Dec. 5, 1961 H. O. ULRICH 3,011,474

XEROGRAPHIC DEVELOPMENT ELECTRODE APPARATUS

Filed Feb. 6, 1959 4 Sheets-Sheet 1

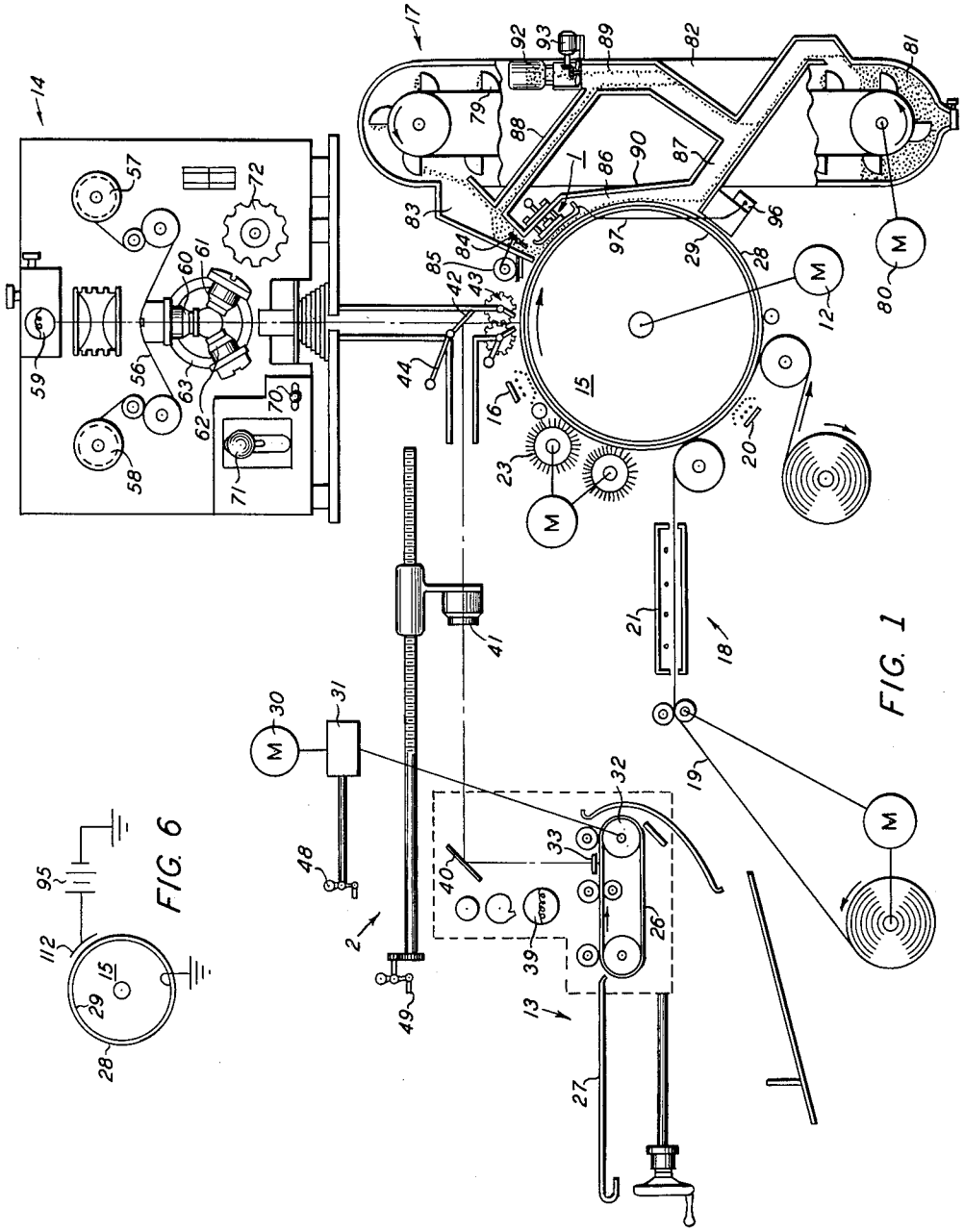


FIG. 1

FIG. 6

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XEROGRAPHIC DEVELOPMENT ELECTRODE APPARATUS

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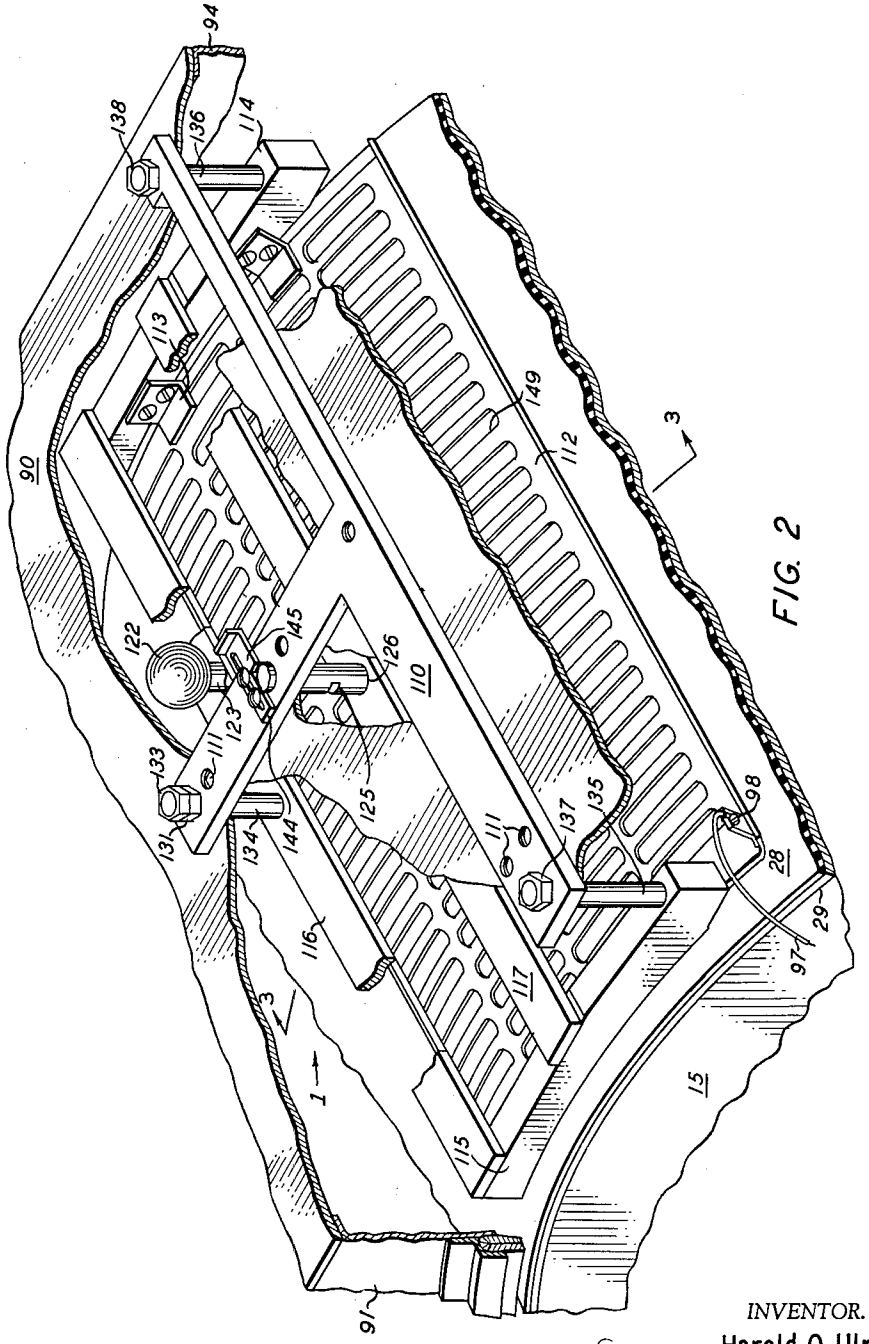


FIG. 2

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XEROGRAPHIC DEVELOPMENT ELECTRODE APPARATUS

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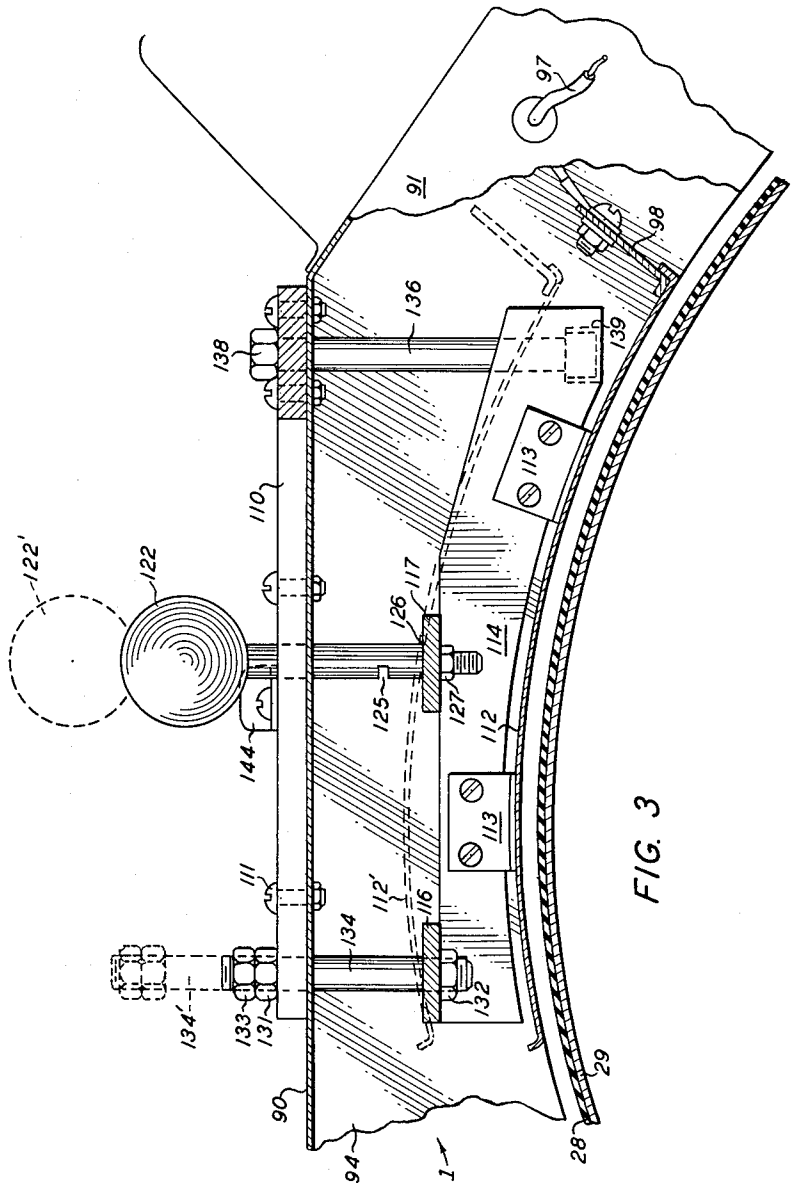


FIG. 3

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XEROGRAPHIC DEVELOPMENT ELECTRODE APPARATUS

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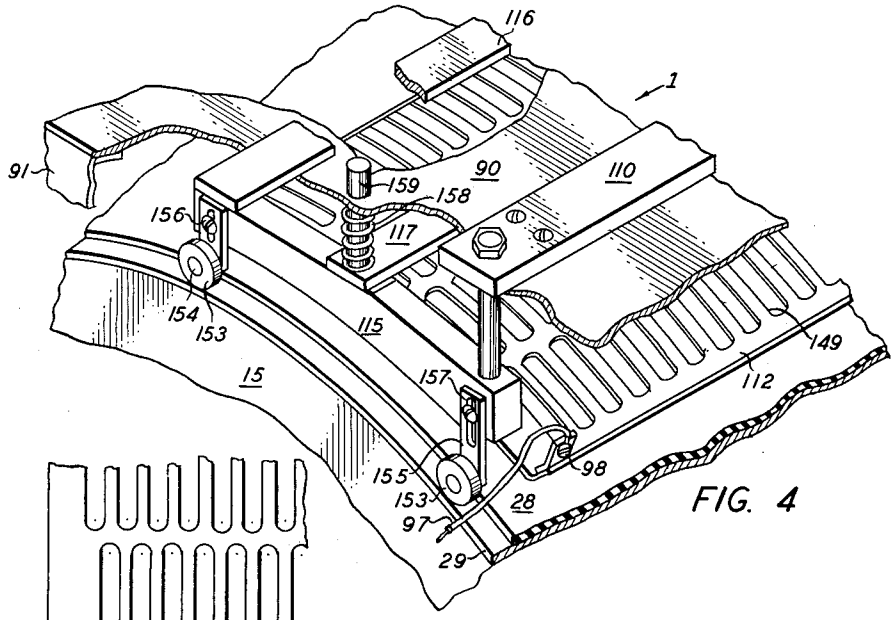


FIG. 4

FIG. 7

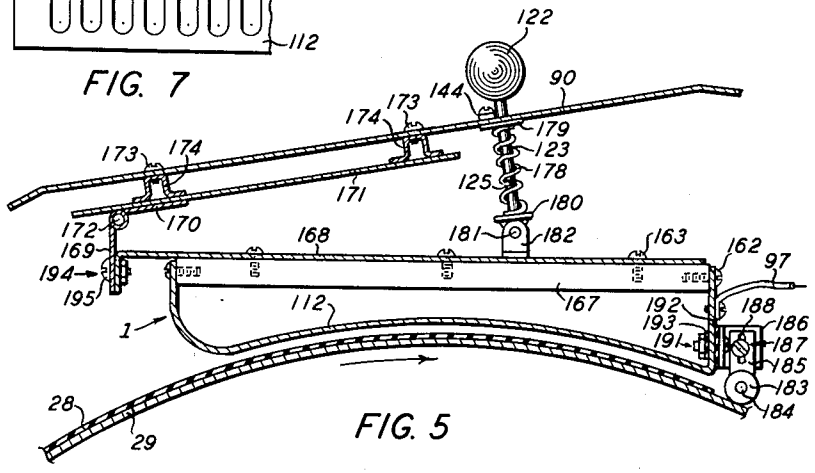


FIG. 5

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3,011,474

Patented Dec. 5, 1961

3,011,474
XEROGRAPHIC DEVELOPMENT ELECTRODE APPARATUS

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Filed Feb. 6, 1959, Ser. No. 791,570
5 Claims. (Cl. 118—637)

This invention relates to an improved development electrode apparatus for the formation of a xerographic powder image on a cylindrical xerographic drum. More specifically, this invention relates to improvements in development electrode apparatus to facilitate the use of such apparatus in automatic xerographic machines.

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 them, 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 xerographic powder image is usually transferred to a support surface to which it may be fixed by any suitable means.

In a usual line copy form of xerographic development such as black letters on a white background, developer powder is cascaded over the photoconductive plate surface whereat it adheres to the eelctrostatic latent image with sharpness and uniform density. However, where copy to be reproduced is possessed of images not of line copy form but having instead wide solidly dark areas, the usual cascade development results in the wide areas being black or dark adjacent to their edges and light or white at the central areas owing to the improper and non-uniform adherence of developer powder thereto. This effect is as a result of the lines of force which emanate from the undischarged or image areas being directed in curved paths from the edges or outer portions thereof to the adjacent discharged or background areas effecting a dissipation of force lines from the image area.

When employing a development electrode for xerographic powder image development, it has been established that the problem of non-uniformity of powder adherence in wide solid image areas is substantially overcome. A form of development electrode is disclosed in Gundlach Patent U.S. 2,777,418 wherein an electrical field is created between the development electrode and xerographic plate which causes the lines of force emanating from the undischarged or image areas on the photoconductive surface to be directed in generally parallel relation toward the development electrode in perpendicular relationship to the image surface. This results in uniform adherence of the developer powder over the image area and produces a uniformly dark image in the areas desired.

The effectiveness of the fields produced for effecting powder image development increases with a decrease in spacing between the electrode and the plate surface and decreases with an increase in spacing. For equal effectiveness over the entire plate area, the spacing must be uniformly maintained. It has been established that the development electrode is most effective at spacings of less than ¼" and increasingly effective at spacings of ⅛" or less.

Optimum spacing is largely determined by the physical characteristics of the developer powder and means of distributing it between the plate and electrode. Developer powder employed may be a form of two component material such as disclosed in Walkup Patent 2,638,416 wherein the developer powder is comprised of an electroscopic toner powder which is consumed in the developing process combined with a hard granular carrier bead. A form of two component developer powder currently in wide commercial use is manufactured by Haloid Xerox Inc., of Rochester, New York, having carrier beads of which approximately ninety percent vary in dimension between .0176 and .023 inch in diameter. Because the beads are in loose granular form, some piling tends to occur in cascading flow such that spacing therefor between the plate surface and electrode must be sufficiently large to permit gravitational bead passage.

In the aforementioned Gundlach patent a spaced distance between a plate surface and a development electrode of approximately 3/32" is uniformly maintained. However, the apparatus of Gundlach is primarily intended for image development on flat xerographic plates wherein development is effected by hand motivated cascadements of developer powder which usually require several passes in order to assume uniform contact of developer powder with the electrostatic latent image. On a cylindrical drum type xerographic plate of the type employed on automatic xerographic reproduction equipment, a large volume of developer powder is cascaded over the image surface in the direction of drum rotation at a gravitational rate which exceeds the peripheral drum speed. Complete development is effected in a single pass within the developing cycle which usually comprises less than 90° of drum rotation. At minimum drum to electrode spacings excessive amounts of cascading powder unable to effect immediate passage have a tendency to pile up between the electrode and the image surface effecting a block of the gravitational passage. Unless the developer pile-up is prevented by a form of relief or escape, the hard carrier beads of the developer powder caught between the rotating drum surface and the electrode act as an abrasive against the drum, scoring and damaging the relatively soft photoconductive drum surface.

It is therefore a principal object of this invention to improve the construction and arrangement of development electrode means whereby drum damage from excess accumulation of developing powder can be prevented. Since many originals being copied are of line copy form not requiring the application of a development electrode and whereas the need for a development electrode may be intermittently required, it is a further object of this invention to increase the versatility of automatic xerographic equipment by employing the development electrode assembled to the xerographic equipment whereby the electrode can selectively be made effective in close relation to the drum surface or be moved away from the image bearing drum surface to an ineffective position, as required.

These and other objects of the invention are attained by means of an improved development electrode construction wherein the electrode is curved to conform to the curvature of a xerographic drum and is provided with a plurality of slots or openings arranged in a manner to minimize the possibility of pile up of developer material during the developing operation. In addition, means are provided to adjust the position of the development electrode relative to the xerographic drum to place it in an effective or ineffective position, as desired, in accordance with the type of copy being reproduced.

The invention is shown in the accompanying drawings, in which:

FIG. 1 is a schematic side elevation of an automatic xerographic reproduction apparatus in conjunction with the development electrode of the invention;

FIG. 2 is an isometric view of the development electrode of the invention in operative relation to a xerographic drum;

FIG. 3 is a sectional view taken substantially on the line 3—3 of FIG. 2;

FIGS. 4 and 5 illustrate alternative structures for assembling the development electrode of the invention in relation to a xerographic drum;

FIG. 6 is a wiring diagram; and

FIG. 7 illustrates a typical slot pattern for the conducting plate of the invention.

Referring to the drawings, there is illustrated in FIG. 1 a development electrode assembly, generally designated by reference character 1, that is assembled in an automatic xerographic equipment 2 which includes components for effecting the xerographic process consisting of an opaque original exposure means 13 and/or a microfilm exposure means 14, either of which may be employed to effect exposure of an original to be reproduced onto a rotating xerographic plate or drum 15 bearing a uniform electrostatic charge on its photoconductive surface 28 applied thereon by electrostatic charging unit 16. Exposure of the original to be reproduced forms an electrostatic latent image on or in the photoconductive surface 28, which is subsequently developed into a xerographic powder image by developing unit 17. After development, paper handling mechanism 18 transports a paper support 19 onto contact with a xerographic powder image on surface 28 which is transferred to support surface 19 by electrostatic attraction applied from electrostatic charging unit 20. Mechanism 18 continues transport of support surface 19 until the xerographic powder image thereon passes through heat fuser 21 wherein the powdered image is affixed to support surface 19. After transfer, residual powder on drum 28 is removed by brush cleaners 23.

More specifically, drum 15, consisting of a photoconductive surface 28 on an electrically conductive backing 29 is driven at a constant rate of rotation by motor 12. After an electrostatic charge is applied to surface 28 by charging unit 16, which may be of a type disclosed in Walkup U.S. Patent 2,777,957, an opaque original to be reproduced may be exposed to photoconductive surface 28 by exposure means 13 which may be of a type disclosed in copending application Serial No. 837,173, filed August 31, 1959, in the name of A. Cerasani et al. When employing exposure means 13, an opaque original may be exposed at variable magnification ratios onto surface 28 by feeding an original from tray 27 onto moving belts 26 whereat belt movement is effected by motor 30 through variable speed transmission 31 which drives roller 32 engaging belts 26. Passing below glass plate 33, an original is illuminated by lamp 39, and the image thereon is reflected to mirror 40 wherefrom it is caused to be reflected through the optical axis of lens 41 to mirror 42 thence through variable exposure means 43 normally onto surface 28. Variable magnification of an opaque original to be reproduced is effected by proper correlation of transmission speed from transmission 31 through adjustment of rotatable knob 48, accurate positioning of lens 41 through adjustment of rotatable knob 49, and effecting a required length of the optical path emanating below glass plate 33 to surface 28 by rotatable adjustment of handwheel 50.

In the alternative, microfilm originals to be reproduced can be projected from microfilm 56 onto photoconductive surface 28 by microfilm projection apparatus 14 which may be of a type of microfilm projection apparatus disclosed in copending application Serial No. 796,561, filed March 2, 1959, in the name of S. R. Johanson. When employing apparatus 14, microfilm originals are transported from supply spool 57 onto take-up spool 58 by

motor and variable speed transmission means (not shown). While in transport, microfilm is caused to transport through an optical path normal to surface 28 whereat the image is illuminated by lamp 59 and projected by a lens 60, 61 or 62, through variable exposure means 43 onto photoconductive surface 28; mirror 42 being moved to a vertical position by control rod 44 so as not to obstruct the optical path. Lenses 60, 61 and 62 are lenses of different focal lengths and are each secured to rotatable turret 63 whereby projection of microfilm onto surface 28 may be effected at variable magnification ratios by selectively aligning and adjusting the appropriate lens into the optical path, effecting correlation of film transport speed to drum speed through motor speed and transmission speed selector switches 70 and 71, respectively, and effecting the proper spaced distance in the optical path between microfilm 56 and surface 28 through the rotation of adjustment knob 72.

Thereafter, development of the electrostatic latent image is effeced by developing unit 17 which may be of a type disclosed in copending application Serial No. 393,058, filed November 19, 1953, in the name of Clyde R. Mayo et al., wherein a continuously operative conveyor 79 driven by motor 80 scoops developer powder 81 from the bottom of housing 82 wherefrom it is conveyed to the top of 82 and dumped into hopper 83. Gate 84, positioned by motor 85, is either open or closed dependent upon whether the xerographic apparatus is "on or off" respectively and when open permits powder 81 to cascade over rotating surface 28 and below development electrode assembly 1 wherefrom it gravitates through chute 86 having a top wall 90 and side walls 91 and 94 which cooperate with the drum to form a substantially powder tight passage therebetween. From chute 86 the powder gravitates to chute 87 wherein it is returned to the bottom of housing 82. A maximum level of developer powder is maintained in hopper 83 by overflow chute 88. As the toner component of the developer powder is consumed in development it is replenished from toner dispenser 92 at a rate dependent upon the variable speed of motor 93 wherefrom it gravitates with the overflow powder through chute 89 until mixed with developer powder returning in chute 87.

For effecting development of wide solid areas of image as aforesaid, development electrode assembly includes (refer also FIGS. 2, 3 and 6) a potential of approximately 60–90 volts supplied from batteries 95 housed in battery case 96 and wired therefrom by lead 97 to clip 98 electrically secured to conducting plate 112. In developing a positive print of a positive original it is the usual practice to employ a negatively charged electroscopic powder which is attracted to the positive image on the xerographic plate and for which a development electrode biasing voltage of 60–90 volts has been found satisfactory. However, in a reversal form of development, that is, in a negative original to a positive print it is the usual practice to employ a positive electroscopic powder which is repelled by the charged non-image areas on the plate and in this instance a development electrode biasing voltage of approximately 500 volts is preferred.

T-shaped support bar 110 is secured from the top wall of 90 of chute 86 by several screws 111. Conducting plate 112 is secured by clips 113 to insulating side bars 114 and 115 which are braced in fixed relation by support members 116 and 117. Ball-knob 122 is secured to vertical shaft 123 which has a positioning groove 125 and a shoulder 126 seated on the top side of support member 117. Nut 127 serves to maintain 117 in firm engagement against shoulder 126.

In FIG. 3 the comparative spaced relation of conducting plate 112 is illustrated for both effective and ineffective positions of the development electrode assembly wherein the 112' dashed outline represents the ineffective position of conducting plate 112 and the solid outline in close relationship to surface 28 represents the effective position to

effect spacings between the electrode and drum surface of 1/8" to 5/16" which have shown to give optimum development results without damaging the drum surface. In effective position in a preferred embodiment of the invention the inherent weight of the electrode apparatus maintains conducting plate **112** in close relationship to surface **28** with its forward position (as viewed in the direction of drum rotation) aligned by nuts **131** and **132** secured to bolt **134** with nut **133** serving as a lock nut. The rearward position of conducting plate **112** is adjustably obtained by socket head bolts **135** and **136** having their socket ends inserted upward into each of counterbores **139** of side bars **115** and **114** respectively, and their threaded ends secured by nuts **137** and **138**, respectively. For securing the development electrode in ineffective position, clip **144** is slidably secured to the horizontal surface of support bar **110** whereby its lip **145** can be made to engage or disengage groove **125** when in upper position. When clip **144** is slid out as to disengage **125**, shaft **123** is freely movable vertically whereby conducting plate **112** can be moved toward or away from surface **28** into effective or ineffective relation, respectively. Thus, by raising or lowering the development electrode it can selectively be applied to the developing cycle when required to attain the desired development effects obtainable thereby.

To provide relief from developer pileup so as to prevent drum scoring, conducting plate **112** includes a plurality of elongated slots or openings **149** whereby drum motion forces excess developer to ascend through slots **149** whereat it continues gravitationally to cascade over the top of **112** seeking a slot whereat it can descend onto surface **28**. In the arrangement shown openings **149** are approximately 3/32" wide but of width preferably greater than three bead diameters. In addition, the slot ends are semicircular and the slots are approximately 3/4" in length to the extremities, and are spaced approximately 7/32" on center in direction of drum width. Although openings **149** may advantageously be formed in the manner defined, it is obvious that the particular configuration of the openings is not critical to the proper functioning of the apparatus of the invention. Openings **149** may be made and spaced in any of a variety of configurations. The only known limitations are that they should be arranged in a manner to permit pileup relief over the entire developing area, and that the minimum dimension of the openings should be greater than three diameters of the developing material carrier.

By the arrangement of preferred development electrode assembly described, wherein a uniform spaced relation is maintained by the inherent weight of the electrode, in addition to pileup relief afforded by the elongated slots **149**, relief to a lesser degree is effected by excess developer urging the conducting plate **112** away from surface **28** whereafter its weight restores the relation.

Typical alternative structures embodying the invention are shown in FIGS. 4 and 5 wherein FIG. 4 illustrates substantially the same development electrode assembly described in the preferred embodiment of FIGS. 2 and 3, but in addition thereto four wheel type followers **153**, two on each side of bars **114** and **115**, are each secured to a pin **154** which is rotatably secured in turn to suitable bearing means (not shown) of adjustable support bracket **155**, which by screw **156** through slot **157**, are secured to insulated side bars **114** and **115**. Resilient spring means **158**, on opposite sides of assembly **1**, encircling pins **159** and secured between support member **117** and the top wall **90**, urge each of the followers toward the drum such that the spacing between the drum and conducting plate **112** as effected by the setting of adjustable brackets **155** is maintained against any eccentricity of surface **28** as may be encountered in drum rotation.

In FIG. 5, a slightly different geometric configuration at the ends of conducting plate **112** is indicated, but in all other respects is substantially similar to that previously described. Conducting plate **112** is secured with screws **162** to insulating bar **167** in turn secured with screws **163** to horizontal support members **168** which is secured with screw and nut assembly **194** to pivot member **169**. Pivot member **170**, secured to support plate **171**, supports rotatable pin **172** to which pivot member **169** is secured. Support plate **171** is secured to the top wall **90** through screws **173** and brackets **174**. Compressed spring **178** encircles shaft **123** and is secured between plate **179** and swivel seat **180**, seat **180** being secured to pin **181** which is rotatably secured between parallel legs of bracket **182** in turn secured to support member **168**. Two wheel-followers **183** on opposite sides of plates **112** are each secured to a pin **184** which are rotatably secured in suitable bearing means (not shown) of a support bracket **185** which is adjustably secured through slot **188** to a brace **186** by screw and nut assembly **187**. Brace **186** is secured to conducting plate **112** by screw and nut assembly **191** being electrically insulated from conducting plate **112** by insulator washers **192** and **193**. Alignment of **112**, in relation to surface **28**, is achieved at the forward end (as viewed in direction of drum rotation) by the position at which screw and nut assembly **194** is secured through slot **195** of **169** and at the rearward end by the adjusted position of brackets **185** in relation to **186**. With development electrode assembly **1** in effective relation as shown in FIG. 5, wheel followers **183** are maintained in contact with conducting surface **29** by the urging resilient action of spring **178**. Lifting of ball knob **122**, against the urging force of **178** causes the assembly to pivot about pin **172** where ultimately shaft **123** can be secured in uppermost position by latching clip **144** to seat in groove **125**.

In operation, with drum **15** in constant rotation and all the components of the xerographic reproduction apparatus operative, it is first determined whether the opaque original or the microfilm original to be reproduced is of a form for which a development electrode assembly is properly applicable, that is, whether the original is a straight line-copy form reproduction, or whether the original to be copied possesses wide solid image areas which can be developed in accurate duplication only by employing a development electrode assembly. Having determined that the development electrode can be effectively utilized for the original to be reproduced, in the preferred arrangement, clip **144** is first slid out so as not to engage groove **125** whereon ball knob **122** can be lowered so as to place conducting plate **112** in effective spaced relation to rotating surface **28**. After an electrostatic latent image is formed on charged surface **28** by exposing an original to be reproduced thereto by means of unit **13** or **14**, the latent image thus formed rotates into contact with developer powder **81** cascading from hopper **83**. Developer powder continues to cascade between conductor plate **112** and surface **28** until falling away from surface **28** into chute **87**. In the event a pileup of developer powder should occur between surface **28** and conducting plate **112** as a result of being unable to gravitate freely therebetween, the excess powder ascends through one of the many perforated slots **149** of conducting plate **112** wherefrom it continues to cascade to the top of **112** until descending through a slot opening past the pileup onto surface **28**. Development electrode assembly **1** can be left in place for successive and subsequent developments, or if subsequent developments are not of the form wherein a development electrode can be beneficially applied, it can be rendered ineffective by lifting ball knob **122** until lip **145** of clip **144** can be inserted into groove **125**, thereby to secure conducting plate **112** in ineffective relation.

Thus, there has been described a development electrode apparatus to be employed in conjunction with development of a xerographic powder image on a cylindrical xerographic drum whereby the development electrode is movable such that it can selectively be rendered effective or ineffective in relation to development of a xerographic

powder image, and whereby in effective relation, a uniform close spacing of the development electrode to the drum surface is maintainable which saves the photoconductive drum surface harmless from the effects of excess developer powder accumulation.

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

What is claimed is:

1. In a xerographic developing apparatus for developing an electrostatic latent image on the surface of a cylindrical xerographic drum having a photoconductive layer on a conductive backing wherein a development electrode is arranged in closely spaced relation to a portion of the surface of said xerographic drum and is arranged in an electrical circuit to establish an electrical field between the development electrode and the drum and wherein development of said electrostatic latent image is effected by cascading developing material between said drum surface and the development electrode, said developing material including a component having a dimension such that binding of developing material particles can occur; the improvement which comprises a development electrode having a plurality of openings throughout its area whereby excess developing material may pass through said openings and away from said drum surface.

2. In a xerographic developing apparatus for developing an electrostatic latent image on the surface of a cylindrical xerographic drum having a photoconductive layer on a conductive backing wherein a development electrode is arranged in closely spaced relation to a portion of the surface of said xerographic drum and is arranged in an electrical circuit to establish an electrical field between the development electrode and the drum and wherein development of said electrostatic latent imag is effected by cascading developing material between said drum surface and the development electrode, said developing material including carrier beads of a dimension such that binding of carrier beads can occur; the improvement which comprises a development electrode having a plurality of perforations throughout its area, said perforations having a minimum dimension greater than three carrier bead diameters whereby excess developing material may pass through said perforations and away from said drum surface.

3. In a xerographic developing apparatus for developing an electrostatic latent image on the surface of a cylindrical xerographic drum having a photoconductive layer on a conductive backing wherein a development electrode is arranged in spaced relation to a portion of the surface of said xerographic drum and is arranged in an electrical circuit to establish an electrical field between the development electrode and the drum and wherein development of said electrostatic latent image is effected by cascading developing material between said drum surface and the development electrode, said developing material including a component having a dimension such that binding of developing material particles can occur; the improvements which comprise a development electrode having a plurality of perforations throughout its area whereby developing material may pass through said perforations and away from said drum surface, and variably settable mounting means for the development electrode which includes means to place said development electrode into closely spaced relation with said drum surface or to place said development electrode into ineffective spaced relation therewith.

4. In a xerographic developing apparatus for developing an electrostatic latent image on the surface of a cylindrical xerographic drum having a photoconductive layer on a conductive backing wherein a development electrode is arranged in closely spaced relation to a portion of the surface of said xerographic drum and is arranged in an electrical circuit to establish an electrical field between the development electrode and the drum and wherein development of said electrostatic latent image is effected by cascading developing material between said drum surface and the development electrode, said developing material including carrier beads of a dimension such that binding of carrier beads between the drum surface and the development electrode can occur, the improvement which comprises a development electrode having a plurality of perforations throughout its area, said perforations having a minimum dimension greater than three carrier bead diameters, a follower means secured thereto and extending therefrom toward said drum surface, and resilient means urging said follower means into contact against said surface whereby effective spaced relation between said development electrode and said drum surface is uniformly maintained.

5. An apparatus for developing line-copy or solid-area electrostatic latent images on the surface of a xerographic plate, said apparatus including a xerographic plate in the form of a cylindrical drum, means to cascade developing material over the image-bearing drum surface, a development electrode formed to conform to and overlie a portion of the drum surface over which developing material is cascaded, wherein the developing material includes a component having a dimension such that binding of developing material particles between the drum surface and the development electrode can occur, and wherein the development electrode is provided with a plurality of openings throughout its area whereby excess developing material may pass through, said drum and said development electrode being connected in an electrical circuit to establish an electrical field therebetween, support means to support the development electrode in spaced relation to said drum surface portion, and selectively settable means connected to the support means to position the support means either in a first position in which the development electrode is in closely spaced relation to said drum surface portion, whereby the electrical field therebetween is effective to effect image development, or in a second position in which the development electrode is further removed from the drum surface, whereby electrostatic latent images on said drum surface are developed independently of said development electrode.

References Cited in the file of this patent

UNITED STATES PATENTS

2,573,881	Walkup et al.	Nov. 6, 1951
2,777,418	Gundlach	Jan. 15, 1957
2,803,177	Lowrie	Aug. 20, 1957
2,831,409	Bixby et al.	Apr. 22, 1958
2,877,132	Matthews	Mar. 10, 1959
2,911,944	Hayford et al.	Nov. 10, 1959