United States Patent

Moorhusen

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[54] **SHORT FOCAL LENGTH OPTICAL IMAGING SYSTEM**

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[73] Assignee: **Xerox Corporation,** Rochester, N.Y.

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[52] **U.S. Cl.** **355/65,** 355/8, 355/51
[51] **Int. Cl.** **G03b 27/70**
[58] **Field of Search**............355/8, 50, 51, 52, 65, 70, 355/73; 95/15; 350/167 X, 190

[56] **References Cited**

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FOREIGN PATENTS OR APPLICATIONS

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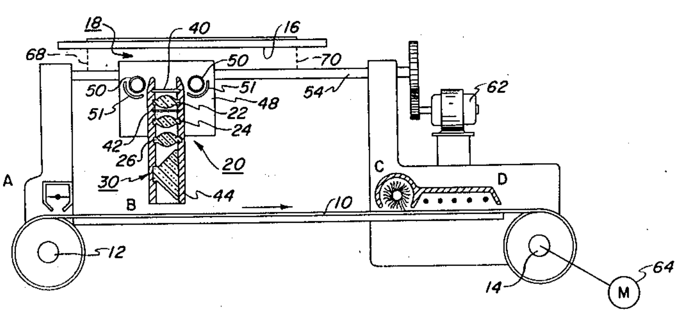
[57] **ABSTRACT**

An optical imaging system including a document supporting surface, an imaging device and a light responsive member. The document to be reproduced is fixedly supported adjacent the light responsive member with a short conjugate light imaging device therebetween. The imaging device is mounted for movement in the same direction of movement as the light responsive sheet but at substantially half the speed thereof to thereby create a usable pattern on the surface of the sheet in conformity with the document being reproduced.

1 Claim, 3 Drawing Figures



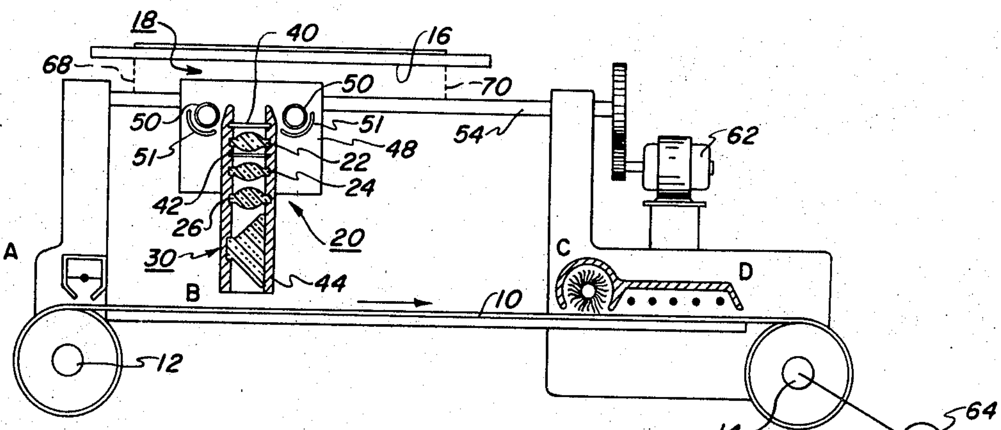


FIG. 1

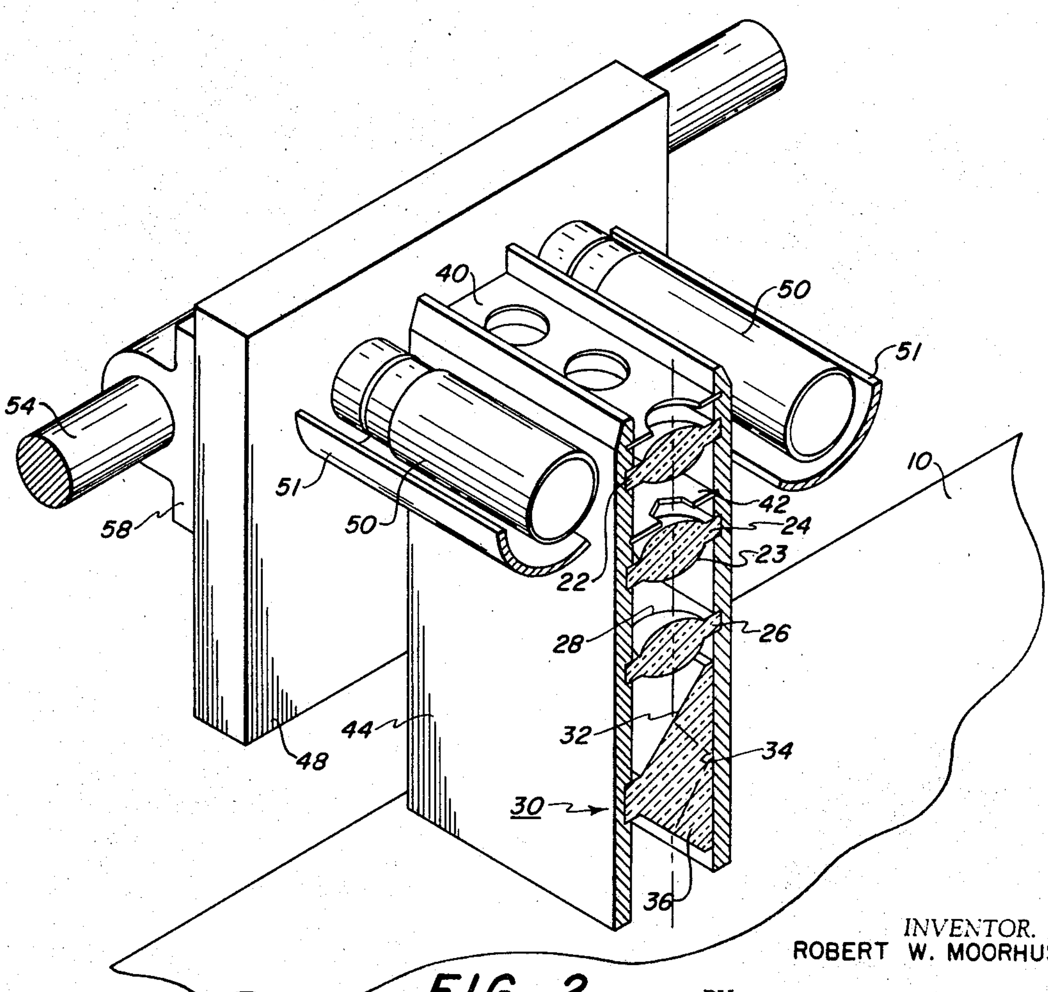


FIG. 2

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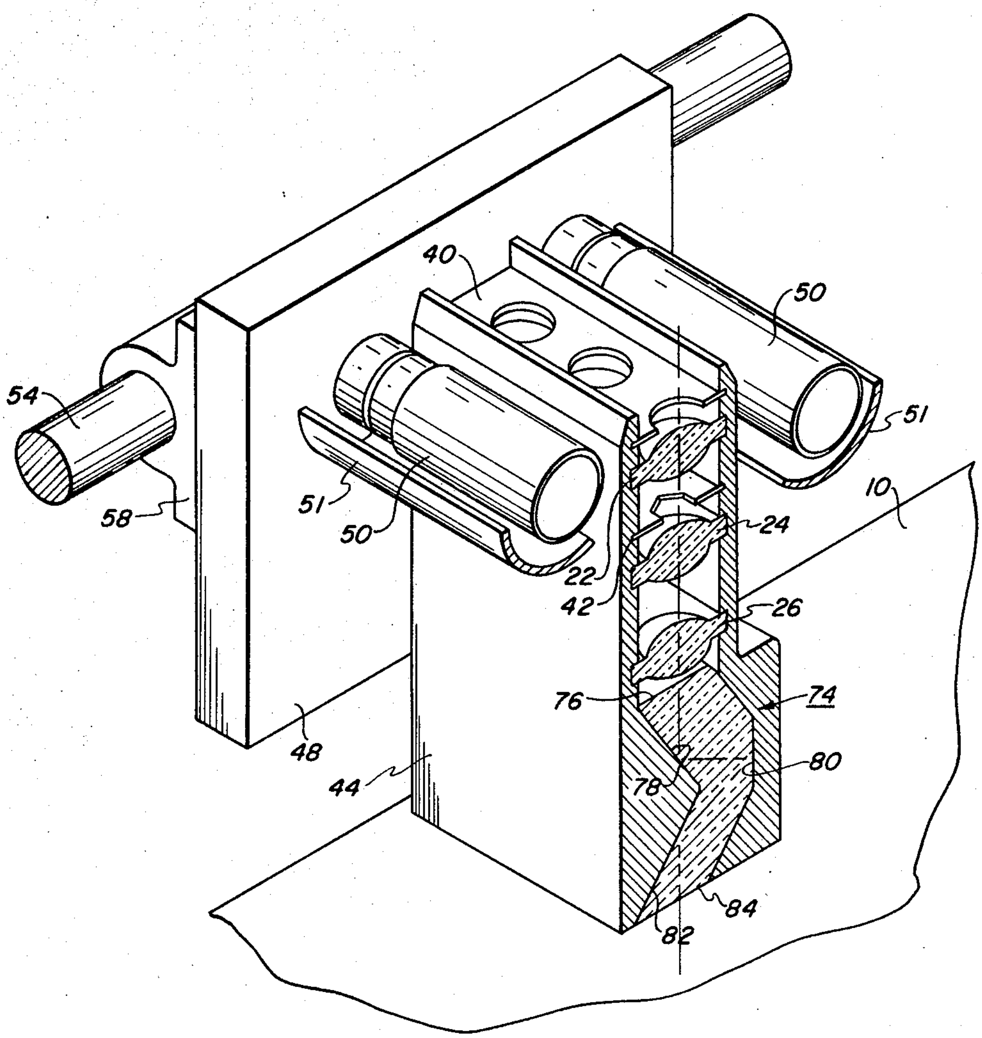

FIG. 3

SHORT FOCAL LENGTH OPTICAL IMAGING SYSTEM

This invention relates to a short conjugate length imaging system and in particular to an imaging system wherein an immovably supported document is imaged onto the surface of a moving light responsive member by a short conjugate length imaging device moving therebetween.

In the process of xerography, as described for example in U. S. Pat. No. 3,121,006 to A. E. Middleton et al, a light responsive member comprising a layer or coating of a photoconductive material such as zinc oxide or the like on a moderately conductive backing such as paper is used to support electrostatic images. In the usual method of carrying out the process, the surface of the xerographic member 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 powder. The powder is held in image areas by the electrostatic charges on the layer. Where the charge field is greatest, the greatest amount of material is deposited; where the charge field is least, little or no material is deposited. Thus a powder image is produced in conformity with the light image being reproduced. The powder may be subsequently affixed to the photoconductive material to form a permanent copy of the original document.

Most commercial reproducing machines in use today employ imaging systems requiring a large conjugate length between the original document and light responsive surface. In general, this distance must be about equal to twice the length of the diagonal of the portion of the document being optically projected. With the trend towards more compact reproducing machines, it has been found desirable to employ imaging techniques which permit the reduction of the conjugate length and consequently the size of the imaging zone.

An imaging system capable of projecting light images of an original document onto a light responsive surface held a short distance away is described in pending applications Ser. Nos. 683,988 filed Nov. 17, 1967 in the name of Osmar A. Ullrich, Jr., 683,837 filed Nov. 17, 1967 in the name of Robert W. Gundlach and 683,987 filed Nov. 17, 1967 in the name of Robert W. Gundlach et al. According to the preferred embodiments of those disclosures, it is necessary to support the object being reproduced and the light responsive surface immovable with respect to each other during imaging. Imaging occurs in a flowing manner as the imaging device moves relative to the fixed object and light responsive surface. The imaged member may then be developed and transferred to the final backing sheet.

Another short conjugate length optical imaging system is disclosed in Canadian Pat. No. 771,916 issued Nov. 21, 1967 in the name of Kaufer et al. In that disclosure, it is necessary to move both the light responsive surface and document being reproduced in opposite direction with respect to each other to effect correct imaging. The imaged sheet may then be developed and fixed to thereby form the final copy.

Such prior art imaging systems are not universally suited for use in continuous and automatic xerographic reproducing machines. For example, expanded utility of a reproducing machine may be attained if the elements of the imaging system may be made to function in a continuous mode as the other xerographic processing stations. This continuous mode cannot necessarily be attained if the light receiving surface must be stopped during the imaging steps. Furthermore, the utility of a reproducing machine may be expanded if the original to be copied is held stationary during its imaging. When an imaging system permits the scanning of a fixed original, it then becomes easier to create copies of three dimensional objects or the like. In such a fixed-original system, document handling is also eliminated since the document need never be grasped or forwarded by document handling mechanisms.

The use of one or more folding mirrors in a short conjugate imaging system is not always in the best interest of machine design. When a plurality of folding mirrors are spaced in and throughout the lens strip imaging elements, the entire imaging device may be forced to conform to a cross-sectional configuration which does not permit a direct and compact throughput of light rays from optically opposed object and image planes. Furthermore, the use of individual folding mirrors requires the adjusting of these supplemental optical elements with respect to each other as well as to the lens elements of the system so as to achieve their proper orientation with respect to each other and the document and light responsive surface.

It is therefore an object of the instant invention to optically project an image of an object to be reproduced onto a light responsive surface with a short distance therebetween.

It is a further object of the instant invention to flowingly project light rays from a fixedly supported object onto a moving light responsive surface by projection along a short conjugate length.

It is a further object of the instant invention to dissipate an electrostatic charge on the surface of a light responsive member in accordance with a light pattern projected from a document fixedly supported with respect to the light responsive member.

It is a further object of the instant invention to create an electrostatic charge pattern on a light responsive member through a short conjugate imaging system moving between the member and a fixedly supported document being reproduced.

These and other objects of the instant invention are attained in accordance with the present invention by an imaging system including a document supporting surface, an imaging device and a light responsive member. The document to be reproduced is fixedly supported adjacent to the light responsive member with a short conjugate length imaging device therebetween. The imaging device is moved in the same direction of movement as the light responsive sheet but at half the speed thereof to thereby create a usable pattern on the surface of the sheet in conformity with the document being reproduced.

Further objects together with additional features and advantages thereof will become apparent from the following description of two embodiments of the invention when read in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic illustration of a continuous and automatic reproduction machine employing the imaging system of the instant invention.

FIG. 2 is a perspective view of the imaging system shown in FIG. 1; and

FIG. 3 is a perspective view of an alternate embodiment of the imaging devices shown in FIGS. 1 and 2.

Referring now to the drawings, there is shown in FIGS. 1 and 2 an embodiment of the subject invention in a suitable environment such as an automatic xerographic reproducing machine. The automatic xerographic reproducing machine includes a xerographic member **10** in the form of a flexible web or sheet including a layer of a light responsive or photoconductive material or the like on a moderately conductive paper backing. The sheet is formed as a continuous web and is wound upon suitable rollers **12** and **14** to sequentially move the sheet in the direction of the arrow in a path of movement past the various xerographic processing stations. It should be understood, however, that the imaging system is employable to image any light responsive members including, for example, photographic materials. For the purpose of the present disclosure, the several xerographic processing stations in the path of movement of the web may be described functionally as follows:

A charging station A at which a uniform electrostatic charge is deposited on the light responsive sheet;

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

A developing station C at which xerographic developer material in the form of toner particles having an electrostatic charge opposite that of the latent electrostatic image is caused to contact the surface of the sheet as by the use of a fur or magnetic brush whereby the toner particles adhere to the latent electrostatic image to form a toner image in a configuration of the copy being reproduced; and

A fusing station D at which the toner image is fixed to the surface of the support web to form a permanent copy of the document or object being reproduced.

It is felt that the preceding description of the xerographic processing stations is sufficient for an understanding of the instant invention. Further details of the xerographic process may be had by reference to the aforementioned U. S. Pat. to Middleton et al.

In order to operate the imaging system device of the instant invention, it is first necessary to place the document or object to be reproduced on the transparent document supporting surface **16**. The document supporting surface is a flat orientation parallel with a flat orientation of the web in this area to define an imaging zone **18** therebetween. Positioned between the document supporting surface **16** and the xerographic web **10** is the optical imaging device **20**.

The imaging device is constructed generally in accordance with that disclosed in the aforementioned Gundlach et al application. This device includes a plurality of transparent light refracting lens strip **22, 24** and **26** having lens portions **28** formed therein. Lens strip **22** may be positioned two focal lengths away from the object to be reproduced as well as the intermediate field lens **24**. The lens portions **28** of this lens strip **22** are adapted to project light images from the document and to individually invert and revert the scan segments of the image. The lens strip **26**, which may be positioned two focal lengths away from the intermediate field lens **24** and slightly greater than two focal lengths from the light responsive sheet **10** will, in like turn, invert and revert the images formed adjacent the field lens **24** to ultimately project upright wrong reading images of the scanned portions of the document toward the light responsive surface **10**.

If the light rays projected from the lens strip **26** were directly permitted to form an image on the light responsive surface, it would be upright and wrong reading with respect to the original document reproduced. But since it is intended to develop the electrostatic image formed on the light responsive surface, it is necessary to optically revert the image prior to discharging the charge on the light responsive member. This is achieved by the dove prism **30** positioned between the light responsive surface **10** and the lens strip **26**. This same result could be achieved by locating the prism, for example, between lens strip **22** and the document. This dove prism which extends the length of the lens strips and the width of the light responsive surface reverts the projected image to thereby discharge the charge on the web in an upright, right reading representation of the document being reproduced.

The view of the prism, as shown in FIG. **2**, illustrates the light rays being refracted by the input surface **32** of the prism, reverted by the reflective surface **34** and then again refracted by the output surface **36** of the prism to thereby revert the light rays moved from lens strip **26** toward the surface of member **10**. The use of the dove prism in this application provides for a relatively straight line path of travel, from a machine configuration standpoint, of the light rays from the document to the light responsive surface. The use of the prism, with its refractive and reflective surfaces in a unitary device permits the accurate reversion of light images without the adjustment of these various refractive and reflective surfaces with respect to each other.

The light rays thus striking the light responsive surface will thereby discharge the original charge on the light responsive surface into a latent electrostatic image corresponding to the document being reproduced. An aperture stop **40** and a field stop **42** limit the intensity and amount of light projected from the document to the light receiving surface for ensuring an even distribution of light energy across the web. As can be seen, the imaging device is compactly arranged so that all of the optical elements are within the imaging zone at all times during scanning.

The various optical elements including the lens strip, stops, and prism are secured in position with respect to each other by side plate members **44** which, like the lens strip and prism extends the length of the document and the width of the web thereby ensuring that the entire length of the document will be projected and imaged onto the light responsive surface. End support plates **48** support the side plate members and imaging elements with respect to each other to define a light-shielded tunnel from an area adjacent the document supporting surface and the photoconductive web.

Lamps **50** with reflectors **51** are supported on end plates **48** near the document for its illumination.

The end plates **48** are mounted for reciprocation on lead screw **54** through nut member **58** on end plate **48** for oscillating the imaging device in a path of movement parallel to the fixedly supported document and traveling web. The opposite end plate supports a bearing member which slidably receives a shaft parallel to lead screw **54**. In this manner the distance between the first lens strip **22** and the document can be maintained constant during the reciprocation of the imaging device. This arrangement also ensures that the distance between the prism **30** and the light responsive web is, in like fashion, held in a fixed distance during operation. The document and light responsive member could be supported in concentric curves in which case the imaging device **20** could be moved in an arcuate path concentric therewith.

Power is imparted to the imaging device through motor means **62** adapted to rotate lead screw **54**. This rotation of the lead screw causes the nut member **58** on end plate **48** to traverse the lead screw and consequently causes the imaging device **20** to scan the document. A power source to move the imaging device **20** at a predetermined speed during scanning and to quickly return the imaging device to the start of scan position is desirable.

In operation, the xerographic reproducing machine is started by activating the various processing stations including the imaging station. The take up roll **14** for the photoconductive web is rotated by motor **64** to pull portions of the web sequentially through the various xerographic processing stations at a constant speed in the direction of the arrow as shown. This will sequentially bring a portion of the web beneath the charging corotron to provide a uniform charge on the web. After charging, the leading edge of the web passes beneath the imaging device **20** at the input end **68** of the imaging zone **18** at which time the motor **64** will be activated to move the imaging device in the direction of advancement of the web as shown by the arrow. This will sequentially image the original document onto the sheet in a flowing fashion. The imaging device travels at a speed half that of the speed of the web to thereby effectively scan the document as if the imaging device **20** were stationary and the document and the light responsive surface were moving at equal speeds but in opposite directions.

After the imaging device **20** has traversed the imaging zone **18** and arrived at the output end **70** of the imaging zone, motor **64** will act to quickly return the imaging device to its start-of-scan position to begin a second imaging of a subsequent section of the xerographic surface **10**. It is understood that the light responsive member could be a cut sheet or a series of sequentially fed cut sheets fed in a spaced fashion by suitable conveyors. The machine may readily be programmed to stop after one or a predetermined number of oscillation of the imaging device and consequently stop the creation of electrostatic images on the web after a predetermined number of cycles.

The imaged portion of the web is then developed as it moves past the development station C and is fixed during movement past fusing station D, whereafter it is stored in a roll on roller **14**.

Shown in FIG. **3** is a perspective view of an imaging device similar to that shown in FIG. **2** but employing a K prism instead of the dove prism shown in FIGS. **1** and **2**. In this embodiment, the action of the xerographic machine will be the same while the action of the imaging device is substantially the same. The K prism **74** includes an input surface **76** to receive light rays from the lens strip **26**. Refraction of the non-axial rays occurs at this time. The light rays are then reflected from surfaces **78, 80** and **82** whereafter the non-axial rays will be again refracted as they pass through the output end **84** of the prism. Here again, the entire prism acts to revert projected light rays to create an upright, right reading light pattern of the document on the xerographic surface for development and fusing.

The refractive nature of the image reverting prisms **30** and **74** is such as to cause light rays to travel non-symetric paths between the document and lens strip **22** and the lens strip **26** and light responsive surface **10**. That is, while the lens strip would be equidistant between the object and image planes if no refractive member were employed, its presence generally requires a different distance between the lens strip and plane separated by the prism. This is because the light rays folded by the prisms are traveling through a different medium. This non-symetric orientation can be utilized for creating a greater variety of configurations of the optical elements in imaging devices.

While the instant invention as to its objects and advantages has been described as carried in specific embodiments hereof, it is not intended to be limited thereby but it is intended to be protected in the scope of the appended claims.

What is claimed is:

1. An imaging system including

a planar document supporting surface adapted to maintain a document fixed during imaging thereof,

an opaque light responsive member supported adjacent said document supporting surface to define an imaging zone therebetween with its surface facing the document supporting surface capable of having a reflective image created thereon,

a short focal length optical imaging device positioned in the imaging zone between the document supporting surface and a surface of said light responsive member, said imaging device including a plurality of transparent lens strips having lenses formed thereon, the lens strip closest said document supporting surface being adapted to invert and revert light rays and form an intermediate image, the lens strip closest said light responsive member being adapted to invert and revert light rays and project the intermediate image toward said light responsive member,

said imaging device also including a single reverting prism located between said lens strips and one of said surfaces having at least one reflective surface for reverting light rays from all the lenses in said imaging device through reflection as they pass from the document supporting surface to said light responsive surface for creating a right-reading image on the light responsive surface facing the document supporting surface

means to move said light responsive surface in a path of movement parallel to the document supporting surface in the same direction in which light rays are reverted by said reverting prism and

means to move said imaging device in a path of movement parallel to said light responsive Surface in the same direction at a speed substantially half of the speed of the light responsive surface.

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