

[54] TONER DISPENSING SYSTEM

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[58] Field of Search 118/7, 637; 117/17.5

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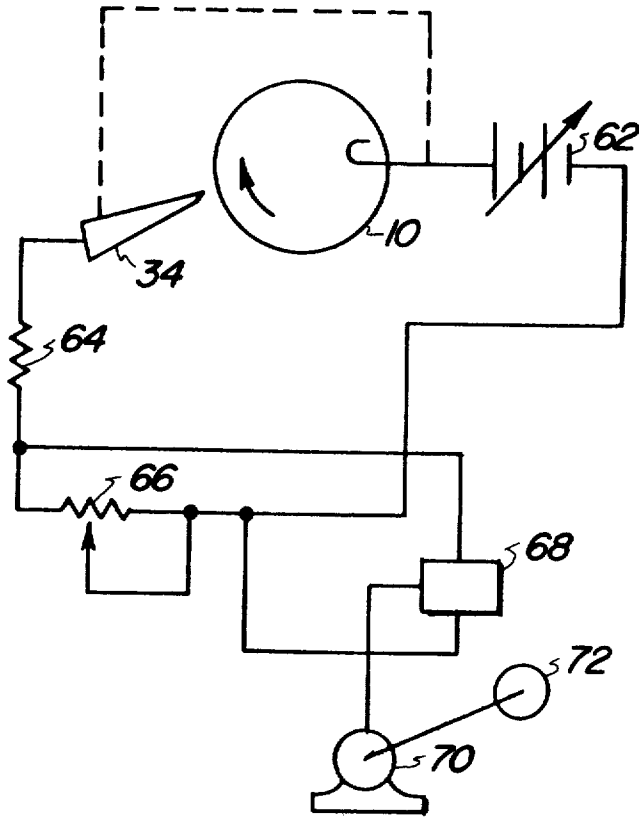
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Primary Examiner—Mervin Stein
Assistant Examiner—Douglas Salser

[57] ABSTRACT

An automatic developability control for a two-component development mixture having toner and conductive carrier. Additional toner may be supplied to the developer mixture when the ratio of toner to carrier has been depleted beyond a predetermined optimum. The developer with its conductive carrier is movable through a space where an electrical potential exists. Shorting is encountered when the toner concentration is so low that toned carrier beads will permit flows of current across the space, creating electrical shorts. Utilizing this effect, a toner dispenser may be triggered in accordance with the number of shorts per unit time.

2 Claims, 3 Drawing Figures



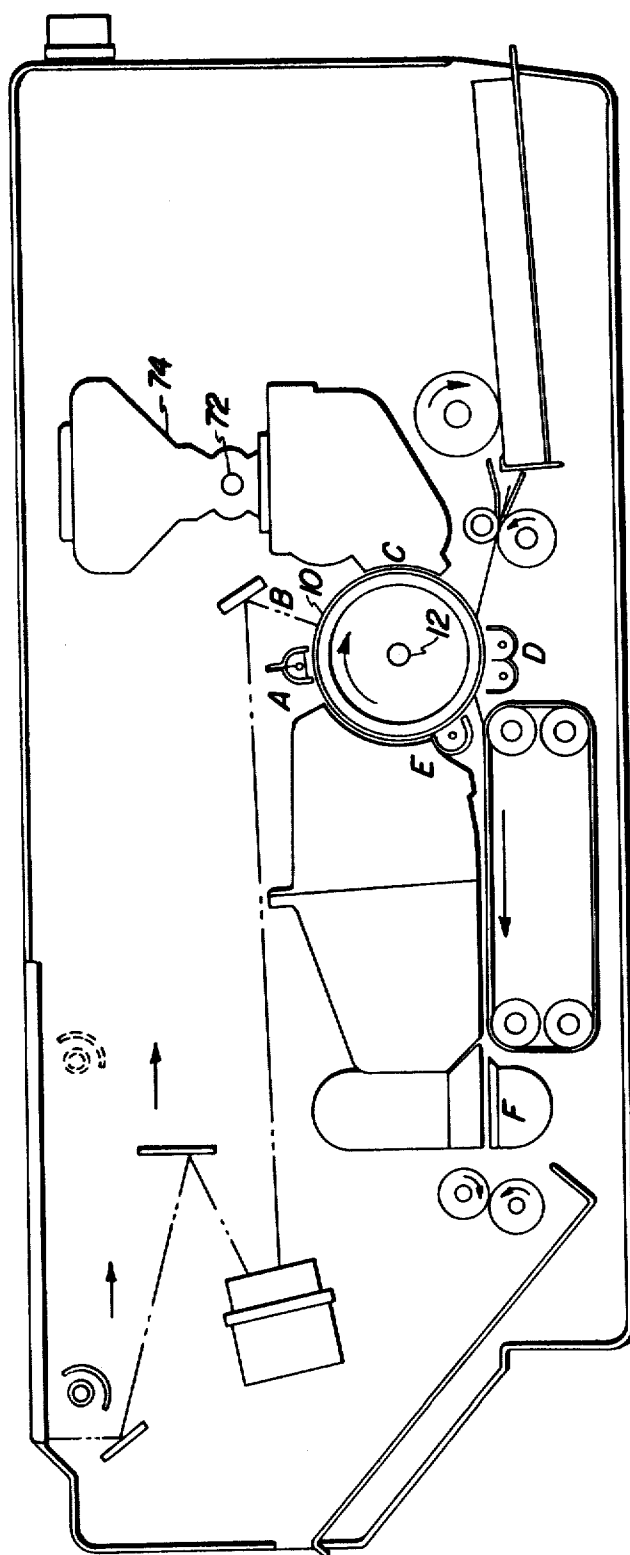


FIG. 1

TONER DISPENSING SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to xerographic development and in particular to a control adapted to sense the concentration of electroscopic toner particle in a xerographic development mixture and to dispense toner to the system in response to undertoned carrier.

More specifically, this invention relates to a control system for use with toned, electrically conductive carrier whereby toner depletions from the developer mixture may act as a sensor for determining the lack of toner and for dispensing additional toner powder into the mixture when the toner concentration is below a predetermined level.

In the process of xerography as described in U.S. Pat. No. 2,297,691 to Chester F. Carlson, a xerographic surface comprising a layer of photoconductive insulating material affixed to a conductive backing is used to support latent electrostatic images. In the usual manner of carrying out the process, the xerographic surface is electrostatically charged uniformly over its surface and then exposed to a light pattern of the image being reproduced to thereby discharge the charged surface in the areas where light strikes the layers. The undischarged areas of the layer thus form an electrostatic charge pattern in conformity with the configuration of the original light pattern corresponding to the original document to be reproduced.

The latent electrostatic image can then be developed by contacting it with a finely divided electrostatically attractable material such as powder. The powder is held in image areas by the electrostatic charge gradient on the layer. Where the charge field gradient is greatest, the greatest amount of toner material is deposited. Where the charge field gradient is the least, little or no toner material is deposited. Thus, the powder image is produced in conformity with the light image of the original being reproduced. The powder is subsequently transferred to a sheet of backing material such as paper, wherein it is affixed thereto to create the final and permanent copy.

As the toner powder in the developer mixture is depleted through the development of latent images on the xerographic plate, more toner powder must be added to maintain the desirable level of copy density. The amount of toner depletion varies with the nature of copy being reproduced. In the event that too much powder is added to the developer mixture, heavy deposits of toner in the image areas in combination with an undesirable deposit of toner in non-image areas or background areas result in producing prints of poor contrast with blotchy images or poor resolution. In addition, overtoning adds to the severity of toner powder accumulating on critical machine components in the systems. Undertoning of the developer results in undesirably light copy being reproduced. Thus, with an automatic toner powder control system incorporated in a xerographic machine to regulate the concentration of toner powder in the developer mixture, fewer service calls are necessary to keep the quality of the xerographic reproductions at a high level.

It is therefore an object of the instant invention to improve xerographic reproducing apparatus.

Another object of the instant invention is to adjust the toner concentration of two component developer in a development system.

A further object of the instant invention is to improve xerographic development by sensing the developer mixture at a time prior to its contacting the image to be developed and by adding toner to the system when depletion thereof has been sensed.

SUMMARY OF THE INVENTION

In accordance with the principles of this invention, apparatus is provided for controlling the concentration of toner powder in the developer mixture by continually inspecting and monitoring the concentration of toner powder in the mixture immediately prior to the developer being brought into contact with the latent image to be developed. The inventive apparatus provides for a continuous monitoring of the electrical conductivity of the developer mixture whereby the increase in conductivity will cause periodic shorts in a control circuit, the sensing of which is utilized as a signal to add additional toner to the system. This addition reduces the shorts and brings the concentration up to an appropriate level for high quality xerographic development.

There is provided a biased magnetic brush roll and an adjacent trimmer bar spaced therefrom. An electrical potential between these members will result in short circuits when there is moved therebetween conductive carrier granules with insufficient associated toner for optimum xerographic development. When these shorts occur over a predetermined period time, the output of the circuit can be used to activate a toner dispenser to increase toner to the system to relieve the shorts and thereby bring the toner concentration back to an optimum level.

It is therefore a feature of this invention to add toner to a developer mixture in response to electrical shorts over a period of time, which shorts are indicative of a deficiency of toner in the developer mixture.

DESCRIPTION OF THE DRAWING

The foregoing will be readily apparent from the following description of the invention when read in conjunction with the accompanying drawing wherein

FIG. 1 is a schematic side elevation of a continuous and automatic reproducing machine constructed in accordance with the principles of this invention,

FIG. 2 is an enlarged side elevational view of the development zone shown in FIG. 1, and

FIG. 3 is an electrical schematic of the circuit utilized in the FIGS. 1 and 2 hardware.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing, there is shown in FIG. 1 an illustrative embodiment of the subject invention in a suitable environment such as an automatic xerographic reproducing machine. The machine includes a xerographic plate or surface 10 formed in the shape of a drum. The plate has a photoconductive layer or light receiving surface on a conductive backing, journaled on the shaft 12 in a frame to rotate in the direction indicated by the arrow. The rotation will cause the plate surface to sequentially pass a series of xerographic processing stations. For the purpose of the present disclosure, the several xerographic processing stations in the path of movement of the plate surface may be described functionally as follows:

A charging station A at which a uniform electrostatic charge is deposited on a photoconductive plate;

An exposure station B at which light or radiation pattern of copy to be reproduced is projected onto the plate surface to dissipate the charge in the exposed areas thereof to thereby form a latent electrostatic image of the copy to be reproduced;

A developing station C at which xerographic developing material including carrier granules and toner particles having an electrostatic charge opposite to that of the electrostatic image, is brought in contact with the plate surface whereby the toner particles adhere to the latent electrostatic image to form a toner powder image in a configuration of the copy being reproduced;

A transfer station D at which the toner-powder image is electrostatically transferred from the plate surface to a transfer material or a support surface such as paper;

A drum cleaning and discharge station E at which the plate surface is cleaned to remove residual toner particles remaining thereon after image transfer and exposed to a relatively bright light source to effect substantially complete discharge of any residual electrostatic charge remaining thereon; and

A fixing station F wherein the paper and toner particles are subjected to fusing elements remote from the drum to affix the toner particles into the support material to create a permanent copy of the original.

Referring now specifically to the Figures, the apparatus of the present development system 14 includes an electrically isolated magnetic brush developing apparatus contained within a housing 16. The housing is substantially enclosed by means of end walls and a top cover plate. Preferably, at least the main housing of the developer unit and the cover plate attached thereto are fabricated of a conductive, nonpermeable material such as aluminum or the like capable of supporting an electrical bias thereon. The cover plate is adapted to cooperate with the main body of the housing to provide an elongated opening 18 in the side wall of the unit which is positioned adjacent to the moving photoconductive drum surface. The opening extends longitudinally at least across the entire photoconductive layer carried on the drum surface and provides a means through which a magnetic developing brush, which is formulated within the developer unit, can operatively communicate with the latent electrostatic image carried on the photoconductive surface.

Basically, the developer housing contains a single magnetic brush forming unit 20 which is positioned adjacent to the elongated opening 18 and a magnetic developer lifting unit 22 which is positioned directly above, and in parallel alignment with, the brush forming unit. As clearly illustrated in FIG. 2, developer material that is stored within the sump region 24 of the housing moves down into the restricted entrance region 26 to the developing zone 28 formed between a roller 30 and the complementary bottom surface 32 of the housing and is initially picked by the brush forming unit and passed through the active development zone 28. A trimmer bar 34 contacts the developer immediately prior to the developer contacting the photoconductor to accurately control the length of the developer bristles. The developer is eventually transferred to the lifting mechanism 22 which transports the material to the top of the unit. The developer material is released from the lifting mechanism and deposited upon an inclined chute 36 where, under the influence of gravity, the ma-

terial is allowed to move down the chute where it ultimately falls into a series of cross mixing baffles 38. The cross mixing baffles 38 are arranged within the developer housing to interrupt and redirect the downward flow of the developer material in order to create sufficient agitation between the toner particles and the carrier beads to triboelectrify the toner particles. They also uniformly redistribute the toner material across the entire width of the housing. Upon leaving the cross mixing baffles, the now properly charged and uniformly distributed developer material is allowed to fall back into the sump 24 where it can once again be used in the development process.

Structurally, both the magnetic brush forming unit 20 and the magnetic developer lifting unit 22 are generally made up of an outer applicator roll member 30 and 40 that is arranged to substantially enclose magnetic flux generating devices. The lower magnetic brush forming unit includes the cylindrical roll member 30 being closed and supported at both ends by means of end caps while the upper magnetic lifting roll unit is similarly constructed of a cylindrical roll member 40 being supported upon end caps. The two units are rotatably supported between the end walls of the developing system by means of similar support structure.

The lower cylindrical roll member or sleeve encompasses a magnetic brush forming unit made up of a non-permeable mounting element 42 rigidly affixed to the stationary support shaft. The mounting element carries two directional magnets, 46 and 48, a larger brush forming magnet 46 and a smaller pickup magnet 48. The brush forming magnet is positioned on the stationary shaft so that its main flux field is directed at the xerographic drum in a substantially horizontal direction. In practice, the flux field is arranged to pass through the nonpermeable roller member or sleeve 30 of the brush forming unit, through the opening in the developer housing, and then into operative communication with the moving photoconductive drum surface. The smaller pickup magnet 48 is secured to the bottom surface of the mounting element with its flux field directed toward the sump region of the developer housing. The poles of the two directional magnets are oppositely arranged in regard to the rotating sleeve. The pickup magnet is arranged so as to draw developer material from the sump and hold the material against the rotating surface of the sleeve whereby the material is brought into the developing zone. The brush forming magnet on the other hand is adapted to erect the developer material delivered into the developing zone away from the sleeve surface and direct it toward the xerographic plate where it can be used to accomplish image development.

The magnetic developer lifting unit 22 also has a series of small magnetic poles 50 arranged within the sleeve. The poles are supported in a semi-circular manner upon a conductive support bracket 52 which is affixed to the stationary support shaft 54. Each adjacent pole in the series is oppositely aligned in relation to the pole next to it whereby a series of relatively strong magnetic links are provided extending from approximately a 6 o'clock sleeve position to about an 11 o'clock sleeve position. Because of the pole arrangement, a magnetic network is formed about the outer periphery of the rotating nonpermeable sleeve member that is capable of securely holding developer material against the sleeve in a manner that enables the sleeve to carry

the material upwardly to the top of the developer housing. The flux fields associated with both the magnetic brush forming unit and the magnetic developer lifting unit are coupled together within the regions separating the two units so that the developer material being moved out of the developing zone by sleeve 30 is magnetically transferred to the lifting unit sleeve 40 without the need for resorting to bulky mechanical handling devices and the like.

In operation, the cylindrical sleeve 30 associated with the magnetic brush forming unit 20 is driven sequentially through the developer sump and the active development zone. In the sump region, the developer material is attracted into contact with the rotating sleeve surface by means of the pickup magnet provided. The material is then carried on the surface of the rotating body into the main flux field of the brush forming magnet wherein the developer particles are caused to align themselves along the main lines of flux to form a brush-like structure. Because of the magnet arrangement, the brush fibers extend outwardly through the developer housing into operative communication with the rotating photoconductive drum surface. As the xerographic drum rotates in the direction indicated, the brush fibers are caused to be drawn over the photoreceptor as it is moved through the development zone. As a consequence, toner particles are electrically transferred from the brush fibers to the imaged regions on the plate by means of the classical magnetic brush developing mechanism, thereby rendering the images visible. The developer material continues to move through the active development zone and is brought into the developer exit region in close proximity with the lifting unit sleeve. Here, the developer material moves across the magnetic bridge linking the two units and is secured against sleeve 40 which, in turn, carries it to the top of the developer housing and deposits it upon the inclined chute. As previously noted, the chute directs the developer material into the cross mixing baffles where it is subsequently returned to the developer sump region.

An electrical force field is used in conjunction with a magnetic brush forming flux field to enhance the developability of the magnetic brush system to assist in sensing toner depletion. Conventionally, an electrode is generally placed within the active development zone in close proximity to the xerographic plate surface and an electrical bias having a potential somewhere close to the background potential recorded on the plate surface is applied thereto. Background is a term of art used to define those regions on the photoconductive plate which, although carrying a weak potential, nevertheless contain no input scene information. Although these specific background regions are reduced to a relatively low charge potential during the xerographic exposure process, they can, under certain conditions, attract and hold randomly dispersed toner particles that are brought in contact therewith. By biasing the development electrode to a potential somewhat greater than the background potential found on the plate surface, an electrical force field is established within the development zone which tends to pull toner away from the plate when a background region is moved there-through, thereby suppressing background development. When a latent image is brought into the development zone, the image force field becomes the dominant factor in the system and the toner in this region is attracted toward the plate. During the image develop-

ment, the development electrode also cooperates with the xerographic plate to contour the electrical fields associated with the latent electrostatic image and thus enhance the developability of the system, particularly with regard to the ability of the system to develop large solid areas of charge.

As shown in FIG. 2, a trimmer bar 34 is positioned a predetermined fixed distance from the developing roll. The trimmer bar is electrically conductive and isolated electrically from the developer housing by appropriate insulating barriers 60. It is coupled electrically with the magnetic brush development roller by the circuit of FIG. 3. Such bias from potential source 62 is normally of an electrical potential substantially equal or slightly above background areas of the latent electrostatic image on the drum, i.e., about a positive 350 volts.

Within the circuit coupling the trimmer bar and the magnetic brush roller is a limiting resistor 64 which according to the instant embodiment is of a 47K ohm value coupled in series with a 10K ohm variable resistor 66 functioning as a potentiometer. The variableness of this resistor 66 gives a variable time constant in the circuit when measuring shorts across the gap between the trimmer bar and magnetic brush roller. Also coupled in the circuit directly to the magnetic brush roller is the positive potential power supply 62. This assists in creating the above-referred-to development electrode effect for the development of the image and provides the potential source for permitting the flow of current in the form of shorts across the gap to the trimmer bar.

In determining the characteristics of the system, a cathode ray oscilloscope and counter was placed in parallel one with another and parallel with the potentiometer whereby the shorting phenomenon could be observed and counted in order to optimize the characteristics of the instant invention. According to the preferred instant embodiment, however, a suitable RC time constant circuit 68 was utilized to activate a motor 70 to drive the automatic toner dispenser shaft 72 to add toner to the system in response to a predetermined number of measurable shorts occurring across the gap in a given time.

The excess toner is stored in container 74, the lower portion of which is open and located in communication with the sump 24 immediately above chute 36. The opening in the container has an open cell polyurethane foam roller fixedly supported on shaft 72. Rotation of shaft 72 by motor 70 thus moves toner from the container to above the chute, thereby permitting the dispensing of toner from container 74 to the undertoned developer mixture through the action of gravity. Toner is added to the mixture by this action to replace that toner lost from the mixture through the normal development of images.

As can be understood, as the electrically conductive carrier granules are appropriately triboelectrically coated with plastic toner marking particles, no current flow can jump the gap between the biased roller and the trimmer bar. Consequently, no shorts will occur and none will be measured on the short sensing circuit. Even if small numbers of shorts do occur in limited quantities as can occur by the uneven distribution of toner through the development system, these shorts will be of such small magnitude as not to be counted in sufficient number within a particular period of time to activate the toner dispenser motor.

If, however, the shorts are of sufficient magnitude and come with a predetermined frequency such shorting will activate the counter circuit 68 to thereby actuate the toner dispenser motor 70 to rotate shaft 72 to dispense toner into the development system. The number and frequency of electrical shorts are inversely proportional to the amount of toner in the developer mixture and directly proportional to the conductivity of the developer contacting the trimmer bar which acts as a sensor.

It is apparent that the counter circuit bridges the potentiometer resistor of the system in such fashion that current can flow through the resistor or through the counter circuit and since the potentiometer is variable, a sufficient degree of latitude may be worked into the system for a wide range of toners and/or gap sizes. The optimum gap size for the disclosed embodiment is between 0.040 and 0.045 inches.

Although now shown, the counter circuit could be a conventional flip-flop timing circuit so that if more than a predetermined number of shorts per unit time occurs the toner dispenser motor is activated to dispense toner into the system for a predetermined period of time. So long as shorting continues to occur, the toner dispenser motor continues to run until the toner deficiency situation is alleviated through a proper toner concentration having been attained.

While the instant invention has been disclosed as being carried out in a specific embodiment thereof, it is intended to cover the invention broadly within the scope of the appended claims.

What is claimed is:

1. In a magnetic brush development system wherein a two-component developer, including conductive carrier particles and thermoplastic resinous toner particles adhering thereto tribo-electrically, is brought into contact with a photoreceptive surface to be developed under the effect of a magnetic field generated by a magnetic brush roller, the improvement comprising, conducting means spaced from said magnetic brush roller by a predetermined gap through which the magnetically conveyed developer is passed, means to bias the magnetic brush roller, circuit means coupling said biased magnetic brush roller with said conducting means, means responsive to shorts caused by undertoned carrier passing through said gap to determine the level of toner in the developer mixture, and means to dispense additional toner into the developer mixture in response to a predetermined number of shorts per unit time.

2. The structure as recited in claim 1 wherein said conducting means is a trimmer bar.

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