

Feb. 24, 1970

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3,497,296

XEROGRAPHIC EXPOSURE APPARATUS

Filed June 12, 1967

2 Sheets-Sheet 1

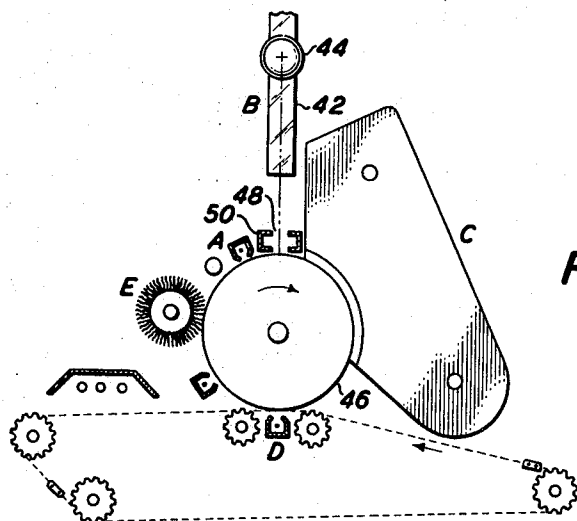


FIG. 2

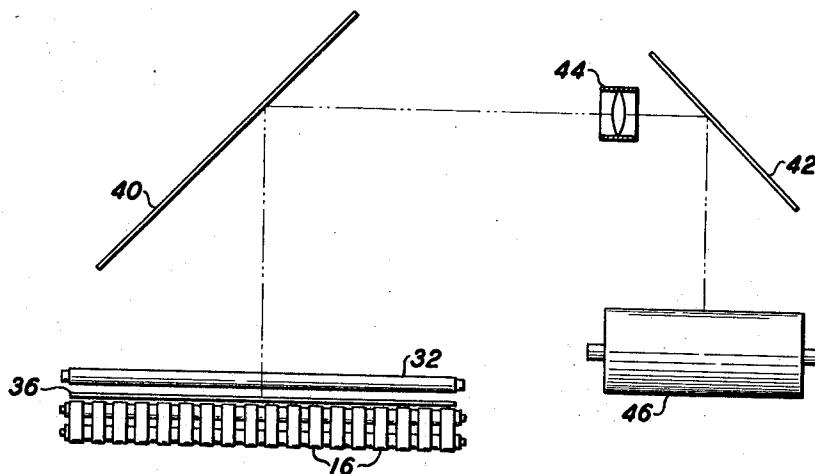


FIG. 1

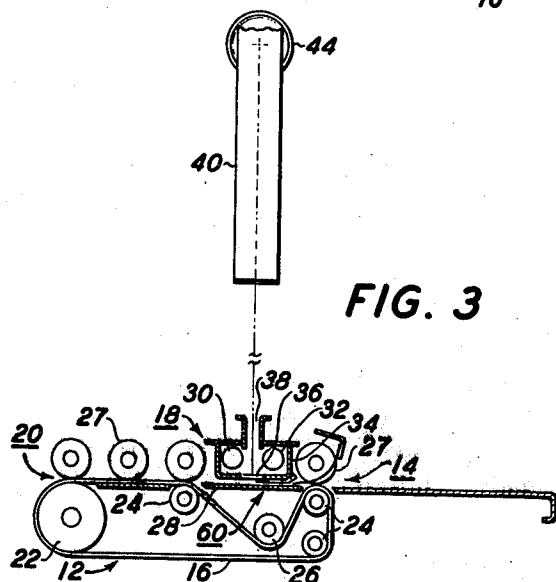


FIG. 3

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2 Sheets-Sheet 2

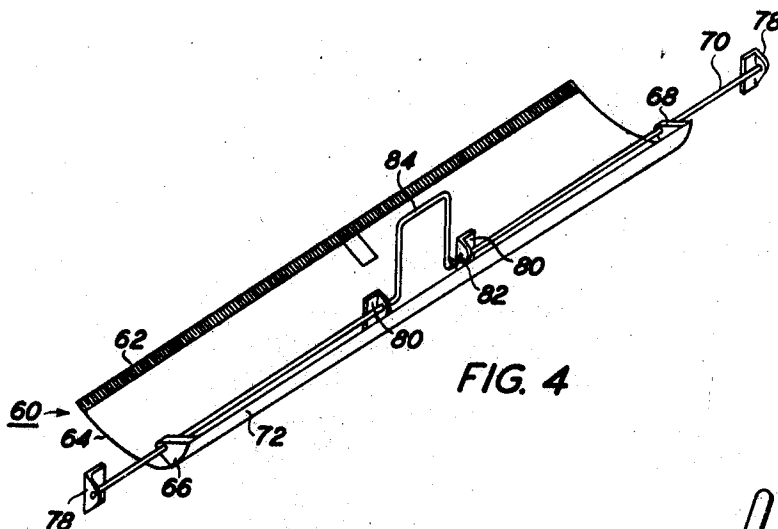


FIG. 4

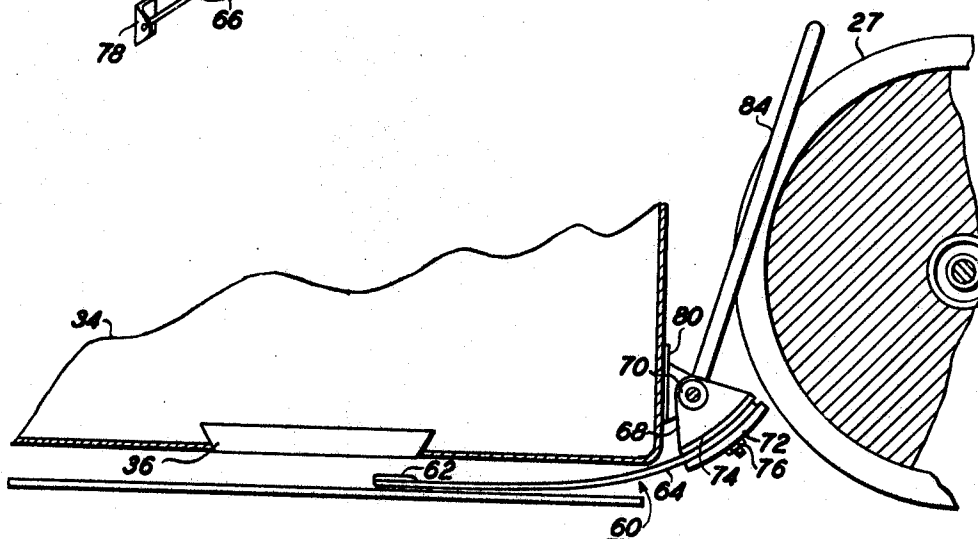


FIG 5

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XEROGRAPHIC EXPOSURE APPARATUS

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7 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for breaking up latent electrostatic images into an array of parallel lines of high and low charge for improving solid area and half tone development capabilities of xerographic devices. The apparatus is used in a system wherein an original document is optically scanned to sequentially image the document on a moving xerographic surface. The apparatus includes an opaque sheet positioned adjacent the document to be reproduced. It is of such size as to extend across the width of the document and of a length to overlie a portion of the document as it is moved through the imaging station. The sheet has closely spaced parallel dark and light lines running parallel to the direction of document movement to project a line screen pattern onto the charged xerographic surface during imaging of the document.

This invention relates in general to xerography, and in particular, relates to xerographic solid area coverage apparatus by which continuous tone and solid area images can be faithfully reproduced.

In the practice of xerography as described in U.S. Patent No. 2,297,691 to Chester F. Carlson, a xerographic surface comprising a layer of photoconductive insulating material affixed to a conductive backing is used to support electrostatic images. In the usual method of carrying out the process, the xerographic plate is electrostatically charged uniformly over its surface and then exposed to a light pattern of the image being reproduced to thereby discharge the charge in the areas where light strikes the layer. The undischarged areas of the layer thus form an electrostatic charge pattern in conformity with the configuration of the original light pattern.

The latent electrostatic image can then be developed by contacting it with a finely divided electrostatically attractable material such as a resinous powder. The powder is held in image areas by the electrostatic charge fields on the layer. When the charge field is greatest, the greatest amount of material is deposited; and where the charge field is least, little or no material is deposited. Thus, a powder image is produced in conformity with the light image of the copy being reproduced. The powder is subsequently transferred to a sheet of paper or other surface and suitably affixed to thereby form a permanent print.

The electrostatically attractable developing material commonly used in xerography consists of a pigmented resinous powder referred to here as "toner" and a "carrier" of larger granular beads formed with glass, sand or steel cores coated with a material removed in the triboelectric series from the toner so that a triboelectric charge is generated between the toner powder and the granular carrier. Such charge causes the toner to adhere to the carrier. The carrier also provides mechanical control so that the toner can readily be handled and brought into contact with the exposed xerographic surface. The toner is then attracted to the electrostatic image to produce a visible powder image on the xerographic surface. Thereafter the developed xerographic image is usually transferred to a support or transfer material to which it may be fixed by any suitable means.

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Good results have been obtained with this process especially with cascade development using toner-carrier mixtures. This is especially true in automatic and continuous xerographic machines for line copy such as letters or lines on a white background.

Due to the electric field conditions in the region of the electrostatic images, however, large solid areas do not develop uniformly. Xerographic development of such areas delineate their outline in charge gradient areas only, the centers of the areas not being developed or filled in with powder, unless a closely-spaced development electrode is used in the development zone, as described in U.S. Patent 2,952,241 to H. E. Clark et al. Continuous-tone images suffer in like manner, the tonal rendition being poor unless a development electrode is used. However, with continuous automatic equipment it is not usually feasible to provide a development electrode closely-spaced enough to the xerographic drum surface for the purpose without somewhat interfering with the flow of developer and hence slowing down the speed of the machine, and also producing undesirable developer jamming at times.

U.S. Patent 2,598,732, to Walkup discloses a method of overcoming these difficulties in stationary flat-plate xerographic equipment by exposing the xerographic plate to a screen pattern in addition to the image pattern to be recorded, thereby breaking up the image into a half-tone pattern. However, Walkup has not disclosed means which are suitable for application to automatic continuous machines where the surface carrying the electrostatic image is moving, such as in the case with a rotating xerographic drum.

Another technique for reproducing continuous tone and solid area images xerographically is disclosed in U.S. Patent 3,120,790 to Carlson et al. This technique employs a screen formed of transparent and opaque lines to dissipate the original charge on a xerographic drum in a pattern of lines parallel to the direction of drum rotation. The charge dissipation may be either before, during or after xerographic development.

According to this technique the screen is positioned either (1) to extend over the entire exposure slit so that various portions of the image are always blocked by the opaque lines of the screen or (2) in a location as to require an additional source of illumination. In either instance, the screen employed must include transparent and opaque sections and must be positioned adjacent the drum surface.

The present invention is an apparatus for improving xerographic reproductions of continuous tone and solid area images and constitutes an improvement over the aforementioned techniques.

It is, therefore, an object of this invention to improve continuous xerographic apparatus for the rendition of such matter having variations in tonal value throughout all or part of the area being reproduced.

Another object of this invention is to improve xerographic reproducing apparatus affecting improved continuous tone rendition of images and solid area coverage of images being reproduced on a moving electrostatic image carrying surface.

Another object of the instant invention is to concurrently project a scanned original document and line screen pattern onto a moving xerographic surface with improved and simplified apparatus.

These and other objects of the instant invention are achieved by an opaque sheet positioned adjacent the document being reproduced. The sheet is fixedly positioned at the imaging station while the document is continuously moved through the imaging stations partially beneath the sheet during the projection of images onto the xerographic surface. This motion continually projects the

sheet while sequentially projecting the document onto a moving xerographic surface during the exposure process. The sheet is of a width to extend across the entire width of the document and of a length to cover a portion of area being projected. It is provided with light and dark lines running parallel to the direction of motion of the document to break up the charge on the xerographic surface concurrently with the imaging of the document. Latent electrostatic images developed after such an imaging process produce copies with improved solid area portions.

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

FIG. 1 is a front view of continuous and automatic xerographic machine provided with the line screen mechanisms of the instant invention with the cabinet covers of the apparatus removed to show the internal structure of the machine;

FIG. 2 is a schematic view of the xerographic portion of the machine shown in FIG. 1;

FIG. 3 is a sectional view of the apparatus taken through the imaging portion of the machine shown in FIG. 1;

FIG. 4 is a perspective view of the line screen sheet and mechanisms for securing it in position in the machine of FIG. 1; and

FIG. 5 is an enlarged sectional view similar to that of FIG. 3 but showing the line screen sheet and its securement in the document scanning station with greater clarity.

Shown in the figures is a xerographic machine including a line screen sheet constructed in accordance with the instant invention. The other elements of this machine, which is constructed for continuous and automatic operation, are fully described in U.S. Patent 3,236,165 to J. Rutkus, Jr., et al. For the purpose of the present disclosure, the several xerographic processing stations in the path of movement of the xerographic surface for each machine may be briefly described as follows:

A charging station A, at which a uniform electrostatic charge is deposited on the photoconductive layer of the xerographic drum or other cylindrical surface;

An exposure station B, at which the light or radiation pattern of copy to be reproduced is projected onto the drum surface to dissipate the drum charge in the exposed areas thereof to thereby leave a latent electrostatic image of the copy to be reproduced;

A developing station C, at which a xerographic developing material, including toner particles having an electrostatic charge opposite to that of the electrostatic latent image, are cascaded across the drum surface, whereby the toner particles adhere to the electrostatic latent image to form a xerographic powdered image in the configuration of the copy being reproduced;

A transfer station D, at which the xerographic powder image is electrostatically transferred from the drum surface to a transfer material or a support surface; and

A drum cleaning and discharge station E, at which the drum surface is brushed to remove residual toner particles remaining thereon after image transfer, and at which the drum surface is exposed to a relatively bright light source to effect substantially complete discharge of any residual electrostatic charge remaining thereon.

The apparatus of the instant invention is adapted for incorporation in an exposure or imaging station of the type described in the aforementioned Rutkus patent. This station in general includes a document conveyor positioned to move a document past a light source which scans a document and transmits a light image through a lens system to a charged xerographic surface. The control apparatus is such that the speed of the document on the conveyor is controlled in timed relation to the movement of a xerographic drum. It is also coordinated with the

lens system to produce a preselected enlargement or reduction of the image thus transferred if desired.

The document conveyor 12 is seen in FIG. 3. An original document is fed into the conveyor system at feed-in station 14 and is carried on conveyor belts 16 past scanning station 18 to a discharge point 20.

The conveyor belts 16 consist of a series of continuous belts driven by a drive roll 22 around a series of idler rolls 24 and a tensioning roll 26. Mounted above and in contact with the individual strands of conveyor belt 16 are a series of pressure rollers 27 mounted on a series of shafts. The pressure rollers hold the document down on the conveyor belts 16 for movement through the conveyor system.

A document fed into the conveyor at feed-in station 14 is gripped between the belts 16 and the first pressure rollers and moves forward across a platen 28 at exposure station 18. The document, after passing over platen 28 is again picked up by conveyor belts 16 and the pressure rollers and transported to the discharge station 20. The platen 28 has a reflective or flat white surface to reflect light that has passed through a document back through the document to reinforce the light image reflected from the document surface.

As best seen in FIG. 3, there are a pair of fluorescent lights 30 and 32 mounted directly above the platen 28 and encased in a lamp housing 34. In the bottom of the housing, directly beneath the fluorescent lights 30 and 32, is a glass plate 36 and in the middle top of the housing there is a light tunnel 38. The two fluorescent lights are spaced apart so that as a document passes over the platen 28, light is reflected down through the glass plate 36, onto the surface of the document and reflected from the document or from the reflective surface of the platen upward through the glass plate 36 through the light tunnel 38 to the other optical elements of the apparatus. The imaging area is that area beneath the glass plate 36 which can be projected to the drum through light tunnel 38.

The image reflected from the document surface passes through an optical system, as shown in FIG. 1, to the xerographic side of the apparatus. The optical system consists of two front surface mirrors 40 and 42, and a positionable lens 44. The mirror 40 is an object mirror and is positioned above the scanning station at an angle to receive a light image from the scanning station through the optical system. The mirror 42 is an image mirror positioned above the xerographic processor at an angle to receive a light image from the object mirror and the lens 44 for transmittal to the xerographic drum 46 to thereby discharge the charge on the drum surface. This creates the latent electrostatic image of the document for subsequent development, transfer and fixing on a permanent copy sheet. Both of the mirrors and the lens are adjustable for alignment in the optical system and are mounted to be secured in position once properly aligned. Since the mechanisms for optical reductions are not necessarily part of the instant invention, further descriptions thereof are not considered necessary.

The exposure station on the xerographic drum side of the machine receives the light image from the document being reproduced and permits the light image, to be sequentially placed on the drum surface in timed relation to the movement of the original document through the document conveyor. A light image of the copy being reproduced is reflected from the mirror 44 through a slot aperture 48 in a light shield 50 onto the xerographic drum.

As can be understood, that portion of the document in the imaging zone beneath glass plate 36, at any instant of time, will be reflected through the light tunnel 38, through the mirrors 40, 42 and lens 44, through the aperture 48 in light shield 50 to dissipate the charged xerographic drum 46 in a patterned configuration corresponding to the document portion then beneath glass plate 36. Thus when the document and drum are

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moved in synchronism, the drum surface will be sequentially imaged and its charge dissipated in accordance with the light and dark portions of the document to create a flowing latent electrostatic image of the entire document. Due to the nature of the latent electrostatic image field above the photoconductive layer the electrostatic lines of force tend to concentrate at the edges of areas still carrying a charge after exposure.

Without the screen pattern applied by the present invention, the developing material, or toner, is attracted mainly to the areas where the electric fields are the highest and the lines of force most concentrated. This characteristic is excellent for developing narrow lines of printed or typed characters. Where large solid areas are present in the original, they are not reproduced upon development as solid areas of toner, but rather the toner will deposit heavily along the edges of the solid areas, and very little or none will deposit in the centers, resulting in copy with a halo-like appearance. With continuous-tone originals similar effects are encountered.

In accordance with the present invention, these problems are overcome in rotating drum-type xerographic machines by introducing, in the exposure system of the machine, a shadow-casting member comprising an array of parallel opaque dark and light lines which break up the light into a lined half-tone pattern. The resulting electrostatic images, after exposure, are therefore subdivided into a lined half-tone pattern, resulting in a configuration of the electrostatic fields above the photoconductive surface which causes the uniform half-tone development of large solid areas and the rendering of continuous tones as half-tones.

The line screen apparatus 60 of the instant invention, as more clearly seen in FIGS. 4 and 5, includes an opaque sheet 62 composed of alternating light and dark lines parallel to the direction of document flow. The sheet is adapted for positioning beneath the glass plate 36 but above the flowing original document to be reproduced with the lines of the sheet in the object plane of the original document being reproduced. It is adjustably held in position by a flexible screen mounting strip 64 adjacent the document input end of the glass plate. End brackets 66, 68 are fixedly secured to rotatable shaft 70 and are provided with arcuate bearing plates 72, 74 and securement means 76 for rendering the mounting strip 64 and opaque lined screen or sheet 62 adjustable with respect to the lamp housing 36. First brackets 78, secured to the machine housing and second brackets 80, secured to the lamp housing 34 journal shaft 70 for rotation and consequent adjustment of the lined screen 62 beneath the glass plate 36.

The shaft 70 and, consequently the lined screen 62, are held from extraneous rotation during operation by a coil spring 82. Spring 82 is concentrically arranged around shaft 70 with its first end in bearing engagement with one of the second fixed brackets 80. The second end of the spring 82 is in bearing engagement with a bent portion 84 of the shaft 70. The tension within the spring 82 acts to exert a rotation-restricting force between the fixed bracket 80 and shaft 70 for prohibiting undesired rotation therebetween.

Although the bent portion 84 of the shaft 70 acts as a bearing surface for restricting the rotation of the shaft, its primary function is to constitute a handle for rotating the shaft and lined screen to thereby vary the amount of line screening to be images onto the xerographic drum for a purpose to be later described.

The function of the lined screen is to continually project a pattern of light and dark lines, parallel to the direction of document flow and drum rotation, from the imaging station 18 onto the xerographic drum 46. This acts to dissipate the drum charge into a parallel lined pattern of high and low charge areas to electrostatically break up large solid areas projected onto the drum by the original document. This, as has been explained above, 75

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increases development capabilities of xerographic systems. Consequently, with the lined screen fixed to extend across the width of the glass plate 36, and of a length to continually cover a portion of the document moving beneath it and the glass plate 36, the rotating drum will be continuously exposed to the screened pattern concurrently with the sequential exposure to the flowing document.

It has been found that excellent results occur with the screen extending about 12 percent of the distance of the imaging area beneath the glass plate 36. From 10 to 20 percent was also found suitable. Adequate results also occur when the screen extends into the imaging areas from a negligible amount up to slightly less than 50 percent. Due to the decreased time that the image is actually being exposed for optical projection, a slight increase in illumination power was found beneficial, but not absolutely necessary in improving solid area capability.

The parallel dark and light lines on the opaque screen should be placed as close as possible to the original document to ensure focusing of the lines for proper projection. The placing of the screen beneath glass plate 36 effectively insures proper focusing since the lined pattern is within the optical plane of the original. In the same sense, the instant invention is applicable to xerographic machines wherein the illumination system is moved relative to a fixed original. In that instance, the lined screen sheet would have to move with the optical scanning elements. Furthermore, the screened sheet would again have to extend the width of the imaging area and to a length less than half the length of the imaging area and yet to be sufficiently close to the document to lie within the focal plane, if effective imaging thereof is to be achieved.

Line screen patterns having from 65 to 100 lines per inch, with equal width for the light and dark lines, were successfully used to improve solid area capabilities in the above-described machine. But, as can be understood, finer line patterns can effect a finer break-up of large solid areas. Consequently, it should be understood that finer line patterns are within the scope of the instant invention and could be employed where greater resolution is desired or required.

While the imaging screen of the instant invention is shown adjacent the input end of the imaging station, it could be alternately positioned adjacent the output end thereof, or even across the central strip of the glass plate 36 for document exposure before and after the projection of the screen pattern. In the latter case, however, adjustment capabilities of the screen are eliminated. The placing of the screen adjacent the document input end has been found more desirable than placing it at the output end since less chance exists for the screen to interfere with the flow of the document therebeneath.

While the instant invention has been described with reference to the structures disclosed herein, it is not confined to the specific details set forth, and this application is intended to cover such modifications or changes as may come within the scope of the following claims.

What is claimed is:

1. An exposure mechanism for use in a xerographic reproducing apparatus of the type including a xerographic surface mounted for movement, a charging device to place a uniform electrostatic charge on said xerographic surface, and an optical device adapted to project an image of an original in flowing sequence onto the charged xerographic surface to form a latent electrostatic image on said xerographic surface; said exposure mechanism including a planar opaque member positioned optically between said xerographic surface and the original within the optical plane of the original, said opaque member having substantially parallel light opaque lines and dark opaque lines thereon, and means to cause relative linear motion between said

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opaque member and the original, parallel to the lines of said opaque member, for continuously projecting light images of the lines of said opaque member into the xerographic surface along with the flowing image projection of the original for creating a latent electrostatic image with charge gradient patterns thereon.

2. The exposure mechanism as set forth in claim 1 wherein the means to cause relative motion between said opaque member and the original includes means to move the original through an imaging area and means to fixedly position said opaque member so as to extend into part of the imaging area.

3. The exposure mechanism as set forth in claim 2 wherein said opaque member is of a width substantially equal to the width of the imaging area and is of a length less than half the length of the imaging area.

4. The exposure mechanism as set forth in claim 3 wherein the length of said opaque member is between 10 and 20 percent of the length of the imaging area.

5. The exposure mechanism as set forth in claim 2 wherein the means to fixedly position said opaque member is adjustable to vary the amount to which the opaque member extends into the imaging area.

6. An exposure mechanism for a reproducing apparatus to discharge a light responsive member in an imagewise configuration corresponding to a document to be copied to yield a developable image, including

an opaque member positioned adjacent the document between the document and the light responsive member, said opaque member having substantially parallel opaque lines adapted to discharge the light responsive member in a lined pattern corresponding to the lines of the opaque member when light, reflected from the opaque member is projected to the light responsive member,

means to cause relative movement between the opaque member and the original substantially parallel to the lines of said opaque member,

and common means to simultaneously illuminate the opaque member and sequential sections of the docu-

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ment so that the light responsive member is discharged in accordance with the light pattern projected from both the document and the parallel opaque lines of the opaque members.

7. An optical system for a xerographic reproducing machine to discharge a xerographic member at one end of the optical system in a configuration corresponding to a document to be copied which is positioned at the other end of the optical system to thereby create a developable latent electrostatic image including,

means to cause relative movement between the document to be copied and the optical system whereby, when illuminated, sequential sections of the document will discharge the xerographic member in a configuration substantially corresponding to light rays reflected from the document,

an opaque member positioned within the optical system adjacent the document to be copied and having parallel opaque lines adapted, when illuminated, to reflect light and discharge the xerographic member in a lined pattern corresponding to the lines of the opaque member and

a common light source to simultaneously illuminate said opaque member and sequential sections of the document so that the xerographic member is discharged in accordance with the light pattern projected from both the document and said opaque member.

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U.S. Cl. X.R.

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