Sept. 12, 1972 L. W. NUZUM 3,690,912

METHOD FOR MAGNETIC DEVELOPMENT OF LATENT ELECTROSTATIC IMAGES

Original Filed Aug. 7, 1968 3 Sheets-Sheet 1

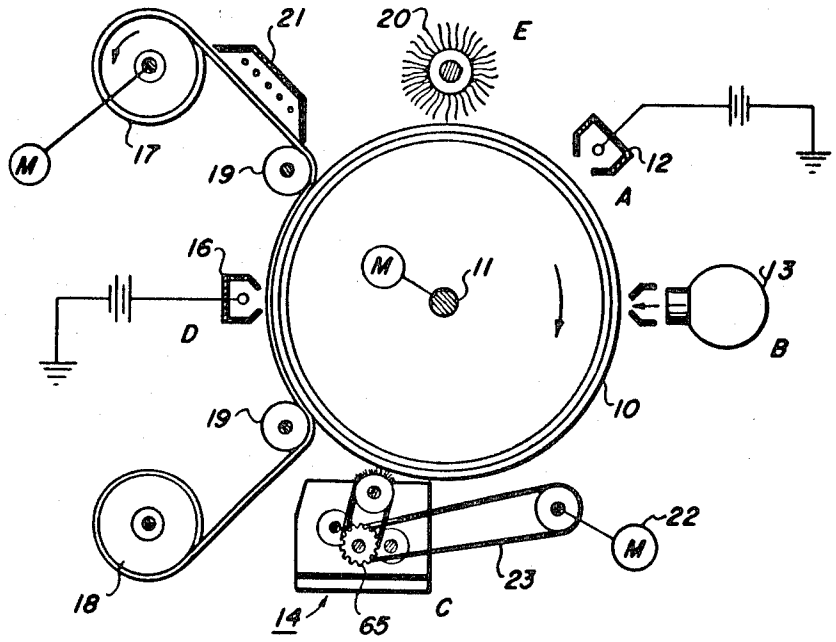


FIG. 1

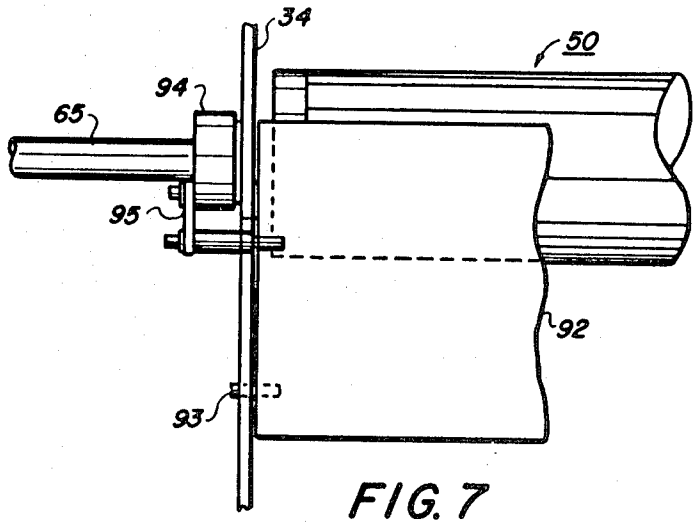


FIG. 7

METHOD FOR MAGNETIC DEVELOPMENT OF LATENT ELECTROSTATIC IMAGES

Original Filed Aug. 7, 1968 3 Sheets-Sheet 2

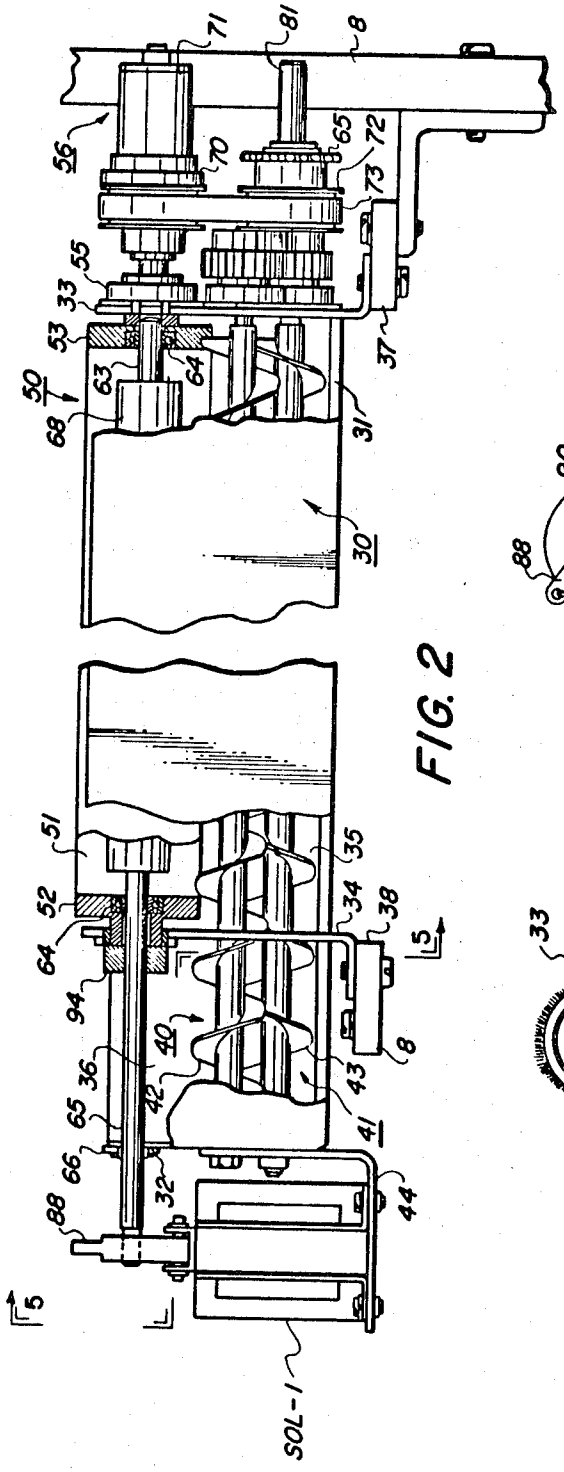


FIG. 2

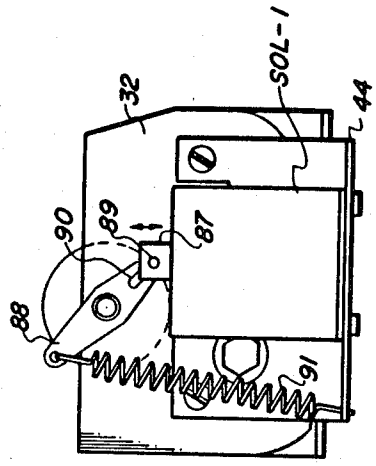


FIG. 4

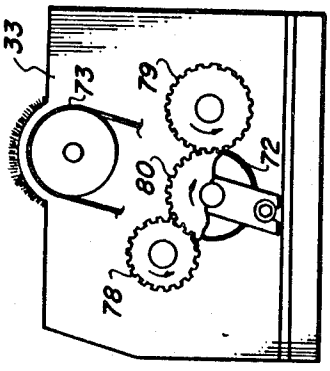


FIG. 3

METHOD FOR MAGNETIC DEVELOPMENT OF LATENT ELECTROSTATIC IMAGES

Original Filed Aug. 7, 1968 3 Sheets-Sheet 3

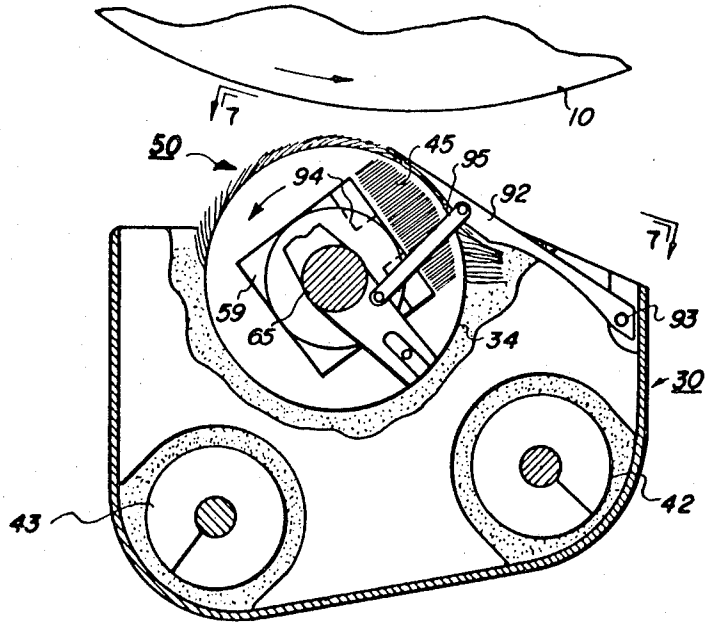


FIG. 5

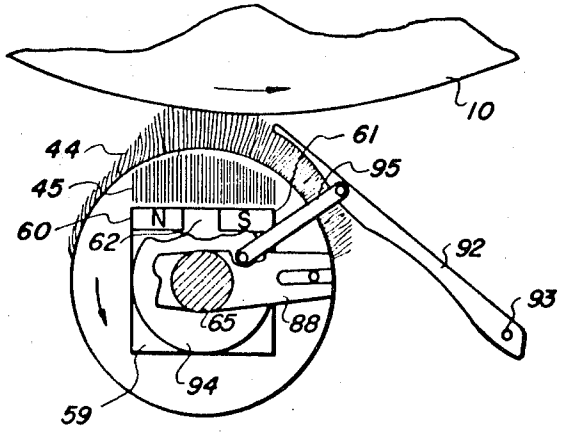


FIG. 6

United States Patent Office 3,690,912 Patented Sept. 12, 1972

3,690,912

METHOD FOR MAGNETIC DEVELOPMENT OF LATENT ELECTROSTATIC IMAGES

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Original application Aug. 7, 1968, Ser. No. 750,852, now Patent No. 3,570,453. Divided and this application June 4, 1970, Ser. No. 57,408

Int. Cl. G03g *13/08, 15/08*

U.S. Cl. 117—17.5 1 Claim

ABSTRACT OF THE DISCLOSURE

This is a method for magnetic development of latent electrostatic images wherein development can be rapidly started and stopped by moving the magnet member relative to the roll member from a first position in which development occurs to a second position displacing the magnetic flux field and bristle-like formation of developer material away from the images on the photoconductive surface, and simultaneously moving a plate member from a first position spaced from the roll member during development to a second position into close proximity and in overlying relationship with the roll member where the magnetic member is displaced away from its first position to its second position to break down any bristles of developer material and prevent unwanted spurious development of images.

This application is a division of application, Ser. No. 750,852, filed Aug. 7, 1968, now issued as U.S. Pat. No. 3,570,453.

This invention relates in general to development of a latent electrostatic image and, in particular, to a magnetic brush developing apparatus the development function of which can be rapidly started or stopped.

In the process of xerography, as originally disclosed by Carlson in U.S. Pat. No. 2,287,691, a plate comprising a conductive backing upon which is placed a photoconductive insulating material is charged uniformly and the photoconductive surface exposed to a light image of an original document to be reproduced. The photoconductive coating is caused to become conductive under the influence of the light image so as to selectively dissipate the electrostatic charge found thereon producing what is known as a latent electrostatic image. The latent image is developed, or made visible, by means of a variety of pigmented resins which have been specifically developed for this purpose. The pigmented resin material, commonly referred to as toner, is electrostatically attracted to the latent image on the photoconductive surface in proportion to the amount of charge found thereon. That is, an area of small charge concentration becomes an area of low toner density while areas of greater charge concentration become proportionally more dense. The developed image is generally transferred to a final support material, as for example paper, and fixed thereto to form a permanent record of the original document.

The principal mechanism for developing the latent electrostatic image in the xerographic process is by means of the classical development-scavenging technique utilizing two-component developer. Two component developer comprises a finely divided toner material and a relatively coarser carrier material. Opposite electrostatic charges are induced in the materials when they are brought into rubbing contact. The oppositely charged toner is attracted to the larger carrier until such time as the carrier becomes electrostatically satisfied. To develop a latent electrostatic image, as for example on a photoconductive surface, the loaded developer material is caused to flow over the photoconductive surface whereby the toner is mechanically and electrostatically dislodged from the carrier material. The latent electrostatic image exerts a force on the toner material and the toner is attracted into the image areas to selectively develop the image in relation to the amount of charge found thereon. The denuded carrier material, still possessing a charge opposite to that of the toner, seeks to scavenge toner away from the electrostatically relatively weak non-image or background areas resulting in the formation of a clean, sharp, visual reproduction of the original document.

The two primary methods of developing a latent electrostatic image using a two-component developer material are magnetic brush development and cascade development. In both these development systems, sufficient flow must be maintained within the system to produce proper mixing and triboelectrification of the materials. Because two-component developer systems are flow-dependent, it is the usual practice in automatic xerographic machines to continually operate the developer system any time the machine is in use such as when a multiple copy run is being made.

In automatic xerography the photoconductive surface is generally continually charged and intermittently imaged. The continuous operation of the developer system has not heretofore been a serious problem in automatic xerography because insufficient electrostatic contrast usually existed in the non-image areas to cause these areas to be developed. However, with the advent of new xerographic developing materials and processing techniques, it is now possible to develop solid areas of relatively uniform charge density on a photoconductive surface. Automatic machines having this good solid area capability, unless controlled in some manner, will produce unwanted development of the charged but non-imaged areas between copies. This development of unwanted images causes excessive toner consumption in the machine as well as producing a high level of dirt. Furthermore, because this unwanted development must be removed from the photoreceptor surface it poses a serious cleaning and toner handling problem.

It is therefore a primary object of this invention to improve apparatus for developing a latent electrostatic image.

Another object of this invention is to provide a two-component developing apparatus having the capability of being rapidly started and stopped.

Yet another object of this invention is to reduce the dirt level and the amount of cleaning required in an automatic xerographic machine having solid area capabilities.

A still further object of this invention is to eliminate unwanted development of charged but non-imaged areas in an automatic xerographic machine having solid area capabilities.

These and other objects of the present invention are attained by means of a housing adapted to support a quantity of magnetizable developer material having an opening at the top thereof, means to produce a directional flux field capable of passing through the opening in the top of said housing, the flux producing means being movably positioned in said housing between a first developing position and a second non-developing position, a hollow applicator roll being arranged to contain the flux producing means and adapted to pass through the developer material in the housing and the main flux field, rotating means to move the applicator roll through the developer material and the main flux field so that a brush of developer material is continually maintained in said flux field means to reposition the flux producing means within the applicator roll from a first developing position to a second non-developing position, and means to collapse the brush when in the non-developing position.

For a better understanding of this invention as well

as other objects and further features thereof, reference is had to the following detailed description to be read in connection with the accompanying drawings, wherein:

FIG. 1 illustrates schematically an embodiment of the instant invention in an automatic xerographic reproducing apparatus;

FIG. 2 is a front elevation in partial section showing the development apparatus of the instant invention;

FIG. 3 is a right-hand end view of the development apparatus shown in FIG. 2;

FIG. 4 is a left-hand end view of the development apparatus shown in FIG. 2;

FIG. 5 is a left-hand sectional view of the development apparatus taken along lines 5—5 of FIG. 2 showing the flux producing means in a developing position;

FIG. 6 is a partial sectional view of the development apparatus as shown in FIG. 5 with the flux producing means in a non-developing position;

FIG. 7 is a partial top view of the development apparatus taken along lines 7—7 of FIG. 5.

In the illustrated embodiment of the instant invention a developer housing is shown in an automatic xerographic reproducing machine. The xerographic apparatus comprises a record receiving member in the form of a xerographic drum **10** rotatably mounted in the machine frame by means of shaft **11**. The drum is rotated in the direction indicated by the arrow to cause the drum surface to pass sequentially through a plurality of xerographic processing stations.

For the purpose of the present disclosure, the several xerographic processing stations in the path of movement of the drum surface may be described functionally as follows:

A charging station A, at which a uniform electrostatic charge is deposited on the photoconductive surface of the drum and includes a corona charging device **12** having a corona discharge area of one or more corona discharge electrodes that extend transversely across the drum surface and are energized from a high potential source;

An exposure station B, at which a light or radiation pattern of the copy to be reproduced is projected onto the drum surface by means of projector **13** to dissipate the charge on the drum surface in the exposed areas thereof to form a latent electrostatic image of the original to be reproduced;

A developing station C, having a magnetic developing system **14** driven by means of motor **22** through chain **23** in which two-component magnetizable developing material is caused to flow in contact with the drum surface so that the toner brought in contact therewith adheres to the latent image to form a powder image of the original document to be reproduced;

A transfer station D, at which the xerographic powder image is electrostatically transferred from the drum surface to a web **15** of final support material by means of a corona discharge device **16** similar to the charge device positioned at the exposure station;

And a drum cleaning station E, at which the drum surface is brushed by means of a natural or synthetic fur brush **20** to remove residual toner particles remaining on the photoconductive surface after image transfer.

The web of support material is held in contact with the drum surface by means of a pair of idler rolls **19**. The web is adapted to move at the same peripheral speed as the drum surface by means of a motor acting on take up spool **17**. The take up spool, in turn, acts to pull or move a continuous supply of support material from freely rotating supply spool **18** through the transfer station D. A fuser assembly **21** is positioned in close proximity to the moving support material subsequent to the xerographic transfer station. Sufficient heat energy is provided by the fuser assembly to fix the xerographic toner image to the final support material as the image is passed thereunder.

It is believed that the foregoing description is sufficient for the purposes of this application to show the general operation of a xerographic reproducing apparatus. However, as will be explained in greater detail below, the magnetic brush developer system as herein disclosed is not limited to this particular xerographic device and because of its novel features is applicable in a wide range of machines and environments.

The development apparatus of the present invention includes a main developer housing, generally designated **30**, comprising a main shell **31** which is closed at both ends by means of end plates **32** and **33**. The main shell of the housing is basically a U-shaped elongated trough-like member in which the bottom section thereof is inclined in relation to horizontal plane. The elongated trough-like areas of the main housing is broken into two distinct areas by means of separator plate **34**. The housing is divided into a main developer area **35**, which is slightly larger than the photoconductive area on the drum surface, and a second supply or reservoir area **36**.

The main housing is supported in machine frame **8** by means of two support pads **37** and **38** securely bolted to the machine frame. End plate **33** and divided plate **34** extend below the bottom portion of the developer housing and have horizontal dependent flanges thereon adapted to be securely mounted upon support pads **37** and **38**, respectively. The developer housing is supported in the machine frame so that the main developer area within the housing is in close proximity and substantially transverse to the lower portion of drum surface **10**.

Positioned in the lower sump portion of the trough are two screw type augers generally designated **40** and **41**. The augers are rotatably supported in bearings, such as fiber bearings, mounted in the end plates of housing **30**. Helical feed screws **42** and **43** associated with augers **40** and **41**, respectively, are positioned in parallel relation to each other running substantially across the full length of the bottom of the housing. Openings are provided in the divider plate to permit the augers to transport developer material between the reservoir area and the main developer area. Delivery auger **40**, positioned at the higher elevation in the housing, is rotated in the manner such that feed screw **42** continually moves a flow of developer material from the reservoir area into the development zone while the lower or return auger **41** transports developer material from the developer zone back into the reservoir area.

The shaft portion of augers **40** and **41** extend external end plates **33** having pinion gears **78** and **79**, respectively, securely mounted on the terminous end thereof (FIG. 3). The two pinions are driven from a common drive gear **80** mounted on stub shaft **81** rotatably supported in the main developer housing. The mechanical action of the augers against the developer material provides sufficient agitation within the developer material to produce mixing and triboelectrification for the two-component xerographic development.

Positioned in the upper portion of the developer area within the developer housing is an applicator roll, generally designated **50**, extending substantially across the length of development area **35**. Applicator roll **50** comprises a hollow cylindrical non-magnetic sleeve **51** supported between end caps **52** and **53** and the end caps suitably mounted for rotation in divider plate **34** and end plate **33**.

Mounted within the applicator roll sleeve **51** is a permanent magnet **68** constructed of Alnico **5** of other similar magnetic materials. The magnet consists of an elongated north pole piece **60** and equally elongated south pole piece **61** separated by insulating strip **62**. The two pole pieces are positioned in relatively close proximity to each other within the applicator sleeve so as to create a main magnetic flux field **45** which is substantially directional. The length of the magnet is slightly longer than the width of the photoconductive area on the drum surface and is positioned so that the main flux field ex-

tends at least as long as the photoconductive area on the drum. Although an elongated permanent magnet is shown in this embodiment it should be quite clear that any other type of magnet capable of producing a substantially directional flux field would be perfectly suitable for use in the instant invention.

Magnet **59** is rotatably supported within applicator roll sleeve **51** so that the magnet can be turned independently of the applicator roll. The right-hand end of the magnet, as shown in FIG. 2, is supported upon stub shaft **63** which is rotatably mounted in end cap **53** by means of roller bearings **64**. The extended shaft is supported between roller bearing **64**, pressed in end cap **52**, and bearing blocks **66** affixed in the housing end plate **32**. A portion of shaft **65** extends beyond the housing and has secured thereto a lever arm **88**, the function of which will be explained in greater detail below.

Stub shaft **81** which drives the delivery and return augers also acts as the main drive shaft for the developer unit. A sprocket **65** pinned to shaft **81** transmits the rotational motion delivered from motor **22** through chain **23** to the shaft. A timing pulley **72**, also affixed to stub shaft **81**, acts through timing belt **73** to drive the applicator roll drive system **56**. As shown in FIG. 2, the applicator drive system comprises an electromagnetic clutch **71** operatively connected to driven timing pulley **70**. Applicator roll **50** is operatively connected to applicator drive roll assembly **56** by means of coupling **55**.

In operation, a continuous flow of developer material is moved from the reservoir area **36** through the development area **35** by means of the rotating delivery and return augers. The rotational speed of the augers is maintained at a level high enough to produce sufficient mechanical agitation to properly mix and triboelectrify the developer material. The developer housing is charged with sufficient developer material so that the applicator roll is partially immersed in the developer material. The applicator roll is immersed sufficiently within the bath of developer material so that the fringe areas of the directional magnetic flux field associated with magnet **59** are felt by the developer material in the housing. The applicator roll, as it rotates through the bath of developer material, brings developer material into the main flux field associated with magnet **59** by magnetic and mechanical forces. As the applicator roll moves through the developer material, the magnetizable particles under the influence of the magnetic flux field are caused to move upwardly into the main flux field to form what is commonly referred to as a magnetic brush. As shown in FIG. 5, the upper delivery auger moves a fresh supply of magnetic developer material transverse to the applicator roll in close proximity to the brush forming area. As the applicator roll continues to rotate the developer material in the brush is caused to move downwardly back into the sump area of the developer housing. In this manner a magnetic brush is continually being formed from fresh developer material as it circulates through the system.

Referring now to FIG. 6 the rotatable magnet is shown positioned in a developing position. Development of a xerographic image on the record receiving member is produced on drum surface **10** by directing the main flux field **45** of the magnet towards the drum surface. The applicator roll, and therefore the magnet contained therein, are supported within the developer housing so that the photoconductive area on the drum surface is caused to pass through the main flux field when the magnet is in the developing position as shown in FIG. 6. Magnetic brush **44** continually carries a flow of fresh developer material into contact with the photoconductive surface to develop a latent electrostatic image thereon. The peripheral speed of the applicator roll, and therefore the flow rate at which the magnetic brush is replenished, and the speed of the xerographic drum are related through integrated drive system (not shown) so that sufficient and uniform application of developer material is produced thereon.

In order to rapidly start and stop the development function of the present development apparatus, the magnet is rotated or repositioned from a first developing position in which the main flux field is directed toward a photoconductive surface and a second non-developing position in which the field is directed away from the surface. The magnet, which is free to rotate independently within the applicator roll, is repositioned by means of solenoid SOL–1 mounted on bracket **44** affixed to end plate **32** of the housing. Shaft **65**, connected to the elongated magnet terminates in lever arm **88** which is operatively connected to the actuator arm **87** of solenoid SOL–1. Lever arm **88** has a slotted hole **90** machined therein in which pin **89**, associated with lever arm **87** of SOL–1 rides. Lever arm **88** is biased into contact with lever arm **87** by means of spring **91** (FIG. 4).

In the magnetic brush apparatus herein described, as in most devices employing two-component developer materials, a powder cloud consisting of free toner material may be formed in the vicinity of the photoconductive surface. The powder cloud generally is formed by toner dislodged from the carrier material due to the mechanical interaction of the moving brush and the moving photoconductive surface. As can be seen, this free toner is available to develop a latent electrostatic image on the photoconductive surface. Because this powder cloud developer is not directly related to the brush position, repositioning of the brush alone may not in itself produce an extremely rapid cessation of the development process, especially in high speed apparatus. Powder clouds formed in the vicinity of a photoconductive surface should therefore be suppressed.

When the development apparatus of the instant invention is in a normal development condition, the solenoid actuator arm is raised causing the lever arm **88** associated with the magnet positioned device to assume approximately a horizontal position as shown in FIG. 6. The magnet, which is securely affixed to shaft **65**, is being supported in a substantially vertical direction with the main flux field directed at the photoconductive surface. The magnetic brush is formed as heretofore explained and the latent image on the drum surface developed. When solenoid SOL–1 is electrically actuated the actuator arm is pulled down causing the elongated magnet and associated flux field to assume the non-developing position as shown in FIG. 5. That is, the magnet is in a position in which the directional flux field is substantially pointed away from the photoconductive surface. A brush collapsing arm **92**, pivotally mounted in the main developer housing about pin **93**, is at the same time actuated and moves down into close proximity to the applicator roll surface to break down the magnetic brush hairs thereby suppressing the means by which a powder cloud could be formed in the vicinity of the drum surface. Breaking down of the brush fibers also eliminates the danger of stray brush hairs contacting and developing the drum surface. A collar **94** is securely affixed to shaft **65** and positioned adjacent to separator plate **34** as shown in FIGS. 2 and 7. A link **95**, rotatably pinned to both the collar and the collapsing arm, moves with shaft **65** as the shaft is rotated between the developing and non-developing position so as to pull the collapsing arm downwardly into the magnetic brush hairs.

As noted, developer material is both magnetically and mechanically pulled from the sump area of housing **30**. The mechanical action of the applicator roll as it rotates through the bath of developer material tends to agitate and mechanically drive developer material out of the bath towards the drum surface. This mechanical action of the applicator roll upon the developer material also tends to produce a powder cloud capable of developing unwanted images on the drum surface regardless of whether the

magnet is in a developer non-developed position. In the present invention, the applicator drive assembly **56** is provided with an electromagnetic clutch capable of engaging and disengaging the applicator roll from the main drive system. In operation, electromagnetic clutch **71** (FIG. 2) is electrically connected in series with the actuating mechanism of solenoid SOL–**1** so that when the solenoid is pulled downwardly to a non-developing position, the rotation of the applicator roll is stopped.

As can be seen, the present apparatus has the capabilities of rapidly stopping and starting the development function of a magnetic brush developing system, as for example between copies in an automatic reproducing machine, while still maintaining all the advantages associated with the classical xerographic development-scavenging process. The apparatus is capable of moving a continuous flow of properly mixed and triboelectrified developer material through the developing apparatus thus maintaining the system at optimum developing conditions and still having the ability to control the developing functions. Without interrupting the flow of material through the system, means are provided by which the magnetic brush, and any powder cloud associated therewith are rapidly moved out of developing contact with the photoconductive surface.

While this invention has been described with reference to the structure disclosed therein, it is not confined to the details set forth, and this application is intended to cover such modifications or changes as may come within the purposes of the improvements of the scope of the following claim.

What is claimed is:

1. In an improved method for magnetic development of latent electrostatic images on the photoconductive surface in which a quantity of magnetizable developer material is carried on a roll member rotated past a magnetic flux field produced from a magnet member positioned within said roll member to form a bristle-like formation of developer material in the vicinity of the magnetic flux field to develop latent electrostatic images on the photoconductive surface, an improvement for rapidly starting and stopping development comprising pivotally moving the magnet member relative to the roll member from a first position in which development occurs to a second position displacing the magnetic flux field and bristle-like formation of developer material away from the images on the photoconductive surface, and

simultaneously moving a plate member from a first position spaced from the roll member during development to a second position into close proximity and in overlying relationship with the roll member where the magnet member is displaced away from its first position to its second position to break down any bristles of developer material and prevent unwanted spurious development of images.

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U.S. Cl. X.R.

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