

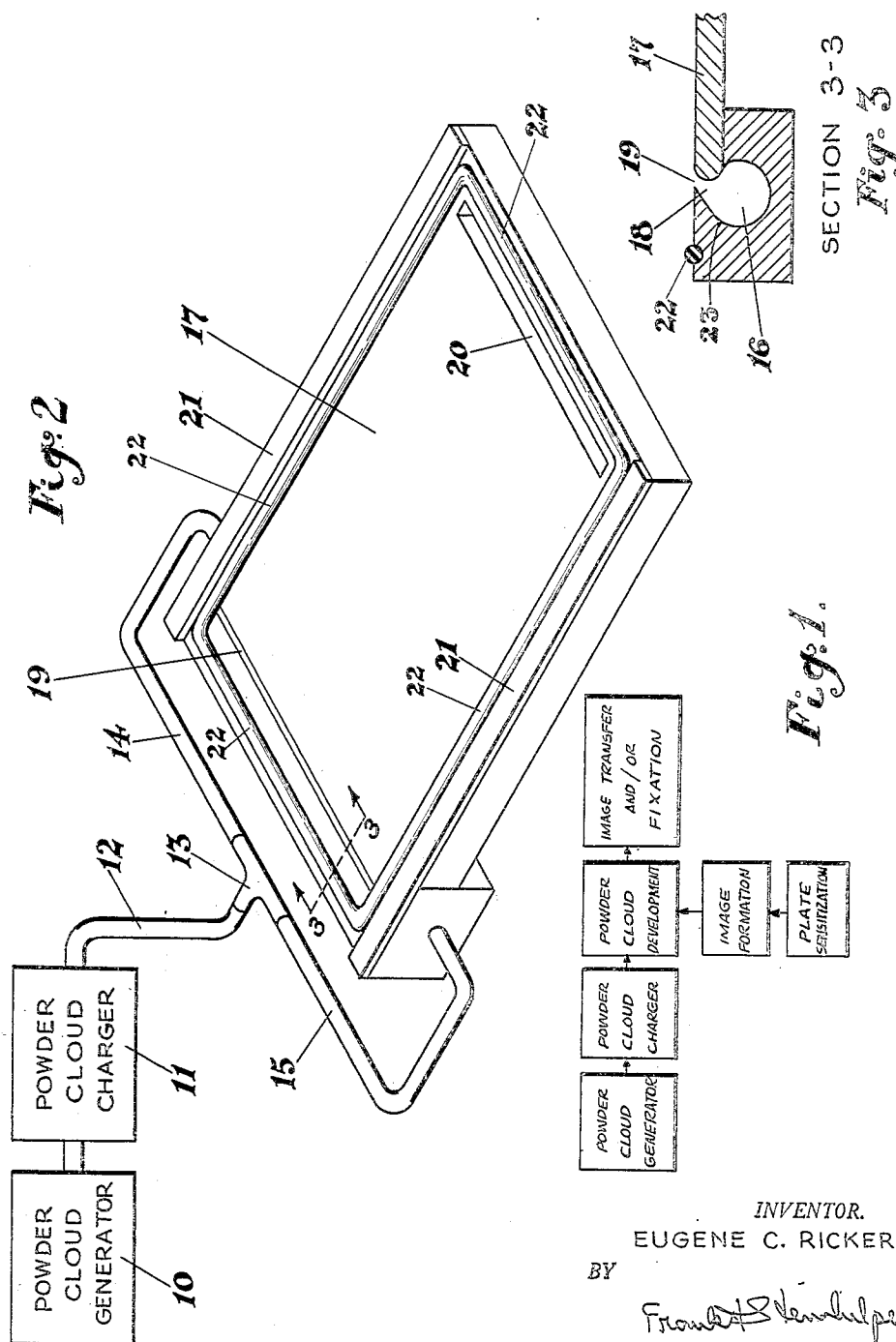
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APPARATUS FOR DEVELOPING XEROGRAPHIC IMAGES

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APPARATUS FOR DEVELOPING XEROGRAPHIC IMAGES

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This invention relates to an apparatus for the development of electrostatic latent images.

In xerography it is usual to form an electrostatic latent image on a surface. One method of doing this is to charge a photoconductive, insulating surface and then dissipate the charge selectively by exposure to a pattern of activating radiation. Other means of forming electrostatic latent images are set forth in U. S. 2,647,464 to James P. Ebert. Whether formed by these means or any other, the resulting electrostatic charge pattern is conventionally utilized by the deposition of an electroscopic material thereon through electrostatic attraction whereby there is formed a visible image of electroscopic particles corresponding to the electrostatic latent image. Alternatively, the electrostatic charge pattern may be transferred to an insulating film and the electroscopic particles deposited thereon to form the visible image. In any case, this visible image, in turn, may be transferred to a second surface to form a xerographic print.

The process of depositing the electroscopic powder on the electrostatic image to render the electrostatic image visible is called the "development step" and is one of the most critical steps of the entire process. The step is of particular importance both on machines designed for continuous operation with any type of copy and in processing continuous-tone images. Now, in accordance with the present invention, an apparatus is provided for substantially improved development of an electrostatic latent image.

Fig. 1 of the attached drawings is a block diagram showing the position of the development step in an overall xerographic process which results in a visible image.

Fig. 2 is an isometric drawing of apparatus according to one embodiment of the invention.

Fig. 3 is a section of this embodiment along the line 3—3 as shown in Fig. 2.

As shown in Fig. 1, the general xerographic process involves the formation of an electrostatic latent image. This is generally, although not always, preceded by a treatment to sensitize the surface on which the electrostatic latent image is to be formed. The electrostatic latent image, to be useful, must then be rendered visible, which is done in a development step. This is accomplished by depositing electroscopic particles either on the surface on which the image was formed or on an insulating surface to which the electrostatic latent image has been transferred.

It is evident that no picture can be better than its development step permits. About the coarsest type of image reproduced by a xerographic process requires a resolution of at least about 50 lines per inch. Commercial, line-copying machines generally have a resolution power of about 125 to 250 lines per inch. The process used in obtaining this resolution is set forth in U. S. 2,618,552 and involves the use of a finely-divided material called a "toner" deposited on a slightly more coarsely-divided material called a "carrier." This two-component developer is cascaded across the electrostatic

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latent image areas. The control of the concentration of toner in the two-component developer becomes extremely difficult in the continuous operation of such line-copy machines. When applied to continuous-tone development where resolutions of about 1200 or more lines per inch are often desired, it has been found impossible to obtain this high quality of reproduction using such a system. Accordingly, a system known as "powder cloud development" is preferred. This is the system incorporated in Fig. 1.

As shown in Fig. 1, a powder cloud is generated as from a dry material or by forming a spray of liquid droplets. The cloud so produced is then charged, the charging step constituting either a separate step, or utilizing the inherent charge on the cloud in the case of a cloud of dry particles. A cloud so generated and charged is then contacted with the electrostatic latent image in the development step. The visible image so produced may be used as such, permanently affixed to the plate, or may be transferred to another material as a sheet of paper or plastic, as is well-known to those skilled in the xerographic art.

While it is possible to obtain a high quality of tonal reproduction using powder cloud development, the various processes for developing electrostatic images with powder clouds differ widely in their characteristics, such as susceptibility to streaking, tearing, halo, graininess, evenness of development from side-to-side and end-to-end, speed of development, and so forth. Electrostatic images developed using the apparatus of the invention are characterized by exceptional evenness from side-to-side, even in the case of exceptionally wide images.

In addition, images developed with the present apparatus show little susceptibility to several of the defects which characterize many other powder cloud development processes. For example, in some processes when the powder cloud in its flow travels over an area that should be dark, the leading edge of the dark area is not developed. On the developed image the dark area appears to be torn so that a white background shows through. Because of this appearance the flaw is referred to as "tearing."

Another defect occurs when the powder cloud travels over a large dark area and then over a large area that should remain white. Although the white area is void of charge, it does not remain free of powder. Developer particles deposit in streaks through this area in amounts roughly proportional to the length of the dark area that immediately precedes the white area. This defect is termed "streaking."

Again, the developer powder is deposited relatively uniformly over a charged area but along the dividing line between the charged and uncharged areas, there is a pronounced absence of the deposited powder. This defect is termed "halo."

Images developed on the apparatus of the instant invention are relatively free of these defects.

The development time is relatively short, a few seconds being sufficient for complete development.

Apparatus according to this invention for developing an electrostatic image comprises a cloud generator, a charging device for the cloud particles, a development electrode, support means to receive and support an electrostatic image-bearing member adjacent to the development electrode and closely spaced therefrom at a distance of not more than $\frac{1}{8}$ ", thereby defining a development zone relative to the development electrode, an entrance chamber extending across one end of the electrode evenly curving in the longest path without sharp turns toward an entrance slot thereby forming a passage of gradually diminishing cross-sectional width which terminates at the entrance slot in a restricted aperture

into the development zone, means to feed the charged cloud particles into each end of the entrance chamber, and exit means at the opposite ends of the development electrode from the entrance slot. In general, then, the apparatus comprises in combination a conductive development electrode having a surface conforming to the shape of a layer bearing an electrostatic image, means to support this layer in spaced substantially parallel relation to the development electrode to provide a development zone between them, walls defining an entrance chamber at one end of the zone, the chamber communicating with the zone by a slot extending across the end of the zone, and means for generating and blowing a gas suspension of finely-divided developing material through the entrance chamber, slot, and development zone in series, the walls forming a tapered converging passage leading from the chamber through the slot to convert the flow of the gas suspension into substantially laminar flow.

A xerographic plate is customarily used in this apparatus to supply the image-bearing surface.

A xerographic plate consists of a layer of a photoconductive insulating material such as selenium, anthracene, selenium-tellurium mixtures, etc. deposited on a conductive backing such as aluminum, brass, conductive glass, etc. Such a plate may be sensitized, i. e. made light-sensitive, by depositing an electrical charge by corona discharge or other means on the photoconductive insulating material.

A specific embodiment of the apparatus for developing the image is shown in Figs. 2 and 3. In this figure the powder cloud generator is 10, the powder cloud charger 11; 12 is a tube connecting the charger to a T junction 13. The T connects the tube 12 to two arms 14 and 15 which lead to each end of the entrance chamber 16 defined by walls 23 which is situated at one end of the development electrode 17. The entrance chamber extends across one end of the development electrode and forms in its upper side a passage 18 which terminates in an entrance slot 19. At the opposite end of the development electrode from the entrance slot are exit means 20 which may be either holes or a slot. On the development electrode are spacers 21 which hold an image-bearing member, such as a xerographic plate, at the desired spacing, which should be no more than $\frac{1}{8}$ ", and electrically insulate the plate from the development electrode. A rubber gasket 22 acts as a dust seal and also helps to electrically insulate the xerographic plate from the development electrode.

Development proceeds as follows: A cloud of electroscopic particles is generated in the cloud-forming device 10, for example, by the agitation of a powder mass in a closed container with a rotating brush as shown by U. S. 2,357,809 to C. F. Carlson or a rotating air mass as caused by laterally-located nozzles or by aspirated air from a powder-loaded belt or disc. If a cloud of liquid droplets is desired, it may be produced by any means known to those skilled in the art, as by spraying through an atomizer as shown in U. S. 2,690,394 to C. F. Carlson.

The cloud, by whatever means produced, is then charged, 11. Where a cloud of dry particles is used, any method of generating the cloud will almost necessarily produce a charge thereon. For some purposes the charge so produced will be adequate. If it is desired to produce a more uniform charge, however, other devices, such as triboelectric charging (as by passing the electroscopic powder through a narrow tube of suitable material in turbulent flow), corona charging, or other device may be used. In the case of a cloud of liquid droplets, charging means, such as induction charging, as shown in U. S. 2,690,394 to C. F. Carlson, corona charging, and so forth, may be used.

The air suspension of electroscopic particles, termed

"the cloud," is blown through the tube 12 to the T junction 13 where it divides and passes through arms 14 and 15 into the entrance chamber 16.

The entrance chamber has a larger cross-sectional area than the input tubes which admit the powder cloud at each end of the chamber. The chamber curves, without sharp angles, into a passage 18 of gradually lessening width which terminates in an entrance slot 19 which presents a substantially restricted aperture to the development zone. This design of the entrance chamber, passage and slot assures uniform distribution of the cloud along the length of the slot and smooths out minor variations in air pressure. The curved passage changes the direction of flow of the cloud so that the cloud emerges from the entrance slot into the development zone in laminar flow approximately parallel to the image-bearing surface. In the development zone the development electrode draws the field of force of the electrostatic image externally from the image-bearing surface. To do this the electrode 17 may be grounded or may be charged to a polarity opposite to that of the image as explained hereafter, and in any event should be no more than $\frac{1}{8}$ " from the image-bearing surface. For xerographs requiring a high degree of resolution, the distance between the electrode and the image-bearing surface should be no more than $\frac{1}{40}$ ". The powder cloud passes through this field of force in the development zone leaving through exhaust means (holes, slots, etc.) at the opposite end of the electrode from the entrance slot.

As a result of this process, the electroscopic particles are deposited on the image areas of the xerographic plate from the powder cloud.

In illustration thereof and not in restriction of the invention the unit shown in Fig. 2 was designed to be used with xerographic plates having overall dimensions of 5" x 7" and an image area of 4" x 5". The overall size of the development electrode was 5" x 6 $\frac{5}{8}$ ". The length of the entrance slot was 4", and the distance from the entrance slot to the exit slot was 5 $\frac{7}{8}$ ". The tube which conducted the powder from the powder cloud generator to the T and thence from the T to each end of the entrance chamber was copper tubing having a $\frac{1}{4}$ " outside diameter. The entrance chamber itself was designed by constructing the lower right-hand portion, as seen in Fig. 3, on a $\frac{3}{16}$ " radius with the remainder of the entrance chamber, including the passage, on a $\frac{3}{8}$ " radius. The thickness of the development electrode shown was $\frac{3}{8}$ ". The entrance slot was .006" wide and the exit slot $\frac{1}{8}$ " wide.

The images so developed may be used as such, permanently affixed to the plate, or may be transferred to another material as a sheet of paper or plastic, as is well-known to those skilled in the xerographic art.

The image so formed is characterized by exceptional evenness of development from side-to-side and is exceptionally free from such defects as tearing, streaking, and halo. Only a few seconds are needed for complete development of the image which is of exceptional tonal quality.

Generally, the powder cloud is charged with a charge of polarity opposite to the polarity of the electrostatic image. However, this is not necessarily so. Thus, reversal development may be effected by charging the powder cloud with a charge having the same polarity as the image areas. Hence, the powder is repelled from the image. When a field is applied by the development electrode which opposes the image field, the powder is attracted to the uncharged "background" areas to develop a reversal print.

Grounding the development electrode is sufficient to draw the lines of force of the image areas externally from the image-bearing surface. However, the development electrode is capable of a far more flexible operation than this. Thus, the quality and character of images can be

controlled by placing various potentials on the electrode. It is often desirable to vary the maximum and minimum density of a print, to control the contrast, and in some cases, to accentuate the development of areas having a given charge density. To increase the brightness of highlights, a field is applied by the development electrode which cancels the field from the highlight areas. To increase the overall density, a field may be applied to aid the deposition of powder over the entire image-bearing surface.

To emphasize the darker areas of the image, a potential may be applied to the electrode for, say, 50% of the time, which is opposite in polarity to the amige and sufficient to produce a field strength which will cancel or reverse the field from all except the most highly-charged image areas. During this period, only the charged areas are developed. For another period, say 40% of the development time, the potential is lowered to permit some development of intermediate tones along with further development of dark areas, and finally, for the last 10% of the cycle, the potential may be lowered still further to allow a slight fill-in in the lighter areas. Other forms of development can also be achieved with such a system.

I claim:

1. Apparatus for developing an electrostatic image on an image layer with a finely-divided material comprising, in combination, a conductive development electrode having a surface conforming to the shape of said image layer, means to support said layer in spaced substantially parallel relation above said development electrode to provide a development zone between them, walls defining an entrance chamber at one end of said zone, the walls of said chamber forming an opening therefrom communicating with said zone and extending across the end of said zone, entrance apertures at each end of said chamber, and means for generating and blowing a gas suspension of finely-divided developing material through said apertures entrance chamber, opening, and development zone in series, said walls forming a tapered converging passage leading from said chamber through said opening to convert the flow of said gas suspension into substantially laminar flow.

2. Apparatus for developing an electrostatic image on an image layer with a finely-divided material comprising in combination an electrically conductive development electrode having a surface conforming to the shape of said image layer, means to support said layer in opposed, spaced substantially parallel relation above said development electrode to provide a development zone between said electrode and said layer, walls evenly curving in the longest path without sharp turns and defining an entrance chamber at one end of said zone, the walls of said chamber forming an opening therefrom that communicates with said zone and extending across the end of said zone, entrance apertures at each end of said chamber, and means for generating and flowing a gas suspension of finely-divided development materials through said apertures, entrance chamber, opening and development zone in series, said walls forming a passage of gradually diminishing cross-sectional width toward said opening to convert the flow of said gas suspension therefrom into substantially laminar flow.

3. Apparatus for developing an electrostatic image on an image layer with a finely-divided material comprising in combination an electrically conductive development electrode having a surface conforming to the shape of said image layer, means to support said layer in opposed, spaced substantially parallel relation no more than about one-fortieth inch above said development electrode to provide a development zone between said electrode and said layer, walls evenly curving in the longest path without sharp turns and defining an entrance chamber at one end of said zone, the walls of said chamber forming an opening therefrom that communicates with said zone and extending across the end of said zone, entrance apertures at each end of said chamber, and means for generating and flowing a gas suspension of finely-divided development materials through said apertures, entrance chamber, opening and development zone in series, said walls forming a passage of gradually diminishing cross-sectional width toward said opening to convert the flow of said gas suspension therefrom into substantially laminar flow.

4. Apparatus for developing an electrostatic image on an image layer with a finely-divided material comprising in combination an electrically conductive development electrode having a surface conforming to the shape of said image layer, means to support said layer in opposed, spaced substantially parallel relation above said development electrode to provide a development zone between said electrode and said layer, walls evenly curving in the longest path without sharp turns and defining an entrance chamber at one end of said zone, the walls of said chamber forming an opening therefrom that communicates with said zone and extending across the end of said zone, entrance apertures at each end of said chamber, and means for generating and flowing a gas suspension of finely-divided development materials through said apertures, entrance chamber, opening and development zone in series, said walls forming a passage of gradually diminishing cross-sectional width toward said opening to convert the flow of said gas suspension therefrom into substantially laminar flow, the cross-sectional area of said chamber being substantially larger than the cross-sectional area of said entrance apertures.

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