liquid electrophoretic development process, it is conventional to utilize a development electrode, arranged so that as the latent image carrier passes through the developer solution, the image surface passes in close proximity to the development electrode surface, while the conductive backing of the carrier is in contact with a ground element. The development electrode contributes to a uniform development action, that is, a deposit of toner in a density closely related to the charge potential present at each incremental area of the image surface. The closer the electrode, the more uniform is the development effect, and the lesser is the tendency to produce edge effects in which toner deposits preferentially at the edges of areas carrying high charge densities. For optimum effects, it is preferred that the development electrode be spaced only about 50 to 500 microns from the image surface.

On the other hand, the closer the electrode is positioned to the image surface, the greater is the problem of feed control to prevent contact between the electrode and the image surface. Such contact is deleterious to the quality of the development, because it discharges image charge in the areas of contact and smudges toner already deposited.

The present invention is directed to overcoming these problems, and enabling an image carrier, particularly a paper or other flexible sheet or web carrier, to be fed through a development station in very close proximity to a development electrode, while retaining a controlled spacing between the image carrier and the electrode. In general, this result is accomplished by embossing the marginal non-image side edges of the carrier, and relying on these embossments to maintain the requisite spacing of a floating electrode from the image surface of the carrier.

Accordingly, it is one object of the present invention to provide for the control of the spacing between a development electrode and the image surface of an electrostatic latent image carrier.

Another object of the present invention is to provide for said control with paper or other flexible sheet or web carriers without resorting to complicated feed control mechanisms.

And still another object of the present invention is to provide for said control by utilizing the carrier itself to maintain the requisite spacing at each incremental length thereof.

Other objects and advantages of the present invention will become apparent to those skilled in the art from a consideration of the following detailed description of illustrative embodiments of the invention, had in conjunction with the accompanying drawings, in which like reference characters refer to like or corresponding parts, and wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of an illustrative electrophotographic apparatus;

FIG. 2 is an enlarged exploded perspective view of a pair of embossing rolls utilized in the practice of the present invention;

FIG. 3 is an enlarged vertical sectional view of the embossing rolls of FIG. 2 in operative relation with an electrostatic latent image carrier sheet; and

FIGS. 4–7 are representations of alternate embodiments of the embossing rolls of FIGS. 2 and 3.

DETAILED DESCRIPTION

Referring to FIG. 1, numeral 1 designates a supply roll of conventional electrophotographic paper, comprising a electrically conductive paper backing, having an electrically insulating photoconductive surface layer, such as photoconductive zinc oxide particles in a resin binder. Electrophotographic paper is fed from the supply roll by feed rolls 2, 2′, and cut into a desired sheet length by cutter 3, 3′. The cut sheet is fed through the apparatus along the path indicated by the dashed line 17 and in the direction of arrow 17*a*. From the cutter, the sheet is carried by endless belt conveyor 5 driven by end rolls 6, 6′, first under the charging station 7 where its photosensitive surface receives a uniform electrostatic charge, and then to exposure station 8 where the optical image of a subject 8*a* is projected by lens 8*b* on the photoconductive sheet. Belt 5 is electrically grounded, so that areas on the photoconductive sheet that are struck by light from subject 8*a* are discharged, leaving an electrostatic latent image of the subject on the image surface of the sheet.

From belt 5, the electrophotographic sheet 1 is conveyed by rolls 9, 9′ under a prewash nozzle 18 to embossing rolls 10, 10′. Rolls 9 and 10, to the extent that they contact the latent image surface of the sheet 1 are electrically insulating, so as not to discharge the electrostatic image on the photoconductive surface of the sheet. Nozzle 18 sprays the sheet 1 with an insulating liquid, preferable the same as that used in the developer, but free of toner. The purpose of this spray is to wet the sheet 1 so that it will not absorb developer during development and obtain a coloration simply as a result of mechanical absorption. The structure and function of the embossing rolls 10, 10′ will be considered subsequently, after the following brief description of the developing apparatus.

From the embossing rolls, the latent image sheet 1 passes between a series of roll type development electrodes 11, 11′, 11″, and 11‴, and their respective

backing rolls 12, 12', 12'', and 12'''. The development electrodes and their backing rolls are mounted to be freely separable by an amount required by the passage of sheet 1 therebetween, such as may be obtained by mounting the axles of rolls 11–11''' so that they may move upwardly freely. Between each adjacent pair of development rolls 11–11''' is a nozzle 19, 19', or 19'' adapted to spray the image surface of the electrophotographic sheet 1 with liquid electrophoretic developer. The toner in the developer deposits on the image surface of the sheet in accordance with the electrostatic charge pattern thereon, as is well understood in the art. Rolls 11–11''' are development electrodes, and therefore they are preferably electrically conductive rolls, although they may each have an insulating surface coating, if desired. Each backing roll 12–12''' in contact with the conductive back side of sheet 1 is likewise preferably a conductive roll. When the sheet 1 emerges from the development area, it passes through the squeeze rolls 13, 13' for removal of excess developer solution.

Development electrode rolls 11–11''' should be maintained out of contact with the image surface of sheet 1 for the reasons previously explained; and at the same time, to obtain the most effective action, these rolls should be positioned very close to the image surface of sheet 1, preferably with a spacing of only about 50 to about 500 microns. The embossing rolls 10, 10' enable attainment of these results. The embossing rolls are configured to create a continuous raised embossment along the side edges of the sheet 1, i.e., the edges extending in the direction of travel of the sheet, in the marginal areas of the sheet outside the image area. The development rolls are thereby held this fixed distance away from the image surface on sheet 1. In this way, a desired close spacing of the development electrodes to the image surface of the sheet being processed can be had, with assurance that at each increment of travel of the sheet the development electrodes will be held out of contact with the image area of the sheet.

One form of embossing rolls 10, 10' is shown in FIGS. 2 and 3. As shown in the exploded view of FIG. 2, roll 10 is formed with annular groove 22 adjacent one end of the roll and an annular groove 22' adjacent the opposite end, while the companion roll 10' has a corresponding pair of mating annular protuberances or ridges 23 and 23' adjacent the ends of that roll. As shown in the sectional view of FIG. 3, when a sheet 1 is fed between these two rolls, the two longitudional marginal edges of the sheet are pressed between the ridges 23, 23' and the mating annular grooves 22, 22' to form the continuous ridges 20, 20'. The embossed ridges 20, 20' thereafter function as spacers when the sheet 1 passes between the development electrode rolls 11–11''' and their respective backing rolls 12–12''', causing the rolls 11–11''' to ride up with their floating axles to maintain a fixed spacing of the height of the embossed ridges 20, 20' from the image area between these two embossed ridges on the upper surface of sheet 1. Optimum results are obtained with embossed ridges 20, 20' having a base dimension of between about 0.2–3 mm. and a height of between about 20 microns and about 1.0 mm.

The cross sectional shape of the embossed ridges 20, 20' shown in FIG. 3 is substantially triangular. Other shapes could be employed, such as trapezoidal, shown in embossed ridges 21, 21' in FIG. 4, or the stepped embossment shown at 26, 26' in FIG. 5.

As mentioned previously, it is important that the embossing cylinder 10 that is juxtaposed with the upwardly facing image surface of the sheet 1 not discharge the electrostatic latent image charge on the sheet 1. It was therefore previously suggested that this roll be made of electrically insulating material, or that it be covered with a layer of insulating material. Alternatively, the roll 10 may be formed with a concave cylindrical surface over the portion corresponding to the image area of sheet 1, as shown in FIG. 4, thereby avoiding contact between roll 10 and the image surface of sheet 1. A similar structure is suggested as an alternative by the dotted lines 29 in FIG. 5.

The embodiments heretofore described all provide continuous embossed ridges along the edges of sheet 1. Instead of continuous ridges, the embossments may be closely spaced intermittent protuberances, such as would be obtained by using the rolls 10 and 10' illustrated in FIG. 6, having spaced knob-like protuberances 31 and 31' on roll 10' designed to mate with the correspondingly spaced depressions 30 and 30' in roll 10.

Each of the foregoing embodiments provides for the embossment of upwardly directed spacers on sheet 1, so as to maintain the development electrode rolls 11–11''' a desired distance from the image surface of sheet 1. As a further feature of the invention, this sheet embossing technique can be utilized likewise to space the back side of the sheet 1 from the backing roll 12–12'''. This result can be obtained with the embossing rolls 10 and 10' configured, for example, as shown in FIG. 7. In this embodiment the ends of roll 10 are formed both with annular recesses 32 and 32' and with annular ridges 33 and 33'. Roll 10' is likewise provided at its ends with annular ridges 34 and 34', and with annular recesses 35 and 35', which are designed to mate with the opposed ridges and recesses in roll 10. A sheet 1 pressed between these rolls will be embossed with continuous upwardly and downwardly facing continuous ridges along its opposite side edges, thereby spacing both the image and back surfaces of the sheet from the electrode rolls 11–11''' and their respective backing rolls 12–12'''. Spacing of the back surface of sheet 1 from the rolls 12–12''' protects the back surface from being smudged with toner that may accumulate on the backing rolls.

Thus, it will be appreciated that the present invention provides a convenient and economical way to insure a fixed and close spacing between an electrostatic image and the electrode elements of an electrophoretic developing system, while preventing the electrode elements from contacting the image areas. This objective is accomplished by embossing the edge portions of the electrostatic image carrier with surface projections which function as spacers to establish an appropriate spacing between the carrier and the electrode elements. It is apparent that various forms of embossments may be employed for the purposes of the present invention, and several illustrative forms have been shown. Other embossment forms, and other variations and modifications of the invention will become apparent to those skilled in the art. Accordingly, the present invention is not limited to the details of the foregoing specific embodiments, and such variations and modifications as are embraced by the spirit and scope of the appended

claims are contemplated as being within the purview of the present invention.

What is claimed is:

1. An apparatus for developing an electrostatic latent image on the image surface of a carrier with a liquid electrophoretic developer, comprising a pair of embossing elements for forming raised embossments from the image surface of said carrier along the side edges of said carrier, and a development electrode and backing element therefor between which said embossed carrier passes during development in said liquid developer, said element and electrode being mounted for freely adjustable separation therebetween, whereby said element and electrode are separated by the passage of said carrier therebetween by an amount substantially equal to the thickness of said carrier and the extent said raised embossments to space the electrode from the image surface of said carrier by the height of said embossments.

2. An apparatus as set forth in claim 1, wherein said embossing elements are a pair of embossing rolls.

3. An apparatus as set forth in claim 2, wherein said electrode and backing element are a pair of rolls.

4. An apparatus as set forth in claim 1, wherein said electrode and backing element are a pair of rolls.

5. An apparatus as set forth in claim 1, wherein said embossing elements are for forming raised embossments from both the image surface and the back surface of said carrier along the side edges thereof, whereby said backing element is also spaced from the back surface of said carrier when the carrier passes between the element and the electrode.

6. An apparatus as set forth in claim 5, wherein said embossing elements are a pair of embossing rolls.

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