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R. E. HAYFORD ET AL
POWDER CHARGING DEVICE

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2 Sheets-Sheet 1

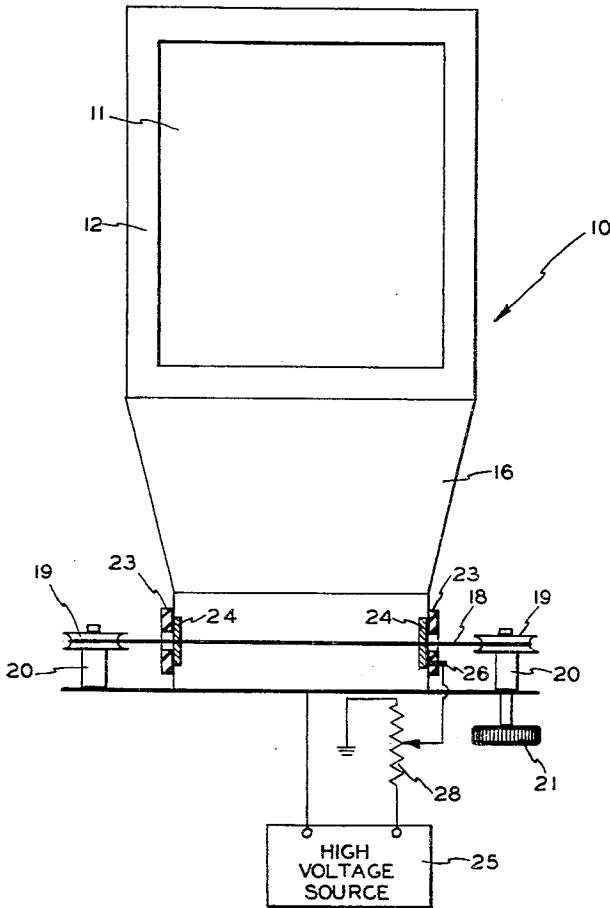


FIG. 1

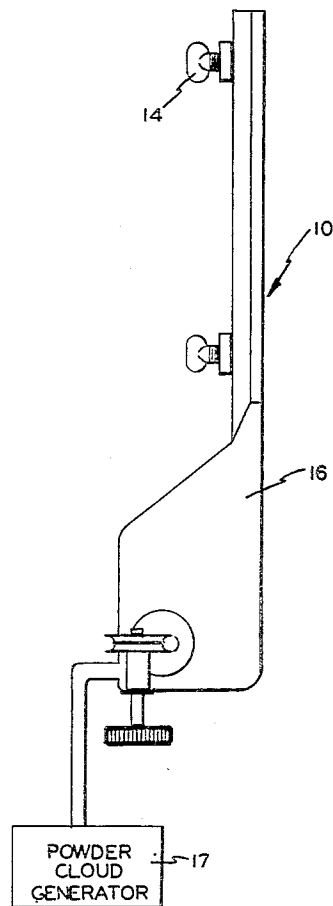


FIG. 2

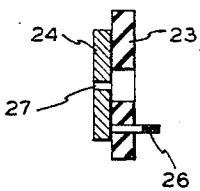


FIG. 3

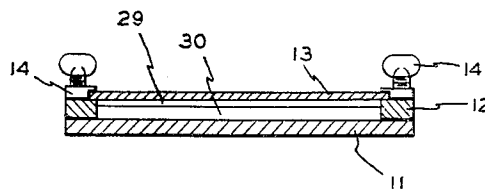


FIG. 4

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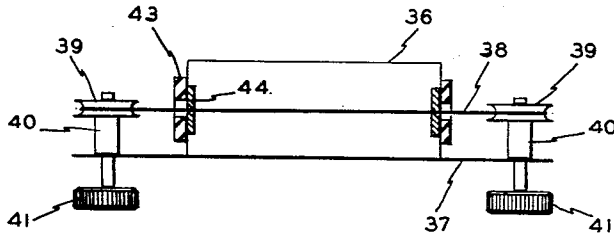


FIG. 5

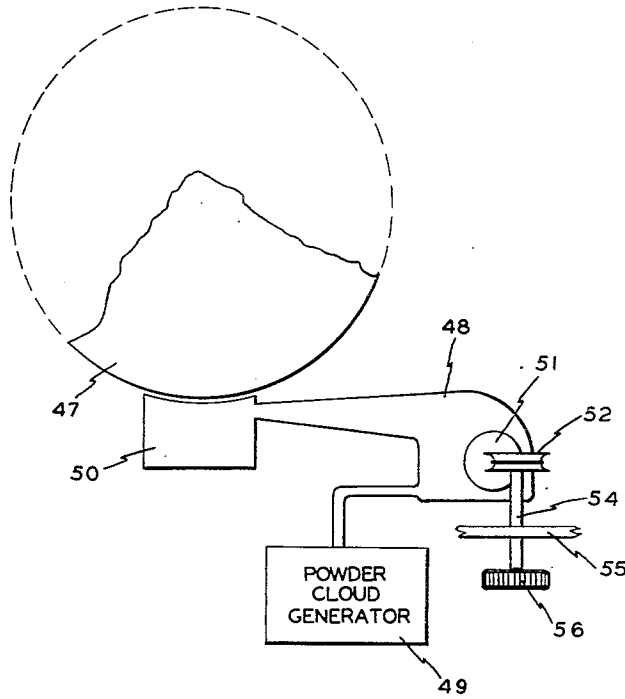


FIG. 6

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POWDER CHARGING DEVICE

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3 Claims. (Cl. 118—637)

This invention relates in general to xerography and in particular to the electrical charging of finely divided developer materials in the development of xerographic images.

In xerography, and in particular in the xerographic reproduction of continuous tone images or pictures, it is usual to develop the electrostatic latent image by presenting to the image surface a cloud or gas suspension of finely divided particulate materials such as a mist or, most often, a cloud of powder particles. The particles in the suspension, such as finely divided particles of pigmented or pigmented material, ink, or the like, are drawn to and deposited on the image-bearing surface in configuration corresponding to the electric field associated with the electrostatic latent image. Thus, by the development step, an invisible electrostatic image is made visible by the deposition of material particles thereon.

It is at once apparent that in order to achieve reasonably good visual or photographic quality in the developed image, it is necessary to have the cloud or particle suspension relatively uniformly and homogeneously charged so that deposition is caused solely by electrical attraction between charged portions of the image surface and the powder particles, with a minimum of deposition, and preferably literally no deposition, in background areas, or caused by charging nonuniformity. Furthermore, in order to achieve consistent, reproducible results it is necessary that the charging be uniform from time to time so that a certain electrical image of specific characteristics will repeatedly yield a developed image of the same contrast, density, and the like.

In the past, one method of achieving charging of the cloud or mist has been to pass the cloud through an atmosphere of ions generated by corona discharge means and thence to the image-bearing surface. Devices operating according to this basis have been constructed and have been found to develop xerographic pictures of relatively good quality, and it seems to be established that the general principle of corona or ion-charging of developer suspensions is well adapted to the operation of xerographic development. In the past, however, it has been found that small amounts of developer tend to deposit on surfaces near which they are passed and this tendency toward deposition includes the deposition of developer on the fine radius corona elements such as needles, wires, or the like. Since the amount of corona current that is carried by a corona discharge system is critically dependent on the effective radius of curvature of the extremely fine corona element, a necessary result of the deposition of even a small quantity of powder or like material on such an element has been to cause substantial change or variation in the charging conditions as the apparatus is operated for relatively longer periods of time. Specifically, when a charging device is intended for continuous operation, or when it is employed in the production of a plurality of xerographic prints, it has been found that the deposition of developer on the corona element

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very quickly causes such impairment of operation as to deleteriously affect contrast or density of the developed image or to result in lateral or area nonuniformity of the image within a given picture or reproduction.

In order to overcome this defect various arrangements have been tried, aimed at shielding the sensitive corona elements from the flow of developer material so that deposition on the elements might be substantially avoided. In practice, however, it has been found that adequate shielding of this sort has not been achieved and that devices which are reasonably adapted to achieve a good degree of such shielding have been found, themselves, to detract from quality of performance. It is, accordingly, an object of the present invention to provide means, methods, and apparatus for high quality uniform charging of suspensions of particulate material, with particular reference to xerographic developer suspensions, which charging is uniform from point to point and is uniform from time to time during continued or repeated operation.

It is another object of the invention to provide a new corona charging element and system which is particularly designed for the continuous or repeated charging of finely divided particulate materials.

It is a further object of the invention to provide developing apparatus, means, and methods for xerographic development wherein a cloud or suspension of developer particles is formed and charged by corona discharge and is thereafter presented to an electrostatic latent image-bearing surface.

Other objects of the invention will in part be obvious and will in part become apparent from the accompanying specification and drawings in which:

Fig. 1 is a diagrammatic front elevation of developing apparatus according to one embodiment of the invention;

Fig. 2 is a side elevation of the apparatus illustrated in Fig. 1;

Fig. 3 is an enlarged cross-section of a cleaning element and electric contact according to the above embodiment of the invention;

Fig. 4 is an end cross-section of the development zone according to the above embodiment of the invention.

Fig. 5 is a diagrammatic front elevation, partially in section, of a powder charging chamber according to another embodiment of the invention;

Fig. 6 is a diagrammatic view of apparatus according to this invention as part of a continuously operating xerographic machine.

Referring to the figures, there is illustrated in Figs. 1 and 2 xerographic developing apparatus generally designated 10 comprising a development electrode 11 having a spacer-frame 12 positioned therearound and adapted to receive in closely spaced parallel position a xerographic plate 13 (see Fig. 4) or other suitable member having a surface bearing an electrostatic latent image to be developed. Suitable clamps or support means 14 are provided on a spacer-frame to secure a xerographic plate in position thereon.

Positioned adjacent to the plate support means, and therebelow as shown in Figs. 1 and 2, is a developer cloud conduit or powder conduit 16 which comprises a housing to contain a charging unit as hereinafter described, and to receive a supply of developer cloud or mist, carrying this supply past the charging unit and feeding it to the development space at the plate support members. The developer cloud conduit or powder conduit is generally tapered in shape and is adapted to receive the developer supply and convey it in smooth and uniform flow to the development space. Preferably, this housing provides a minimum of sharp corners or curvatures in order to achieve maximum ease and uniformity of flow.

Positioned in the charging chamber is a corona discharge assembly including a corona discharge element 18 adapted to be maintained at a corona-generating potential with respect to nearby bodies such as, for example, the walls of chamber 16. Desirably, in accordance with one embodiment of the invention, the corona discharge element 18 comprises a very fine continuous wire loop belt or the like adapted to be moved continuously to the charging chamber and having a uniform cross-sectional area and wire radius or diameter. The corona discharge wire or loop is mounted at each end on an insulating or plastic pulley 19 supported on a bracket 20 with at least one of the pulleys adapted to be driven by a gear or other drive means 21.

At either end of the powder charging chamber is an insulating bracket or washer 23 adapted to support the corona discharge wire at the desired position across the chamber. Mounted on the inside of the washer 23 is a self-cleaning contact-bearing or bushing 24, one or both of which is adapted to be connected to a high voltage source 25 by means of terminal contact 26 or the like. The high voltage source may be of conventional or special design and is a source of high voltage electricity, preferably D. C. or biased A. C. whereby a suitable potential in the order of several thousand volts may be applied to the corona element. Preferably, rectified alternating current in the order of 5,000 to 10,000 volts is available at the power supply.

The corona electrode support is disclosed in more detail in Fig. 3. As thus illustrated a very fine central opening 27 in the contact member 24 is adapted to receive the corona wire 18 in snug sliding contact such as to maintain constant electric contact between member 24 and wire 18 and as to maintain constant cleaning or scraping contact therebetween. Thus, specifically, as the wire passes through the bushing it is constantly cleaned to remove deposited powder or developer material from the wire whereby to provide at all times a clean wire surface.

Suitably positioned at a desired point in the charging housing 16, preferably at a point substantially removed from the development electrode 11, is an inlet for a developer cloud. This inlet generally is so positioned so as to cause the developer cloud to pass through a substantial distance through the charging chamber and preferably to pass adjacent to the corona charging wire 18. In passage through the charging chamber a cloud of developer particles such as, for example, a powder cloud generated by a powder cloud generator 17 is caused to pass within the ionized air or gas volume adjacent to the corona element whereby a substantially uniform deposition of ions or electric charge on the developer particles is brought about. Thus, a suitable mist or cloud of developer is introduced into the charging chamber and conveyed thereby to the development zone, being charged during its passage therethrough.

The powder cloud generator may be any suitable device for creating a cloud or suspension of developer particles, including an atomizer, powder spray gun, or the like. One device found to be satisfactory has been a simple container partly filled with powder and having an air jet directed therein to agitate the powder and air. Alternatively, powder supported on a suitable surface may be formed into a cloud by passing air or other gas against or through the surface.

In Fig. 4 is illustrated in greater detail one form of a development zone for the deposition of powder particles on an electrostatic image-bearing surface. As illustrated, a xerographic plate 13, or similar image-bearing surface, is mounted closely parallel to a development electrode 11 by means of spacer-frame 12 and clamps 14. Preferably the exit end of the development zone is defined by an outlet slit 29 comprising a space or slot between the xerographic plate 13 and the more remote end spacing element 30. If desirable, this

element 30 may be adjustable to vary the width of the slit, thereby controlling the exit or exhaust gas from the development zone. In the embodiment illustrated in Fig. 4 spacing frame 12 may be electrically conductive whereby the backing member of the xerographic plate 13 is maintained at substantially ground potential with respect to the development electrode 11, although spacing frame 12 may be an insulating material and an adjustable bias potential may be applied between plate 13 and electrode 11.

It is to be understood that the corona element 18 is suitably connected to a corona-generating high potential adapted to cause corona discharge or current from the corona element 18 to the walls of chamber 16 or to another suitable counterelectrode with respect to the corona element. Preferably the exact potential applied to the corona element 18 is adjustable as illustrated by its connection to the high voltage source 25 through a potentiometer 28 or other means of adjusting the potential. It is, in fact, a particular object of the present invention to permit such adjustment and control of the corona discharge potential and operation as to provide for optimum corona discharge levels within the charging chamber. Nevertheless, it is possible to give certain general guides as to the potential applied to the corona element with respect to its physical dimensions and the physical dimensions of the entire apparatus. Generally speaking, the corona element is a fine conductive strand, preferably of stainless steel, or other corrosion resistant material, the strand or wire being of minimum diameter compatible with adequate structural strength. An excellent wire diameter considering all factors has been found to be a wire of about 0.0035 inch and a wire of this general diameter spaced at a distance of about one-half inch from its counterelectrode should be maintained at a potential between 4,000 and 10,000 volts with respect to its nearest adjacent counterelectrode, preferably at a potential in the order of about 6,500 to 8,000 volts. With potentials and spacings in this order, a relatively uniform continuous corona discharge or corona glow is observed with the resulting relatively uniform charging of the developer particles. For control and operational purposes it is preferred that the potential on the corona wire 18 be adjusted in order to give a desired flow of corona current as measured by a suitable milliamperemeter in series with the circuit rather than a preadjustment to a predetermined voltage.

In use and operation, a xerographic plate bearing an electrostatic latent image to be developed is placed on its supports and secured in position by tightening clamps 14. The corona element 18 is energized and the level of corona discharge suitably adjusted to give the desired corona current. Drive means 21 is activated to cause the corona wire 18 to pass continuously through the charging chamber 16. The appropriate powder cloud generator or like source of developer material is then activated to supply to the charging chamber a cloud or like suspension of developer material and to carry such developer material into and through the developing zone. As the charged developer powder particles are carried into the development zone, they selectively deposit on the image-bearing surface in accordance with and in conformity with the electrostatic latent image on the surface to yield a developed xerographic print. It is particularly to be understood that the invention as described herein is specifically adapted to the formation of a plurality of successive xerographic prints or for the development of a large size image surface, of a continuously moving image surface whereby operation of the device is continuous and is uniform throughout a long period of time.

In Fig. 5 there is shown a further embodiment of the invention wherein a single strand corona wire is carried back and forth through a powder charging chamber. As illustrated in the figure, a powder supply and charg-

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ing chamber 36 is adapted to carry a corona charging wire 38 which is wound at each end on a plastic or other insulating reel 39 which in turn is supported on a brace or post 40 mounted on a bed plate or support frame 37. Each of the reels 39 is adapted to be driven by suitable drive means such as a gear 41 or like means of propelling the reel at least in the one direction to wind wire 38 upon the reel. Mounted at each end of the chamber 36 is an insulating washer 43 holding a bushing 44. The bushing is of metallic or conductive material such as, for example, Phosphor bronze, and is constructed and adapted to maintain a scraping or cleaning contact with the corona wire whereby as the wire passes through the bushing, deposited powder is scraped therefrom. Suitable electric connectors may be provided on the bushings to cause them to act as electric contacts to maintain the corona wire at the desired corona-generating potential.

In use and operation the device of Fig. 5 is much analogous to the device in the previous figures. In this embodiment of the invention, however, the corona wire 38 is one or more strands of wire, not necessarily endless, and of a length at least about twice the distance between the support reels 39 so that each segment or portion of the wire is adapted to be movable through one and preferably both of the bushings 44. Thus, the wire 38 is wound upon the reel 39 at each end and the reel is adapted to be driven to pull the wire through chamber 36, first in one direction and then in the other so that the working portions of the wire are constantly clean as they leave the chamber. Desirably, the wire 38 may be many times the length of the charging chamber so that during the greater portion of its operation segments of the wire pass entirely through the chamber from one end to the other. The rate of travel of the wire through the charging chamber is such that the wire does not remain in the chamber long enough to gather a substantial deposit of powder, and the result may be achieved under normal conditions of operation by a wire speed to carry the wire through the chamber in about 1 to 15 seconds, although it is presently understood that the speed of travel of the wire through the chamber is not critical except to maintain a sufficient speed to afford constant cleaning of the wire.

In Fig. 6 there is shown, in outline, a further embodiment of the invention comprising a continuously operating xerographic machine, having a charging mechanism of the general type disclosed hereinbefore. As illustrated in this figure, a xerographic cylinder 47 is adapted to be operated through the usual xerographic steps or stages, including sensitization, exposure, development, transfer, and regeneration, or such of those steps or stages as are appropriate for the particular machine, and in the figure is shown diagrammatically the application of the present step to the development zone or stage of such a xerographic machine. A developer charging housing 48 is adapted to receive powder cloud or other developer suspension from a powder cloud generator 49 or the like and is constructed to carry such powder cloud to the development zone 50 of the xerographic machine wherein the powder cloud suspension is presented to the surface of the xerographic cylinder to form a xerographic image thereon. Mounted in each end of the powder charging housing 48 is an insulating support washer 51 through which passes a corona charging wire wound at each end on a plastic or insulating reel 52. The reel in turn is mounted on a support plate 55 and adapted to be driven by gear or like drive means 56. Within the developer charging housing 48 the corona discharge wire passes through a cleaning and electrical contact bushing (see bushing 24 in Fig. 3) which is operably connected to a corona-generating electric potential source (not shown). As in the previous embodiments of the invention the corona discharge wire is passed through the charging housing while the machine is in operation and is con-

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stantly cleaned and maintained at the desired potential by the corona potential and cleaning bushing 24. In operation the xerographic cylinder is rotated through the appropriate xerographic steps or stages, the powder cloud generator is activated to feed a continuous uniform supply of powder cloud to the charging housing, and the corona wire is maintained at the corona-generating potential and moved steadily through the powder charging chamber. In this manner, a constant and uniform supply of uniformly charged developing powder is presented to the xerographic cylinder throughout its continuous operation.

Within the general scope of the invention, it is to be observed that there are certain good engineering or design practices that should be observed to achieve optimum results. Perhaps among the most important of these is the physical design of the powder charging chamber and the conduits and supply means between the powder cloud generator and the development zone. The essential purpose of xerography is to achieve good photographic quality and uniformity and, therefore, it is desirable so to build the powder cloud mechanisms so that uniformity of the powder cloud is achieved as the cloud is passed into the charging chamber and is carried therefrom to the development zone. Good engineering practice should be employed in order to avoid undesirable whirl-pool or eddy currents and to present a laterally uniform powder cloud to the development zone. It is to be understood that such engineering practices and procedures are within the scope of the present invention. Likewise, it will be observed that the corona discharge unit is critically dependent on the radius of the corona wire and accordingly a highly uniform wire of good corrosion resistance should be employed in order to achieve lateral uniformity of the corona discharge and to maintain this uniformity through long-continued operation in spite of the corrosive tendencies of corona discharge.

One specific example of modification that may be made and which essentially will be useful in adapting the invention to truly continuous operation is the provision of means to limit the deposition of powder on the walls and conduits of the apparatus. Particularly, oppositely charged powder may be present and may deposit on such walls. While the deposition on the walls will not be critically detrimental on short runs or in moderate length runs, undue deposition should be avoided. One way of meeting this problem is to provide a means to remove the deposit, such as a vibrator to shake the powder off such walls, and desirably a collection chamber to receive such powder.

It is further understood that numerous variations and modifications in xerography itself may be employed in order to achieve specifically desired end results and that a purpose of the present invention is to be useful in many or all of these variations in xerography so as to produce good quality xerographic reproductions under a variety of operating conditions. Such variations and modifications in xerography likewise are within the scope of the present invention. Thus, for example, the present invention is particularly adapted for operation on a continuous xerographic machine such as a cylindrical machine or on a continuously or continually operating sheet-type or individual exposure type device. The image-bearing surface likewise may be a photoconductive insulating surface as is conventional in xerography, or may be other surfaces adapted to receive an electrostatic latent image in order to support development thereon. It is accordingly to be understood that modifications and variations are expected within the scope of the invention and that the scope of the invention is to be limited only by the appended claims.

What is claimed is:

1. A cloud charging device for substantially uniformly charging a cloud of xerographic developer, said device comprising a cloud generator adapted to form a gas suspension of finely divided xerographic developer powder particles, a developer cloud conduit leading from said gen-

erator to xerographic development apparatus, a movable fine conductive strand mounted in the conduit and extending therethrough, said strand being movable along its length for a distance greater than its length within the conduit, means to move said strand, and electrical contact means through which said strand passes engaging said strand about its transverse periphery and adapted to connect the strand to a corona-generating potential source, said contact means thereby removing deposited powder particles from the surface of the wire, whereby a substantially clean surface is continuously presented in the conduit to assure substantial uniform corona discharge surrounding the wire.

2. A powder cloud charging device for substantially uniformly charging a cloud of xerographic powder developer, said device comprising a powder cloud generator adapted to form a gas suspension of developer powder, a powder conduit leading from said generator to xerographic development apparatus, a movable fine conductive wire mounted in the conduit and extending therethrough, said wire being movable along its length for a distance greater than its length within the conduit, and electrical contact means through which said wire passes engaging said wire about its transverse periphery and adapted to connect the wire to a corona-generating potential with respect to adjacent conduit walls for removing deposited powder particles from the surface of the wire, whereby a substantially clean surface is continuously presented in the conduit to assure substantial uniform corona discharge surrounding the wire.

3. A powder cloud charging device for substantially

uniformly charging a cloud of xerographic powder developer, said device comprising a powder cloud generator adapted to form a gas suspension of developer powder, a powder conduit leading from said generator to xerographic development apparatus, a movable fine conductive non-corrosive wire mounted in the conduit and extending therethrough, said wire being movable along its length for a distance greater than its length within the conduit, electrical contact scraper bushings mounted in the conduit walls and adapted to receive the wire in scraping and electrical contact as the wire passes through the conduit walls, means to connect said bushings electrically to a corona-generating potential source and means to move the wire through the scraper bushings while a cloud of developer is passing through the conduit whereby a substantially clean surface is continuously presented in the conduit to assure substantial uniform corona discharge surrounding the wire.

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