Nov. 8, 1966 E. H. LEHMANN 3,284,224

CONTROLLED XEROGRAPHIC DEVELOPMENT

Filed Jan. 4, 1963 2 Sheets-Sheet 1

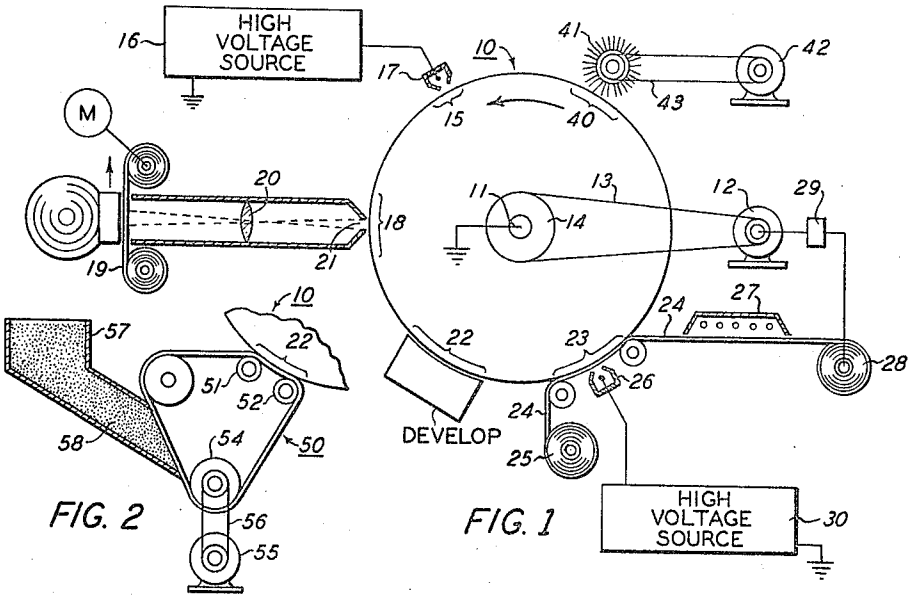


FIG. 1

FIG. 2

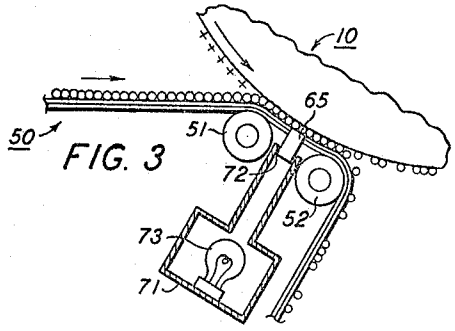


FIG. 3

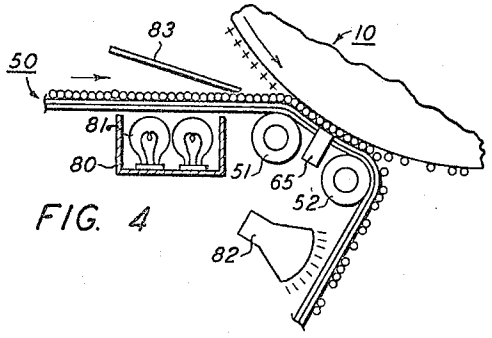


FIG. 4

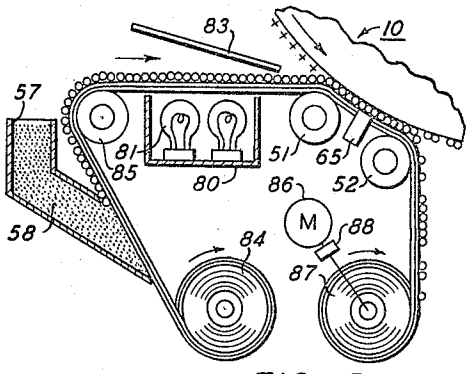


FIG. 5

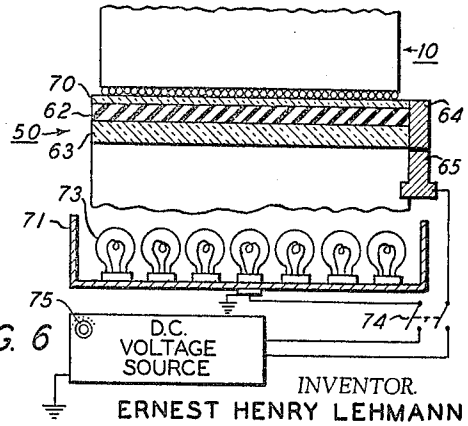


FIG. 6

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CONTROLLED XEROGRAPHIC DEVELOPMENT

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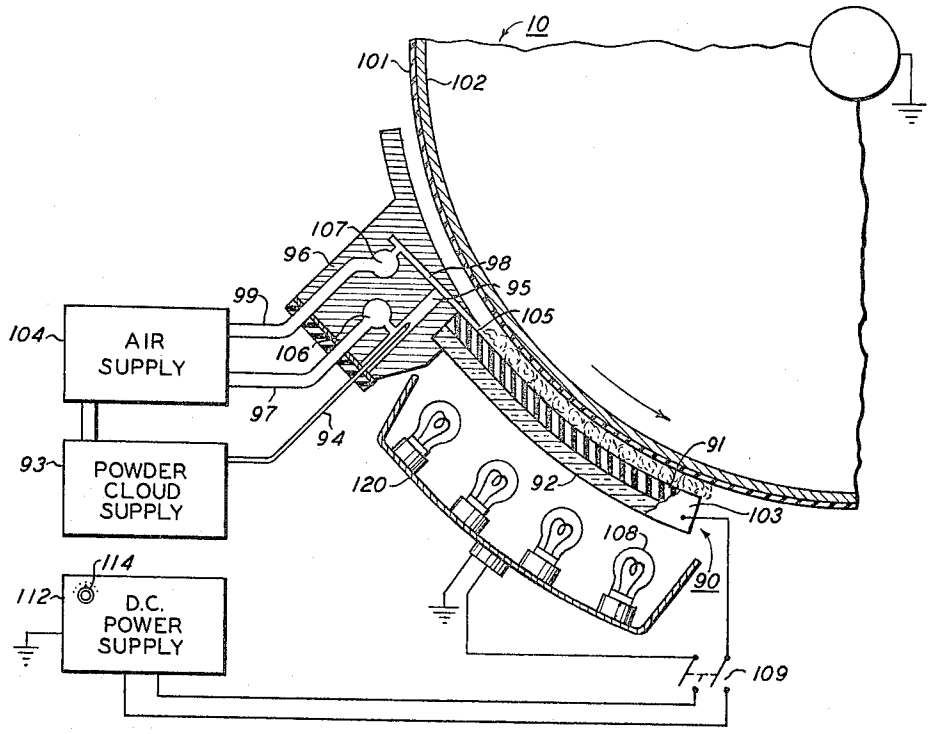


FIG. 7

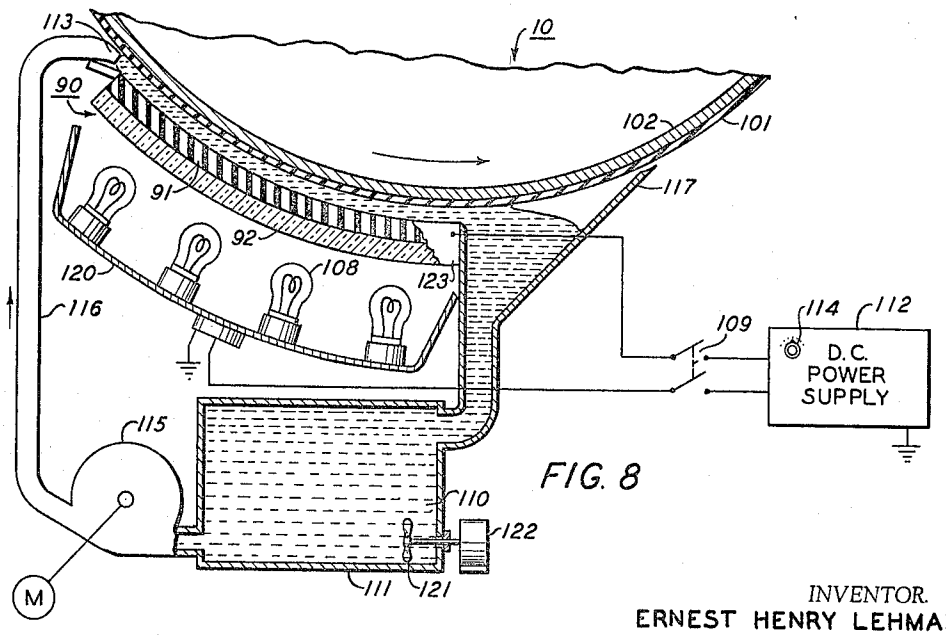


FIG. 8

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CONTROLLED XEROGRAPHIC DEVELOPMENT

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Filed Jan. 4, 1963, Ser. No. 249,482
16 Claims. (Cl. 117—17.5)

This invention relates to xerography and particularly to improvements for developing electrostatic latent images.

In the process of xerography, for example, as disclosed in Carlson Patent 2,297,691, issued October 6, 1942, a xerographic plate comprising a layer of photoconductive insulating material on a conductive backing is given a uniform electric charge over its surface and is then exposed to the subject matter to be reproduced, usually by conventional projection techniques. This exposure discharges the plate areas in accordance with the radiation intensity that reaches it, and thereby creates an electrostatic latent image on or in the photoconductive layer. Development of the latent image is effected with an electrostatically charged, finely divided material such as an electroscopic powder, that is brought into surface contact with the photoconductive layer and is held thereon electrostatically in a pattern corresponding to the electrostatic latent image. Thereafter, the developed image may be fixed by any suitable means to the surface on which it has been developed or may be transferred to a secondary support surface to which it may be fixed or utilized by means known in the art.

Whatever method is employed for forming electrostatic images, they are usually made visible by developing. Various developing systems are well known and include cascade, brush development, magnetic brush, powder cloud, and liquid development, to name a few. In connection with these various development systems, it is known that a conductive control electrode as, for example, disclosed in U.S. 2,808,023, U.S. 2,777,418, U.S. 2,573,881 and others, is highly effective in influencing electrostatic gradients to develop images having various shades and having relatively large solid areas. At the same time, when developing images generally devoid of solid areas and consisting primarily of line copy images, superior results are generally obtainable without the electrode in place.

Another developing method, as disclosed in Mayo patent U.S. 2,895,847, employs a support member such as a web, sheet or other member termed a "donor" which carries a releasable layer of electroscopic marking particles to be presented into close contact with an image bearing plate for deposit in conformity with the electrostatic image to be developed. In connection with this development system, it has recently been discovered that the sheet comprising the donor can be utilized to act as a control electrode. That is, with a donor that is relatively conductive when presenting toner into contact with an electrostatic latent image, it is much more effective than an insulating or highly resistive donor for developing images having relatively large solid areas as well as the various gradations in tone commonly found in continuous tone images. At the same time, when developing images generally devoid of solid areas and gradations in tones and consisting primarily of line copy images, superior results occur when developing with a relatively more resistive donor sheet material than that employed for solid area development.

Prior attempts to provide development flexibility on a practical basis for development of any kind of image have not met with success. This has resulted in limitations on the usual copying system since material to be reproduced cannot be copied in random order.

Now in accordance with the instant invention, there is provided novel method and apparatus adapted to afford control over development properties in accordance with the area characteristics of the latent image to be developed. In accordance with the invention, control is achieved employing an electrode comprising a radiation sensitive photoconductive insulating material and controlling its development electrode effects by exposure to appropriate radiation applied in accordance with development requirements. This affords an expedient and inexpensive solution to overcome the difficulties encountered heretofore while at the same time, enhanciing the latitude and versatility of these various development systems.

It is, therefore, an object of the iinvention to provide a novel control electrode for development of xerographic images.

It is a further object of the invention to provide novel method and apparatus for controlling electrical fields effecting development in a xerographic development system.

It is a further object of the invention to provide novel method and apparatus to adapt xerographic development systems for selective development control over area characteristics of electrostatic images to be developed.

It is a still further object of the invention to provide novel method and apparatus for effecting increased development versatility of a xerographic donor-type development system.

These and other objects of the invention are achieved in accordance with the embodiments of the invention which are exemplified by the following drawings in which:

FIG. 1 schematically illustrates an automatic xerographic apparatus employing development;

FIG. 2 illustrates the donor-type development system as adapted to FIG. 1 in accordance with the prior art;

FIGS. 3, 4 and 5 illustrate three different embodiments in accordance with the invention by which the donor-type development system is improved;

FIG. 6 sectionally illustrates the structure of the donor member for controlling electrical properties of the embodiments;

FIG. 7 sectionally illustrates a powder cloud developing apparatus utilizing the electrode structure of the invention; and

FIG. 8 sectionally illustrates a liquid developing apparatus utilizing the electrode structure of the invention.

Referring now to FIG. 1, there is illustrated a continuous machine adapted to form a xerographic print on a sheet or web member. The apparatus includes a xerographic plate in the form of a cylindrical drum **10** which comprises a photoconductive insulating peripheral surface on a conductive substrate. The drum is mounted on an axle **11**, journalled for rotation, and driven by a motor **12** through belt **13** connected to pulley **14** secured to the shaft **11**.

Positioned adjacent to the path of motion of the surface of the drum **10** is a charging station **15** comprising, for example, a positive polarity corona discharge electrode **17** consisting of a fine wire suitably connected to a high voltage source **16** of potential high enough to cause a corona discharge from the electrode onto the surface of drum **10**. Subsequent to the charging station **15** in the direction of rotation of the drum is an exposure station **18** generally comprising suitable means for imposing a radiation pattern reflected or projected from an orignial copy **19** onto the surface of the xerographic drum. To effect exposure, the exposure station is shown to include a projection lens **20** or other exposure mechanism as a conventional in the art, preferably operating with slit projection methods to focus the moving image at the exposure slit **21**.

Next subsequent to the exposure station is a developing

station generally designated **22** as will be further described. Beyond the developing station is a transfer station **23** adapted to transfer a developed image from the surface of the drum to a transfer web **24** that is advanced from a supply roll **25** into contact with the surface of the xerographic drum at a point beneath a transfer electrode **26**. After transfer, the web desirably continues through a fusing or fixing device **27** onto a take-up roll **28** being driven through a slip-clutch arrangement **29** from motor **12**. Desirably, electrode **26** has its corona discharge electrode operably connected to a high voltage source **30** of like polarity with respect to high voltage source **16** whereby a powder image developed on the surface of the drum is transferred to the web surface. Fusing device **27** permanently fixes the transferred powder image on the web to yield a xerographic print.

After transfer, the xerographic drum **10** continues to rotate past a cleaning station **40** at which residual powder on the drum surface is removed. This may include, for example, a rotating brush **41** driven by a motor **42** through a belt **43** whereby the brush bristles bear against the surface of the drum to remove residual developer powder therefrom. Optionally, further charging means, illumination means, or the like may effect electrical or control operations.

At the developing station in accordance with the embodiment of FIG. 2, there is included a donor member **50** in the form of an endless belt, as will be further described, adapted to pass over a pair of insulating rollers **51** and **52** between which the donor member comes into firm surface contact against the surface of the rotating xerographic drum **10**. Movement of the donor member is effected by means of a drive roller **54** being driven by a motor **55** operating through a belt **56**, preferably to drive the belt in the same direction as the surface rotation of the xerographic drum. The speeds of the donor member and drum may be substantially the same or the donor member can travel at surface speeds as high as 5 to 10 times as fast as the peripheral speed of the drum to effect a skidding or sliding action. Thus, there is maintained between donor member **50** and drum **10** a continuous contact. When a sliding action is used a dual purpose of ensuring an extremely quick contact between all points of the surface of the drum and the donor member, while further bringing to each point of the drum surface a substantially greater quantity of developer material than is carried by any one point on the surface of the donor member.

Adjacent to one portion of the path of motion of the developer donor member **50** is a powder loading station which may, for example, comprise a developer hopper **57** containing a quantity of developing powder which may, for example, be a form of two-component developer mixture as disclosed in Walkup and Wise Patent U.S. 2,638,416. The hopper opens against the donor member, whereby the belt passes in contact with the developer supply and is coated uniformly with the toner powder component of the mixture as the belt passes upwardly against the developer. Other belt loading mechanisms and developer compositions may, of course, be employed including dusting, brushing, or the like.

Referring now to the improvement of the invention as will be described in conjunction with the embodiments of FIGS. 3, 4, and 5, each are to be separately considered in combination with the sectional view illustrated in FIG. 6. As will be understood, the difference between the embodiments is principally in the recovery or regeneration properties associated with the photoconductive insulating materials employed in the donor member.

As is well known in the art, the photoconductive insulator employed for the purpose of xerographic reproduction, as on drum **10**, must be characterized by the property of being electrically insulating in the dark. With this property, the photoconductor can retain an applied electrical charge for a time period at least sufficient to be developed with an electroscopic developing material. Thus, the photoconductor or photoconductive insulator on drum **10** may include, for example, vitreous selenium, zinc oxide in a suitable binder such as silicone or such other well-known photoconductors such as anthracene, sulphur, or the like and as will be further described below. Generally speaking, these photoconductive insulators while in the dark have a resistivity on the order of 10^{13} ohm centimeters and above and when exposed to radiation to which the photoconductor is sensitive, the resistivity is reduced about three orders of magnitude.

The donor member of this invention functions to furnish developer to the photoconductor of drum **10**. Photoconductors suitable for use in the donor member in accordance with the invention are characterized by a surface resistivity which may be changed from more than about 10^{14} ohms per sq. to less than about 10^{12} ohms per sq. by irradiation. Suitable photoconductors include vitreous selenium, zinc oxide, cadmium sulfide, cadmium selenide, gallium phosphide, lead oxide, mercuric sulphide, anthracene, phthalocyanine, and many other organic aromatic organic compounds, such as are well known in the art. To render any of these flexible, as for the embodiment of FIG. 2, they may be mixed with a binder material and supported on a flexible substrate. Alternatively, certain of these (such as vitreous selenium, phthalocyanine, and most of the aromatic organic compounds) may be deposited by vacuum evaporation on the donor substrate. Other suitable photoconductors for this purpose may include cast photoconductive resin films such as the polycarbonates as, for example, disclosed in Miller et al. U.S. Patent 2,999,750; cloth or paper impregnated with photoconductors such as anthracene; and photoconductors in selected binders including, for example, about 3 parts or more of ZnO French Process to about 1 part of a polyvinyl resin.

For clarity of distinction in the discussion to follow, the photoconductive insulator of the donor member will be hereafter termed the "donor-photoconductor" while the photoconductive insulator on xerographic drum **10** will be termed the "xerographic-photoconductor."

Consider now the embodiments of FIGS. 3 and 6, in which there is illustrated fragmentary views of the donor member as it will be employed in the operable embodiment of FIG. 2. For the purpose of this particular embodiment, it is preferred that the donor-photoconductive layer **62** be characterized by either low light fatigue or be capable of rapid regeneration to quickly recover its relatively insulating characteristics after passing through the development zone. With these characteristics, the donor member can be continually recycled and selectively rendered conductive when required for development. For example, vitreous selenium recovers in a matter of seconds without the necessity of regeneration while cadmium sulphide can be regenerated in about one minute by the application of infrared heat to its surface.

As shown, the donor member **50** comprises a donor-photoconductive layer **62** as aforesaid supported on a substrate **63** which may be any generally electrically insulating flexible translucent or transparent material such as the plastics. Mylar has been found suitable for this purpose. Secured along one edge of the donor-photoconductor and in electrical contact therewith is a continuous conductive strip **64** extending the full length of the donor member. Adapted to contact the conductive strip during development is a conductive shoe **65** to which a suitable potential from a power supply **66** can be selectively connected as will be understood. Where desired as for the protection of the donor-photoconductor or to obtain a properly oriented triboelectric relationship between the developing material and the donor surface, the donor-photoconductor can be overcoated with any film-forming dielectric material **70** whose triboelectric properties are such as to charge the toner particles to the desired polarity, either positive or negative. Ma-

terials known to be useful as coatings for carrier beads in the cascade development process are also useful as overcoatings for the donor-photoconductor. Suitable materials include, for example, the coating compositions listed in U.S. Patent 2,618,551.

In addition, certain other materials are useful; for example, a styrenebutyl methacrylate based toner may be charged negative by the use of a poly(vinyl acetate) type resin, such as Geon latex 970–X11 manufactured by the B. F. Goodrich Company.

As described in connection with FIG. 2, the donor member **50** supports a layer of developer on the surface in advancing over the insulating guide rolls **51** and **52** to present the developer into contact with the peripheral surface of the image-bearing xerographic photoconductive surface on drum **10**. For line copy development for which it is preferred that the donor member be relatively insulating, development takes place with the donor-photoconductor employed in its more resistive state.

To render the donor-photoconductor relatively more conductive, where required to effect solid area development, there is arranged a substantially light-tight box **71** having an exposure slit **72** in close proximity to and arranged transversely to the surface of the substrate material **63**. Contained within the box is a plurality of spaced lamps **73** adapted to emit radiation of wave length to which the donor-photoconductor is sensitive. From slot **72** the radiation is transmitted through the substrate onto the surface of the donor-photoconductor to render conductive the entire portion of donor-photoconductor moving therepast and which is immediately opposite the xerographic photoconductor. The lamps are energized by closing a double-pole switch **74**, one contact of which connects to the lamps and the other of which is connected to a shoe **65** through a potentiometer **75**. Along the line of illumination from the slot **72**, it is believed that the lines of force of the latent image contained on the drum **10** are caused to be directed generally in perpendicular relationship to the image surface and to the donor member **50**. This results in uniform adherence of the developer powder from the donor surface over the image area and produces a uniformly dark or concentrated image with lines that are not diffused. By comparison, when the donor-photoconductor is in its more resistive state, it is belived that only the lines of force from the edges or outer portions of wide or solid image areas extend upward from the image surface, curving back to the adjacent discharged or background areas to effectively develop the edge only. Lines of force associated with the inner portions of solid areas of charge are directed downward to the supporting substrate to be less effective for area development resulting in a lack of uniformity in development of solid areas. These effects are further described in an article by Schaffert entitled "The Nature and Behavior of Electrostatic Images" published in Photographic Science and Engineering, vol. 6, No. 4.

The potential imposed through the shoe **65** may be controlled through a potentiometer **75** and is preferably of the same polarity as the polarity of the charged image areas on the drum **10** while of a voltage usually greater than that retained in the discharged or background areas. This is to prevent fields of force in the background areas and to prevent particle deposition in these same areas.

Obviously the choice of radiation to activate the donor-photoconductive layer will depend upon the choice of donor-photoconductor and the wave length of radiation to which it is sensitive. As, for example, vitreous selenium is sensitive generally in the blue and green part of the spectrum and when doped with arsenic or tellurium has increased spectral sensitivity to about 7,000 angstroms. Opacity of the donor-photoconductor does not usually cause any difficulty. All photoconductors have an intrinsic region of strong light absorption, with extinction coefficients in excess of 10^4/cm. This applies to selenium at wave lengths below about 5500 A.U., ZnO at wave lengths below 3900 A.U., phthalocyanine between 3300–3900 and 6500–7200 A.U. Therefore any practical layer of donor-photoconductor will absorb substantially all radiation within these regions and none will be transmitted through the donor to expose the drum. The donor, therefore, acts as selective filter for radiation which is intensely absorbed by it. It is, therefore, feasible to use a photocondutor on the donor having a sensitivity identical to that of the drum—provided there is filtered out of the donor illumination all weakly absorbed light which could be transmitted by the donor and absorbed by the xerographic photoconductor. As an alternative, of course, it is possible to use photoconductors of different wave length sensitivities for donor and drum, provided the donor light source, its color filter, and the donor-photoconductor itself (which acts as an additional filter) do not transmit to the drum any radiation to which the latter is sensitive. The following table lists a few practical examples of combinations of photoconductors for drum and donor which are usable in the different embodiments described herein:

TABLE I.—PHOTOCONDUCTORS FOR DRUM AND DONOR MEMBERS—PART I

Drum P.C.	Wavelength Region of Sensitivity	Donor P.C.
Selenium	U.V.–5500 A.U.	Selenium.
Do	U.V.–5500 A.U.	ZnO.
Do	U.V.–5500 A.U.	Phthalocyanine.
Selenium sensitized with tellurium.	U.V.–6800 A.U.	ZnO (unsensitized).
Phthalocyanine	3000–3800 A.U. 6400–7200 A.U.	ZnO.
Poly(vinyl carbazole) sensitized with rose bengal dye.	U.V.–6000 A.U.	Phthalocyanine.
ZnO sensitized with fluorescein dye.	U.V.–5500 A.U.	ZnO (unsensitized).
Do	U.V.–5500 A.U.	Phthalocyanine.

PART II

Wavelength Region of Sensitivity	Suitable Light Source for Donor	Wavelength Region for Illum. of Donor
U.V.–5500 A.U.	"Blacklight" fluorescent with purple (BLB) filter.	λ<3900 A.U.
U.V.–3900 A.U.	do	λ<3900 A.U.
3000–3800 A.U. 6400–7200 A.U.	Ruby red incandescent (safelight).	λ>6200 A.U.
U.V.–3900 A.U.	"Blacklight" fluorescent with purple (BLB) filter.	λ<3900 A.U.
U.V.–3900 A.U.	do	λ<3900 A.U.
3000–3800 A.U. 6400–7200 A.U.	Ruby red incandescent (safelight).	λ>6200 A.U.
U.V.–3900 A.U.	"Blacklight" fluorescent with purple (BLB) filter.	λ<3900 A.U
3000–3800 A.U. 6400–7200 A.U.	Ruby red incandescent (safelight).	λ>6200 A.U.

Thickness of the donor-photoconductive layer is largely a function of the selected donor-photoconductor and its particular properties. Vitreous selenium gives acceptable results in the range of about 0.1 to about 40 microns of thickness, subject to limitations imposed by the brittleness of the layer and the minimum radius of curvature of the donor belt. The usual range for this material is about 0.5 to 5μ. Suitable thicknesses for binder layers including, for example, crystalline selenium, zinc oxide, and various organic photoconductors, range from about 0.1 to 40μ and above but preferably are between about 1 and about 10μ.

Referring now to FIGS. 4 and 6, there is disclosed a second embodiment in accordance with the donor belt embodiment of this invention. The embodiment hereof differs from the latter primarily in the characteristic of the choice of donor-photoconductor. Here, the donor-photoconductor is one having a relatively higher light fatigue so that it can be rendered conductive on exposure to actinic radiation in advance of the development zone and will retain its conductivity through the development step.

For this embodiment, the donor-photoconductors which fit this category include the phosphors such as zinc cadmium sulphide phosphor or zinc cadmium selenide phosphor, either or others of which can be regenerated by means of an infrared lamp as disclosed, for example, in Kallman Patent U.S. 2,845,348.

Therefore, in accordance with the above, there is included a donor member **50** which may be endless and which is loaded with developer as aforesaid for presentation against the photoconductive surface of drum **10**. A box or the like, **80**, containing lamps **81** emitting radiation to which the donor-photoconductor is sensitive, is located preceding the development zone in the direction of donor movement to be irradiated and rendered conductive prior to entering the development zone. The lamps are similarly connected as described above in connection with FIG. 3 through a switch **74** which also connects a potential through a shoe **65** to the side strip **64**.

Following development, the donor web is conveniently exposed to an infrared lamp **82** that may be continuously energized or alternatively energized in conjunction with lamps **81**. Others regeneration methods can be employed. Suitable time delays may be incorporated into the circuit to sequentially defer the disconnection of shoe **65** and lamp **82** after lamp **81** is de-energized. A shield **83** prevents any stray light or transmitted radiation from lamps **81** from reaching the surface of drum **10**.

Yet, another donor belt embodiment is illustrated in FIG. 5 which, in combination with FIG. 6, illustrates a donor member containing a donor-photoconductor having a relatively high light fatigue which may be of an expendable or reusable form that may be recycled but preferably is not. Donor-photoconductors which fit this category include various forms of commercially marketed zinc oxide papers and which may be dyed to be rendered sensitive to various wave lengths of radiation. One particularly valuable material for this use is more fully described in Jones copending application, Serial No. 813,242, filed May 14, 1959, now U.S. Patent 3,077,398. This particular layer is capable of being uniformly loaded and results in high quality development. A dyed layer which is quite useful in accordance with this invention is more fully described in Jones copending application, Serial No. 786,975, filed January 15, 1959.

As shown in FIG. 5, a supply of donor member **80** from supply roll **84** is continually drawn by means of a motor **86** connected to take-up roll **87** through a slip-clutch arrangement **88**. The donor web moves past developer hopper **57** over guide roll **85**. After passing guide roll **85**, the donor web can be rendered semi-conductive before entering the development zone similarly as described above in connection with FIG. 4, and after passing the development zone is optionally brushed then wound onto take-up roll **87**. After exhausting the supply of donor web from supply reel **84**, it can be removed from the apparatus, cleaned and stored, if required, to recover its more highly resistive properties while a fresh or recovered supply is inserted to continue operations. Well-known forms of zinc oxide frequently take as long as a few hours to effect a complete recovery. Occasional grounding or charging of the donor-photoconductor in the absence thereof may be required over long periods of operation.

Referring now to FIG. 7, there is illustrated the control electrode of the invention as it is utilized in a powder cloud development system. As there shown and as further described in Hayford Patent U.S. 2,808,023, the control electrode is closely spaced to the drum surface comprising a photoconductor **101** on a conductive substrate **102** to influence image charge gradients thereon. The control electrode is here designated **90** and has a radius emanating from the same axis as the drum in order to geometrically conform to the periphery thereof. The electrode is spaced as close to the drum periphery as feasible to permit developer to flow therebetween. As described above in connection with the above embodiments, the control electrode comprises a photoconductive insulating material **91** contained and supported on a translucent or transparent substrate **92** shown herein to have a conductively connected side strip **103** to which a reference voltage can be connected.

The powder cloud originates from a supply **93** wherefrom it feeds through capillary tubes **94** to a feed slot **95** in the manifold block **96** where additional air fed from air supply **104** through tube **97** is mixed with the powder cloud in the feed slot. The feed slot, in turn, carries the powder cloud now containing additional air to the manifold floor **98** where additional air from the tube **99** is again added to the powder cloud to result in the powder cloud being admitted to the development zone from the manifold block through the entrance slot **105** in approximately laminar flow. The chambers **106** and **107** are expansion chambers which act as reservoirs for the additional air thereby helping to smooth out any fluctuation in pressure in the air supply and assure the same amount of flow from each supplementary air duct. As the powder cloud passes through the capillary tubes, the particles are charged to a desired voltage through the triboelectric contact of the powder particles with the walls of the capillaries. The cloud thereafter flows in the space between the control electrode and the drum surface to effect development of the images thereon.

As before, relative conductivity of the electrode in order to achieve development control over the areas of image charges is instituted by energizing and de-energizing of lamps **108** in a shield **120** via a switch **109** which also simultaneously applies a desired reference potential to the photoconductive material from the power supply **112** having a potentiometer setting **114**. By this means, therefore, control over development can be achieved when desired or required in accordance with the area characteristics of the image to be developed. Where substantially black on white such as line copy is to be developed, the lamps are de-energized and the electrode essentially constitutes an unaffecting electrically insulating surface spaced from the drum periphery.

Referring now to FIG. 8, a control electrode similar to FIG. 7 is utilized in a liquid development system in which a liquid of high electrical resistance containing solid developer particles are presented to the drum periphery for development of images thereon. The developer liquid **110**, which may, for example, be of a type disclosed in Mayer copending application, Serial No. 380,285, filed September 15, 1953, is contained in a reservoir **111** wherefrom it is pumped via a suitable pump **115** through conduit **116** to be discharged from a nozzle **113** in a manner to flow in surface contact between the control electrode and the drum surface. An agitator **121** operated by motor **122** maintains the developer constantly stirred in the liquid. After effecting development, the developer liquid flows into a funnel member **117** to return by gravity to the reservoir. Where development is effected by passing a xerographic plate in contact with or immersed in the liquid, the control electrode may similarly be immersed and operative as above. A reference potential is connected to a conductive strip **123** contacting the length of the photoconductor and control over developed image characteristics by means of the control electrode is achieved in a similar manner as described in connection with FIG. 7.

By the above description, there is disclosed novel method and apparatus by which the utility of control electrodes for development of xerographic images is enhanced and the versatility of the xerographic art is extended. In accordance with the invention, a control electrode that includes an appropriately selected radiation sensitive photoconductive material can be rendered selectively conductive in accordance with the area characteristics of the latent image to be developed. Whereas utility for automatic operation is primarily emphasized, it is not intended

to constitute a limitation since the same described materials, the same principle of illumination and substantially the same operations can be carried out in a largely hand-development step in which positioning or movement of the respective components are effected by hand. Similarly, whereas donor, powder cloud, and liquid have been particularly described as development systems with which the invention can be employed, it is not intended that these systems should constitute utility limits thereof but rather it is intended to encompass all development systems with which it is known in the art to employ a control electrode for developing images on a xerographic plate or any other surface bearing the image as is well known in the art. Furthermore, while persistent semiconductive photoconductors have been specifically mentioned, the invention is intended to also encompass persistently polarized photoconductors or electrets as, for example, disclosed in Kallman Patent U.S. 3,005,707 whereby control of development is achieved with a prepolarized control electrode.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that this description shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. Developing apparatus for the development of electrostatic latent images comprising in combination:

(a) support means to support an image bearing member having on its surface an electrostatic latent image;

(b) means to present developer marking material to the latent image on said member to deposit thereon and effect development;

(c) a control member characterized a changeable electrical property changeable uniformly in response to operation of external control means and supported independent of said developer presentation means spaced closely substantially parallel to the surface of said image bearing member on its support means, said control member being adapted to affect area deposition of developer being presented to said image bearing member for development as a function of its electrical property uniformly current during development; and,

(d) external control means adapted to be actuated selectively in accordance with the area properties of an image to be developed for operation on said control member to effect a uniform property condition thereof during development most appropriate for the area properties of the image.

2. The apparatus according to claim 1 wherein the developer marking material comprises a dispersion in a highly insulating liquid.

3. The apparatus according to claim 1 wherein the developer marking material comprises a cloud-like mass presented in a pressurized aerosol flow.

4. In a xerographic apparatus including developing means to develop an electrostatic latent image formed on an image bearing surface wherein said developing means includes means to present a developer material against the surface on which the formed electrostatic image is to be developed; a development control member supported independent of said developer presentation means and closely spaced to said image bearing surface opposite the area whereat developer material is being presented, said control member being characterized having the capability when subjected to an external control means of being rendered uniformly more electrically conductive in areas subjected thereto; and control means adapted to be actuated selectively for operation on said control member in accordance with area characteristics of said image whereby to effect increased conductivity thereof uniformly in at least portions of said control member from which developer is being presented to the electrostatic image to be developed.

5. In the apparatus according to claim 4 wherein said control member includes a layer of photoconductive insulating material and said control means includes a source of radiation to which said photoconductive insulating material is sensitive.

6. In the apparatus according to claim 5 including means to apply a reference potential to the photoconductive insulating material.

7. In a xerographic apparatus including developing means to develop an electrostatic latent image formed on the surface of a xerographic plate wherein said developing means comprises a donor member supporting on its surface a distributed quantity of electroscopic powder, and means to present the powder on said donor member into face-to-face contact against the surface on which the formed electrostatic image is to be developed; the improvement comprising:

(a) a donor member capable of selectively being rendered uniformly more conductive in response to operation of a control means; and,

(b) control means supported adjacent said donor member and adapted to be selectively operable on said donor to control the conductivity of said donor member uniformly in areas in which the powder thereon is presented to the electrostatic image to be developed.

8. In a xerographic apparatus including developing means to develop an electrostatic latent image formed on the surface of a xerographic plate wherein said developing means comprises a donor member supporting on its surface a distributed quantity of electroscopic powder, and means to present the powder on said donor member into face-to-face contact against the surface on which the formed electrostatic image is to be developed; the improvement comprising:

(a) an elongated donor member;

(b) said donor member including a layer having photoconductive insulating material characterized by having increased electrical conductivity on exposure to radiation; and,

(c) control means comprising a radiation source adapted to be selectively operative in accordance with the area properties of an image to be developed to emit radiation onto said photoconductive insulating layer whereby to control the conductivity of said donor member uniformly in area in which the powder thereon is presented to the electrostatic image to be developed.

9. In a xerographic apparatus including developing means to develop an electrostatic latent image formed on the surface of a xerographic plate wherein said developing means comprises a donor member supporting on its surface a distributed quantity of electroscopic powder, and means to present the powder on said donor member into face-to-face contact against the surface on which the formed electrostatic image is to be developed; the improvement comprising:

(a) an elongated donor member;

(b) said donor member including a composition of photoconductive insulating material characterized by having increased conductivity on exposure to radiation;

(c) control means comprising a radiation source adapted to be selectively operative in accordance with area properties of an image to be developed to emit radiation onto said photoconductive composition whereby to control the conductivity of said donor member uniformly in areas in which the powder thereon is presented to the electrostatic image to be developed; and,

(d) means to apply a reference potential to the photoconductive composition while in its more conductive state in said face-to-face contact.

10. In a xerographic apparatus including developing means to develop an electrostatic latent image formed on the surface of a xerographic plate wherein said developing means comprises a donor member supporting on its surface a distributed quantity of electroscopic powder, and means to present the powder on said donor member into face-to-face contact against the surface on which the formed electrostatic image is to be developed; the improvement comprising:

(a) an elongated donor member;

(b) said donor member including a layer of photoconductive insulating material characterized by having increased electrical conductivity on exposure to actinic radiation; and,

(c) control means comprising a radiation source adapted to be selectively operative in accordance with area properties of an image to be developed to emit radiation onto said photoconductive insulating layer uniformly in areas in which the powder thereon is presented to the electrostatic image to be developed.

11. In a xerographic apparatus including developing means to develop an electrostatic latent image formed on the surface of a xerographic plate wherein said developing means comprises a donor member supporting on its surface a distributed quantity of electroscopic powder, and means to present the powder on said donor member into face-to-face contact against the surface on which the formed electrostatic image is to be developed; the improvement comprising:

(a) an elongated donor member;

(b) said donor member including a composition of photoconductive insulating material characterized by having increased electrical conductivity on exposure to radiation and which conductivity persists for a time period after exposure to radiation; and,

(c) control means comprising a radiation source adapted to be selectively operative in accordance with area characteristics of said electrostatic image to emit radiation onto said photoconductive insulating composition uniformly in areas thereof supporting powder for presentation and within said time period prior to the powder thereon being presented to the electrostatic image to be developed.

12. The improvement according to claim 11 including means to connect a reference potential to said photoconductive insulating material while the powder thereon is being presented to the electrostatic image to be developed.

13. The improvement according to claim 12 including means operable after development to regenerate the photoconductive insulating material from its more conductive state to its more resistive state.

14. A method of developing an electrostatic latent image previously formed on the surface of an image-bearing member comprising:

(a) placing a control member spaced closely substantially parallel to the surface of the image bearing member and which control member is characterized by a changeable electrical property when activated by an applied external control;

(b) presenting a quantity of developer material between the control member and the image bearing member to effect development of the latent image on the image bearing member; and

(c) during said last-recited step selectively applying said control to activate said control member uniformly to an electrical state capable of affecting a more uniform developer deposition on the latent image than when the control member is inactivated.

15. The method according to claim 14 wherein said control member includes a photoconductive insulating material and said applied control includes application of radiation from a source adapted to render the control member relatively conductive.

16. The method according to claim 15 including the additional step of applying a reference potential to the photoconductive insulating material of the control member concomitantly with application of said control.

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