April 2, 1968 L. N. NOST 3,375,806

XEROGRAPHIC DONOR DEVELOPMENT APPARATUS

Filed May 6, 1965 2 Sheets-Sheet 1

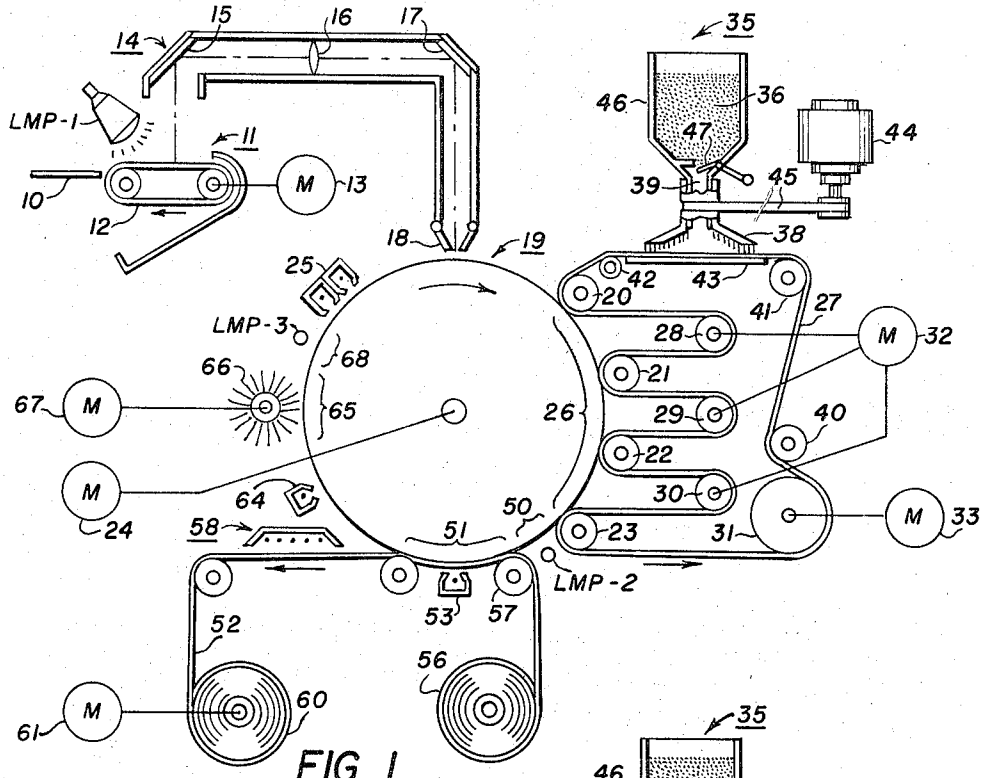


FIG. 1

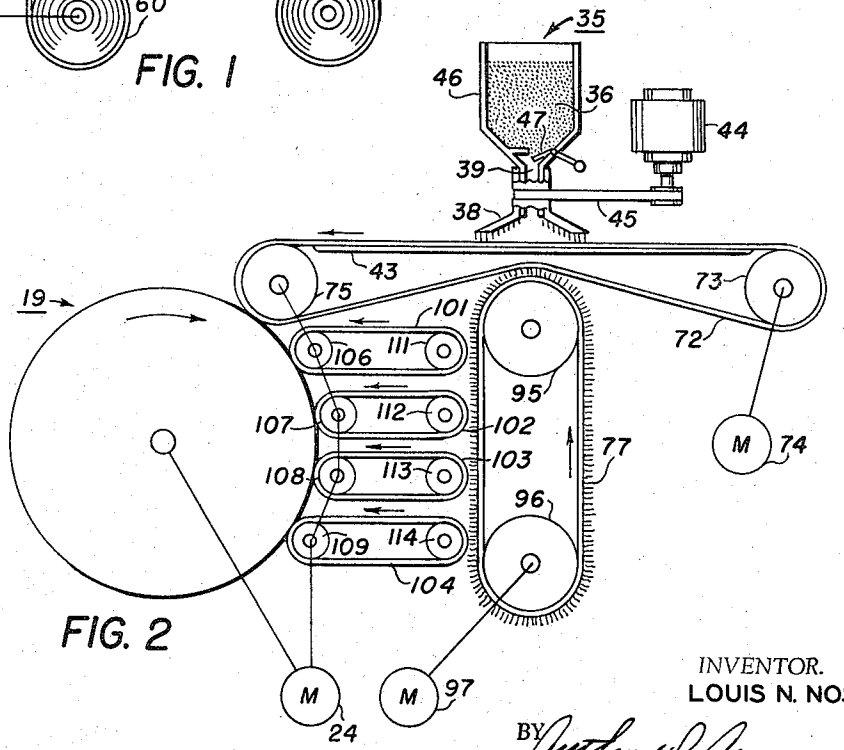


FIG. 2

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XEROGRAPHIC DONOR DEVELOPMENT APPARATUS

Filed May 6, 1965 2 Sheets-Sheet 2

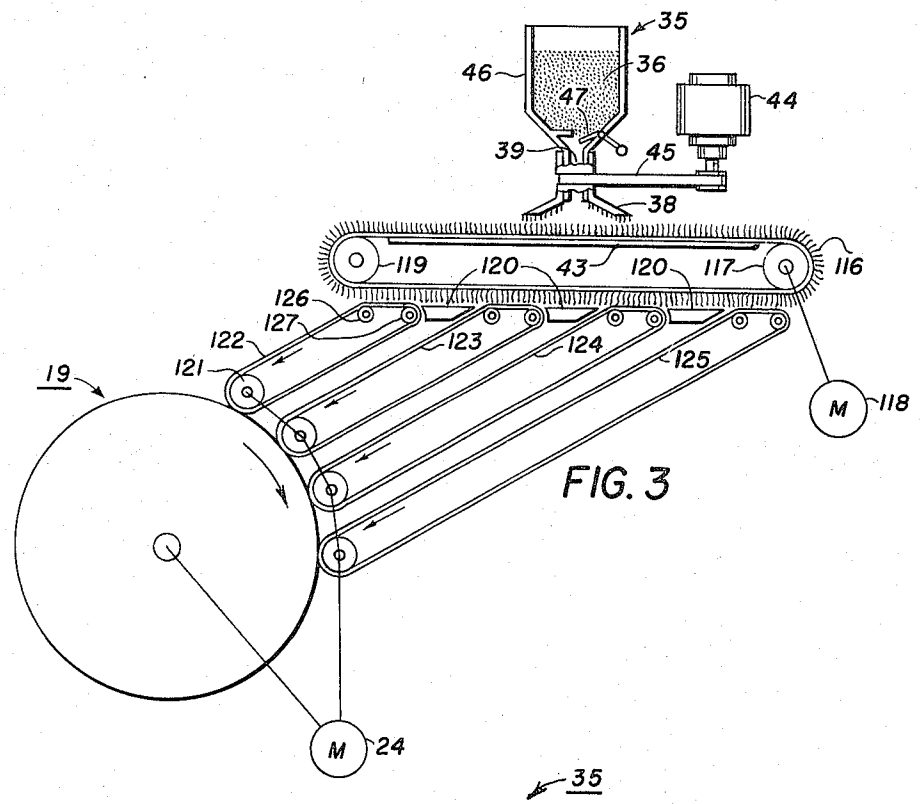


FIG. 3

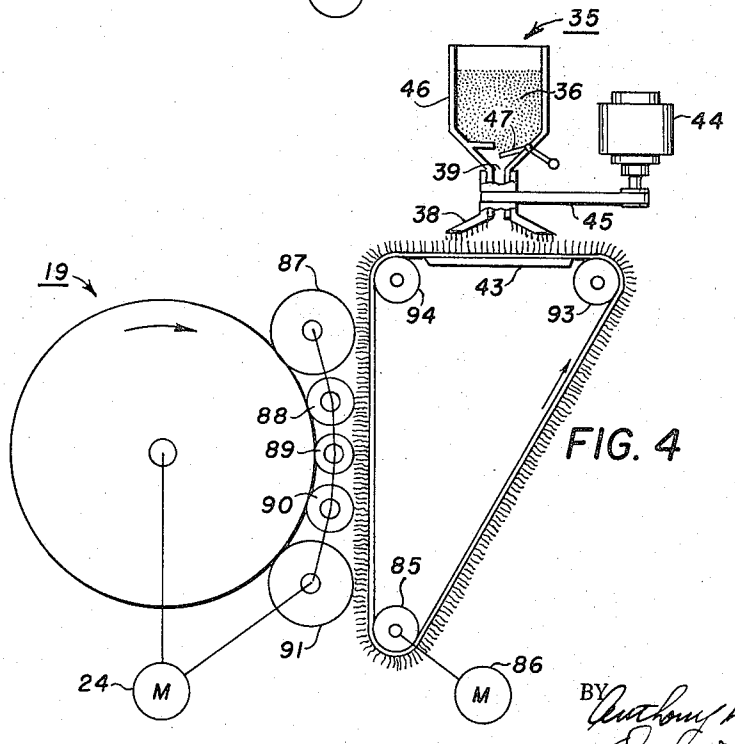


FIG. 4

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XEROGRAPHIC DONOR DEVELOPMENT APPARATUS

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14 Claims. (Cl. 118—637)

ABSTRACT OF THE DISCLOSURE

Apparatus for developing latent electrostatic images on a moving xerographic plate in which electroscopic powder marking particles are uniformly loaded onto donor means and transported by the donor means into contact with the moving xerographic plate at a plurality of different locations positioned serially along the periphery of the xerographic plate.

This invention relates to xerography and, in particular, to novel apparatus for developing electrostatic images of copy.

In the process of xerography, for example, as disclosed in Carlson Patent 2,297,691, issued Oct. 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 a latent electrostatic 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 selective pattern corresponding to the latent electrostatic 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 in the art and include cascade, brush development, magnetic brush, powder cloud, and liquid development, to name a few. Still another developing method is disclosed in Mayo Patent 2,895,847 in which a support member such as a web, sheet or other member termed a "donor" is employed to present a releasable layer of electroscopic marking particles to the plate for deposit thereon in conformity with the electrostatic image.

These various development systems, including the donor method of Mayo, while each offering specific advantages for particular developing situations, also have their limitations. For example, the generally advantageous method of cascade development depends on gravity-flow, thus imposing physical limitations on its position within the apparatus and requiring elevating means to transport the developer from a supply to a release position. The donor method has been found generally advantageous for developing electrostatic images offering the advantage of a more controlled presentation of developer to the xerographic plate without the physical limitations imposed by the cascade system. Despite the advantages afforded thereby, the donor method has been handicapped by the inability to effect high image density and print contrast as compared to results with the cascade system and efforts to overcome these difficulties have been generally unsuccessful.

Now in accordance with the present invention there is provided novel donor type development apparatus which substantially improves image density and contrast of developed images as compared to the prior art. With the apparatus hereof, it is possible to develop prints of high image density and contrast by apparatus designed to present large quantities of developer to the image bearing surface in a controlled and uniform manner. Because of its enhanced development properties, this apparatus is rendered suitable for use in automatic copying machines which operate at high rates of speed, and without the attendant handicaps associated with prior art devices.

The problems associated with prior art donor development devices and processes are therefore overcome in accordance with the apparatus of the present invention in which a moving, powder-bearing donor member effects development by a series of repetitive contiguous approaches to the image areas of an advancing xerographic plate. Each approach may comprise actual contact or a close spacing to within about 300 microns between the developer surface and the image areas of the xerographic plate. After each approach and before the next, redistribution means and/or supplemental powder loading means respectively redistribute remaining powder and/or additionally load the donor uniformly. This acts to renew the depleted donor surface prior to a subsequent approach by increasing the quantity and the distribution uniformity of the developer powder for presentation to the latent image.

Accordingly, it is an object of the invention to provide novel apparatus to effect improved development of electrostatic images.

It is a further object of the invention to provide novel apparatus for improving donor type development in the process of xerography.

It is a still further object of the invention to provide donor type development apparatus able to produce prints of improved image density and contrast as compared to prior art donor development apparatus.

It is a still further object of the invention to provide donor type development apparatus adapted for high speed, automatic operation.

For a better understanding of the invention as well as other objects and further features thereof, reference is made to the following detailed description to be read in connection with the accompanying drawings in which:

FIG. 1 is a schematic side elevation of an automatic xerographic copying machine employing a first development apparatus embodiment of the invention; and,

FIGS. 2, 3, and 4 are schematic side elevations of additional embodiments for effecting development in accordance with the invention hereof.

For a general understanding of the xerographic processing system in which the invention is incorporated, reference is had to FIG. 1 in which the various system components are schematically illustrated as in all xerographic systems based on the concept disclosed in the above-cited Carlson patent, a radiation image of copy to be reprodced is projected onto the sensitized surface of a xerographic plate to form an electrostatic latent image thereon. Thereafter, the latent image is developed with an oppositely charged developing material to form a xerographic powder image corresponding to the latent image on the plate surface. The powder image is then electrostatically transferred to a support surface to which it may be affixed by a fusing device whereby the powder image is caused permanently to adhere to the support surface.

In the illustrated xerographic apparatus, original copy to be reproduced is placed on a support tray **10** from which it is fed onto a transport apparatus generally desig-

nated **11**. On the transport apparatus, the original is moved on an endless belt **12**, driven by motor **13**, to pass the optical axis of projection lens system **14** that is illuminated by projection lamp LMP–1. The image of the original is reflected by a mirror **15** through an adjustable objective lens **16** and then reflected by mirror **17** downwardly through a variable slit aperture assembly **18** and onto the surface of a xerographic plate in the form of drum **19**.

Xerographic drum **19** includes a cylindrical member mounted in suitable bearings in the frame of the machine and is driven in a clockwise direction by a motor **24** at a constant rate that is proportional to the transport rate of the original, whereby the peripheral rate of the drum surface is identical to the rate of movement of the projected radiation image. The drum comprises a layer of photoconductive material on a conductive backing that is sensitized prior to exposure by means of corona generating device **25**, which may be an adaptation of the type disclosed in Vyverberg Patent No. 2,836,725 that is energized from a suitable high potential source.

Exposure of the drum surface to the radiation image discharges the photoconductive layer in the area struck by radiation whereby there remains on the drum a latent electrostatic image in image configuration corresponding to the radiation image projected from the original.

As the drum surface continues its movement, the latent electrostatic image passes through developing station **26** whereat the latent image is developed by a first embodiment for developing in accordance with the invention as will be described below.

After development, the xerographic powder image passes a discharge station **50** at which the drum surface is illuminated by lamp LMP–2 whereby residual images on the non-image areas of the drum surface are completely discharged.

Thereafter, the powder image passes through an image transfer station **51** at which the powder image is electrostatically transferred to a moving support surface **52** by means of a second corona generating device **53** similar to corona charging device **25**, mentioned above.

The moving support surface **52** to which the powder image is transferred may be of any convenient type, such as paper, and may be obtained from a supply roll **56**, fed over guide roll **57** and over suitable tensioning rolls being directed into surface contact with the drum in the immediate vicinity of transfer corona generating device **53**. After transfer, the support surface **52** is separated from the drum surface and guided through a fusing apparatus **58** wherein the powder image is permanently affixed thereto. Thereafter, the support surface may be fed over a further system of guide and tensioning rolls, and onto a take-up roll **60** that is driven through suitable drive means by motor **61**.

After separation of the support surface **52** from the drum, a corona generating device **64** directs electrostatic charge to the residual power image on the drum surface. Thereafter, the xerographic drum surface passes through a cleaning station **65** whereat its surface is brushed by a cleaning brush assembly **56**, rotated by a motor **67**, whereby residual developing material remaining on the drum surface is removed. The drum surface then passes through a second discharge station **68** at which it is illuminated by a fluorescent lamp LMP–3, whereby the drum surface in this region is completely flooded with light to remove any electrostatic charge that may remain thereon. Suitable light traps are provided in the system to prevent any light rays from reaching the drum surface, other than the projected image during the period of drum travel immediately prior to sensitization by corona generating device **25** until after the drum surface is completely passed through the developing station **26**.

Referring now to the embodiment of the developing apparatus as illustrated in FIG. 1, the apparatus is comprised of an endless powder bearing donor belt **27** which is caused to advance by means of motor **33** and drive roller **31** through a series of sinous bends into and out of contiguous approaches to the surface of the rotating xerographic drum. The belt **27** may be electrically conductive or insulating within ranges to be described and may comprise most any material flexible and durable enough to be formed into an endless belt. The belt may comprise such materials as metal sheets, conductive rubbers, paper, Mylar (a durable film of polyethylene terephthalate resin), or the like, governed by such other factors such as cost, availability, useful life, etc. It was found that all types of copy including line copy, continuous tone, half tone and solid area are satisfactorily developed with belt materials having an electrical resistivity generally not more than 10^8 ohm centmeters. With electrical resistivity of from about 10^8 to 10^{12} ohm centimeters, and above, good quality line copy reproductions are produced while continuous tone and half tone reproductions experience decreased quality at the higher resistivities.

Before the belt **27** is presented to the drum surface it is initially loaded with a thin, uniformly distributed, releasable layer of electroscopic marking particles **36**, which may be of the general composition and nature as described in Carlson Reissue 25,136. Loading can be effected by various techniques known in the art such as wiping, brushing, cascading or the like. In a preferred manner in accordance herewith, loading is effected by means of a device **35** comprised of a circular brush **38** rotated symmetrically about its vertical axis by motor **44** and drive belt **45** while belt **27** passes about supporting rollers **41** and **42** and supporting platen **43**. The brush is funneled about its center portion **39** to which marking particles **36** are dispensed from a stationary feed hopper **46**. The hopper outlet is mounted coaxial with the brush at which there is included a gate **47** to supply controlled quantities of marking particles to the bristles thereof and which in turn apply the particles to the surface of the donor belt as it passes below in its rotating, scuffing action therewith. With the constant relative movement between the brush and belt the particles are uniformly distributed onto the belt surface. Brushes of diameters from about 8 to 12 inches with rotational rates of from about 45 to 68 r.p.m. distribute the particles at rates of between about 0.2 to 2.0 milligrams per square cm. at belt speeds up to about 50 inches per second.

After passing from the loading apparatus **35**, the belt enters the developing station **26** as it passes about roller **20** to effect a first contiguous approach to image areas on the drum surface. Thereafter, the belt approaches the drum surface repetitively as it passes over rotating guide rollers **21**, **22** and **23**, angularly displaced about the drum circumference juxtaposed thereto. Intermediate each pair of the aforesaid rollers serving to direct the belt in its sinuous, tortuous path of drum approaches are off-set guide roller brushes **28**, **29** and **30** driven by motor **32**. The latter guide rollers rotate at a peripheral rate slightly greater or less than the travel rate of the belt as to produce a relative surface motion therebetween effective to uniformly redistribute the remaining developer powder on the belt surface. This ensures uniform powder distribution for the next approach to the drum surface. Optionally, a hopper similar to feed hopper **46** can be positioned to supply marking particles onto brushes **28**, **29**, and **30** for reloading the donor belt as the brushes rotatingly brush thereagainst.

Guide rollers **20**, **21**, **22** and **23** are preferably surface layered with an elastomeric material such as a ⅛ inch layer of polyurethane flexible foam, on a supporting substrate such as aluminum. This aids in providing for substantially uniform pressures across the width of the donor belt where it directly contacts the image areas on the drum. When electrically conductive, the rollers can conveniently be biased to a voltage of opposite polarity as that of the toner marking particles in order to suppress background charge and prevent its development. Brushes

28, 29 and 30 are comprised of a supporting roller surface having bristles or the like, such as lambs wool or a synthetic material such as nylon (a generic term for a series of polyamide resins made by the polymerization of a hexamethylene-diamine salt of adipic acid), arnel (cellulose triacetate yarns and fibers), dacron (a synthetic fiber made by the condensation of dimethyl terephthalate and ethylene glycol), or viscose (fibers of regenerated cellulose).

By the embodiment thus described a donor belt in passing about appropriately positioned guide rollers is caused to move into a plurality of sequential contiguous approaches with the drum surface, as previously described, in order that each incremental image area thereon receives marking particles on a corresponding number of occasions. After passing out of each approach, the belt is advanced into brushing contact with the intermediate brushes which effect uniform redistribution of the powder particles on the belt surface. This re-forms a uniform releasable layer of particles to renew the depleted surface and provide an optimum condition for the next approach. Whereas four approaches are illustrated the actual number can be made to vary with requirements such as speed, density and the like.

In FIG. 2, there is illustrated a second embodiment of donor development apparatus in accordance herewith. As there shown, a plurality of individual endless separately loaded donor belts are advanced into and out of contiguous relation with image areas to present particles for selective transfer. Loading of each belt is generally effected by means of two intermediate belts which receive marking particles from apparatus **35**. The first of the intermediate belts is a main duster belt **72** similar to belt **27** and which is advanced by drive roller **73**, driven by motor **74** in the direction shown into brushing contact with brush **38** of loading apparatus **35** and becomes loaded with marking particles similarly as above. The belt is then advanced around roller **75** optionally into a contiguous approach to the drum surface.

The second of the intermediate belts is duster belt **77** likewise similar to belt **27** and having a surface of fibrous or bristle material such as that described on the surface of offset brushes **28**, **29** and **30** of FIG. 1. The belt is advanced by drive roller **96**, powered by motor **97** around roller **95** into a scuffing, brushing, particle transferring contact with main duster belt **72** to uniformly receive particles from belt **72**.

Belt **77**, after being uniformly loaded with marking particles from belt **72**, advances in turn into loading contact with each of the individual endless donor belts **101**, **102**, **103** and **104** to effect the uniform distribution of particles thereon. This distribution is effected in the region where the individual donor belts pass over their respective support rollers **111**, **112**, **113** and **114**. Each donor belt passes endlessly over its respective guide and supporting rollers which are selectively spaced to provide proper belt tension.

Each of the individual donor belts **101**, **102**, **103** and **104** is similar to belt **27**. After being loaded from belt **77**, the surface of each donor belt passes continuously into and out of contiguous relation with the drum surface by guide rollers **106**, **107**, **108** and **109**, respectively, similar to the guide rollers **20** through **23** illustrated in FIG. 1. As each donor belt passes about its guide roller contiguous to the drum surface, powder marking particles thereon are selectively transferred from the surface thereof to image areas on the drum. Portions of each belt, depleted by virtue of image development, are then advanced away from the drum toward their rear support roller to be reloaded with a uniform distribution of powder marking particles by means of belt **77**. This re-forms a uniform releasable layer of particles to renew the depleted surface and to ready the same surface area for the next approach.

In FIG. 3 there is illustrated still another embodiment in accordance with the invention wherein a duster belt **116**, is advanced by drive roller **117**, powered by motor **118**, to pass over supporting plate **43** in brushing contact with brush **38** of a loading apparatus **35**. The latter belt advances around tension and support roller **119** to pass into loading contact with the horizontal portions of the individual donor belts **122–125** as they pass over their respective guide rollers **126** and **127**. Fillets **120**, supported in the frame of the copying machine facilitate the movement of the duster belt **116** as it advances sequentially past each of the donor belts, preventing indiscriminate dusting of particles throughout the machine.

Each of the belts after loading advance over their respective guide rollers **121** driven by motor **24** in a counterclockwise direction to effect the contiguous approach of the advancing belt portions similarly as above. Portions of each belt depleted by virtue of development are then advanced away from the drum toward their supporting and tensioning rollers to be uniformly reloaded by belt **116**. This as before re-forms a uniform releasable layer of particles to renew the depleted surface and to ready the same surface area for the next approach.

In FIG. 4, there is illustrated still another developing apparatus embodiment wherein loading belt **84** is advanced endlessly in a counterclockwise direction by drive roller **85**, powered by motor **86**, in a directional path formed by the relative positions of the drive roller and supporting and tensioning rollers **93** and **94**. Loading apparatus **35**, similar to that described before, loads marking particles onto a duster belt **84**, supported by plate **43** in the loading region. After being loaded belt **84** passes in loading contact with donor members in the form of rollers **87**, **88**, **89**, **90** and **91**. The duster belt effects particle loading onto each of the rollers in a uniform endless layer for presentation to the image bearing drum surface.

The donor rollers, comprised of a surface material of the general nature of endless donor belt **27**, are rotated via motor **24** and are supported as to effect the contiguous approach of powder on its surface with the surface of the drum. Depleted surface areas of each roller are rotated away from the drum toward belt **84** to be reloaded with powder marking particles on the roller surface. This, as before, re-forms a uniform releasable layer of particles to renew the depleted roller surface and to ready the same surface area for the next approach.

Above are described apparatus embodiments for effecting improved donor development of latent electrostatic images on a moving xerographic plate to result in reproductions of improved image density and contrast as compared to prior art devices and further adapted for high speed automatic operation. In the various embodiments, the speed of the donor belts or rollers relative to the speed of the xerographic drum surface is commonly 1:1 to effect a touchdown contiguous relation between image areas and the donor surface. However, the two speeds may be different to effect a slipping contiguous relation between image areas and the donor surface.

By the above description, there is disclosed improved donor development apparatus. By means thereof a large quantity of toner marking particles is presented controllably and uniformly to image areas on a xerographic plate. Print development is effected by a plurality of repetitive, contiguous approaches by a toner loaded donor member to all the image areas on a moving xerographic plate. By the invention herein, the image density and contrast of donor developed prints is improved over prior art donor development methods and apparatus to compare favorably with the high quality prints developed by, for example, the cascade method.

While the invention has been described with reference to the details and construction herein illustrated, it is not intended to be confined to the exact mechanism shown. It is intended to cover such modifications or departures as may come within the purposes of the invention and the scope of the following claims.

What is claimed is:

1. In a xerographic reproduction apparatus wherein latent electrostatic images of copy are formed on the surface of a moving xerographic plate, developing apparatus to render the latent images visible, said developing apparatus comprising in combination,

an endless elongated donor member on which to support a uniformly distributed quantity of electroscopic marking particles for developing image patterns on the surface of said plates,

loading means containing a supply of said electroscopic marking particles for loading uniformly onto the surface of said donor member,

donor support means providing a sinuous arrangement for said donor member and including a first plurality of support members secured contiguously juxtaposed to the plate surface, and a second plurality of support members each intermediate each pair of said first recited members and spaced away from the plate sufficient to off-set the donor member therefrom,

particle distribution means located at the off-set of said donor member on its support for uniformly distributing marking particles on the donor surface thereat, and

drive means to continuously advance said donor member past said loading means and over said donor support means to present the particles to the image bearing surface of said moving xerographic plate as it advances over said first plurality of support members.

2. Apparatus according to claim 1 wherein said particle distribution means forms said second plurality of support members and comprises rotating brush means in brushing contact with the particle bearing surface of said donor member.

3. In a xerographic reproduction apparatus wherein latent electrostatic images of copy are formed on a moving xerographic plate, developing apparatus to render the latent images visible, said developing apparatus comprising in combination,

a plurality of spaced apart endless elongated donor members on which to support a uniformly distributed quantity of electroscopic marking particles for developing image patterns on the surface of said plate,

loading means containing a supply of said electroscopic marking particles for loading uniformly onto the surface of each of said donor members,

donor support means for each of said donor members and including a first support means positioned contiguous to the surface of the xerographic plate and second support means spaced away from the plate surface, and

drive means to continuously advance each of said donor members past said loading means and about their respective support means to present the particles thereon to the plate from the position on said first donor support means.

4. The apparatus according to claim 3 in which said loading means includes a loading member passing in simultaneous contact with each of said donor members on their supports.

5. Apparatus according to claim 3 in which said marking particle loading means includes,

a supply source of marking particles,

a first moving endless belt,

a means to dispense electroscopic marking particles from said supply source onto the surface of said first moving belt, and

a second moving endless belt to receive electroscopic marking particles from said first moving belt and load said particles onto said donor members brushing thereagainst.

6. Apparatus according to claim 5, in which said dispensing means includes a conical brush member rotating about an axis extending perpendicular to the path of said first moving belt and in brushing contact with the surface thereof.

7. In a xerographic reproducing apparatus of the type wherein latent electrostatic images of copy are formed on a moving xerographic plate, developing apparatus for rendering the latent images visible, said developing apparatus comprising in combination,

donor means for transporting uniformly distributed electroscopic powder marking particles contained thereon into contact with said moving xerographic plate at a plurality of different locations positioned along the periphery of said xerographic plate,

loading means including a source of supply for uniformly depositing electroscopic powder marking particles onto said donor means,

means for dispensing electroscopic powder marking particles from said source of supply and for depositing said particles onto said donor means including a conical brush member in communication with said source of supply, said conical brush member being adapted for rotation about the vertical axis thereof, and

drive means operatively connected to said donor means for continuously advancing said donor means whereby to bring successive areas therealong into contact with said loading means and said xerographic plate.

8. Apparatus according to claim 7, said dispensing means further including transport means intermediate said brush member and said donor means whereby to transport electroscopic powder marking particles from said dispensing means onto said donor means.

9. In a xerographic reproducing apparatus of the type wherein latent electrostatic images of copy are formed on a moving xerographic plate, developing apparatus for rendering the latent images visible, said developing apparatus comprising in combination,

donor means for transporting uniformly distributed electroscopic powder marking particles contained thereon into contact with said moving xerographic plate at a plurality of different locations positioned along the periphery of said xerographic plate,

said donor means including a first plurality of spaced support members positioned adjacent the surface of said xerographic plate at said plurality of different locations,

a second plurality of support members spaced from said first recited support members, and

an endless flexible elongated donor member passing over said first and second recited support members, in a generally sinuous arrangement, said elongated member making a series of repetitive contiguous approaches to the image area and contacting said xerographic plate at said first recited support members;

loading means for uniformly depositing electroscopic powder marking particles onto said donor means, and

drive means operatively connected to said donor means for continuously advancing said donor means whereby to bring successive areas therealong into contact with said loading means and said xerographic plate.

10. Apparatus according to claim 9, said loading means including,

a source of supply of electroscopic powder marking particles, and

a conical brush member in communication with said source of supply and in brushing contact with said elongated donor member, said conical brush member being adapted for rotation about the vertical axis thereof.

11. In a xerographic reproducing apparatus of the type wherein latent electrostatic images of copy are formed on a moving xerographic plate, developing apparatus for rendering the latent images visible, said developing apparatus comprising in combination,

donor means including a plurality of donor members for transporting uniformly distributed electroscopic powder marking particles contained thereon into contact with said moving xerographic plate at a plurality of different locations positioned along the periphery of said xerographic plate;

loading means for uniformly depositing electroscopic powder marking particles onto said donor means,

said loading means including at least one elongated endless flexible belt member,

a source of supply of electroscopic powder marking particles, and

a conical brush member in communication with said source of supply and in brushing contact with said elongated flexible belt member, said conical brush member being adapted for rotation about the vertical axis thereof, and

drive means operatively connected to said donor means for continuously advancing said donor means whereby to bring successive areas therealong into contact with said loading means and said xerographic plate.

12. Apparatus according to claim **11**, said donor members comprising elongated endless flexible belt members.

13. Apparatus according to claim **11**, said donor members comprising a plurality of cylindrical members adapted for rotation in contact with said xerographic plate.

14. In a xerographic reproducing apparatus of the type wherein latent electrostatic images of copy are formed on a moving xerographic plate, developing apparatus for rendering the latent images visible, said developing apparatus comprising in combination,

a plurality of spaced apart endless donor members on which to support a uniformly distributed quantity of electroscopic powder marking particles for developing image patterns on the surface of said plate,

donor support means for supporting each of said donor members at a plurality of different locations positioned along the periphery of said xerographic plate,

loading means for depositing a thin uniform layer of electroscopic powder marking particles onto said donor members,

said loading means including a loading member positioned to pass each of said donor members at a position spaced from the surface of said xerographic plate,

said loading means further including a source of supply of electroscopic powder marking particles in communication with said loading member, and

drive means for continuously advancing said donor members and said loading member.

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