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Davidge et al.

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[54] **REPRODUCTION APPARATUS INCORPORATING ALTERNATE REDEVELOPMENT AND REIMAGING CYCLES FOR MULTIPLE COPIES**

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[73] Assignee: **International Business Machines Corporation**, Armonk, N.Y.

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Related U.S. Patent Documents

Reissue of:

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	Filed:	**Dec. 17, 1971**

[52] **U.S. Cl.** **355/14**

[51] **Int. Cl.^{2}** **G03G 15/00**

[58] **Field of Search** .... 355/3 R, 3 DR, 8, 14, 355/17

[56] **References Cited**

UNITED STATES PATENTS

3,528,738	9/1970	Hodges	355/8
3,554,640	1/1971	Hoskins	355/8
3,575,509	4/1971	Suzuki	355/8
3,614,222	10/1971	Post	355/8
3,637,306	1/1972	Cooper	118/637
3,690,760	9/1972	Banks et al.	355/14

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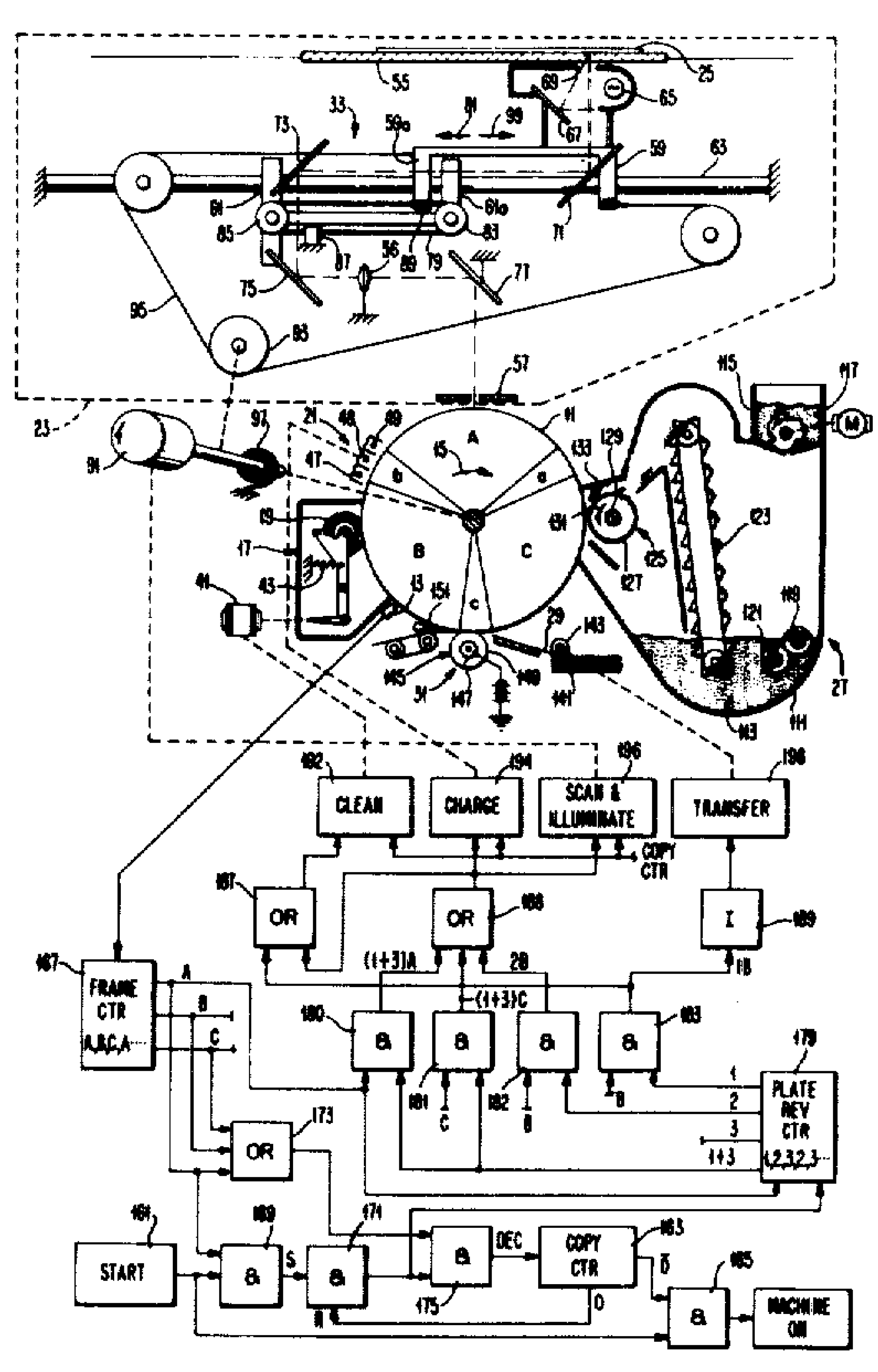
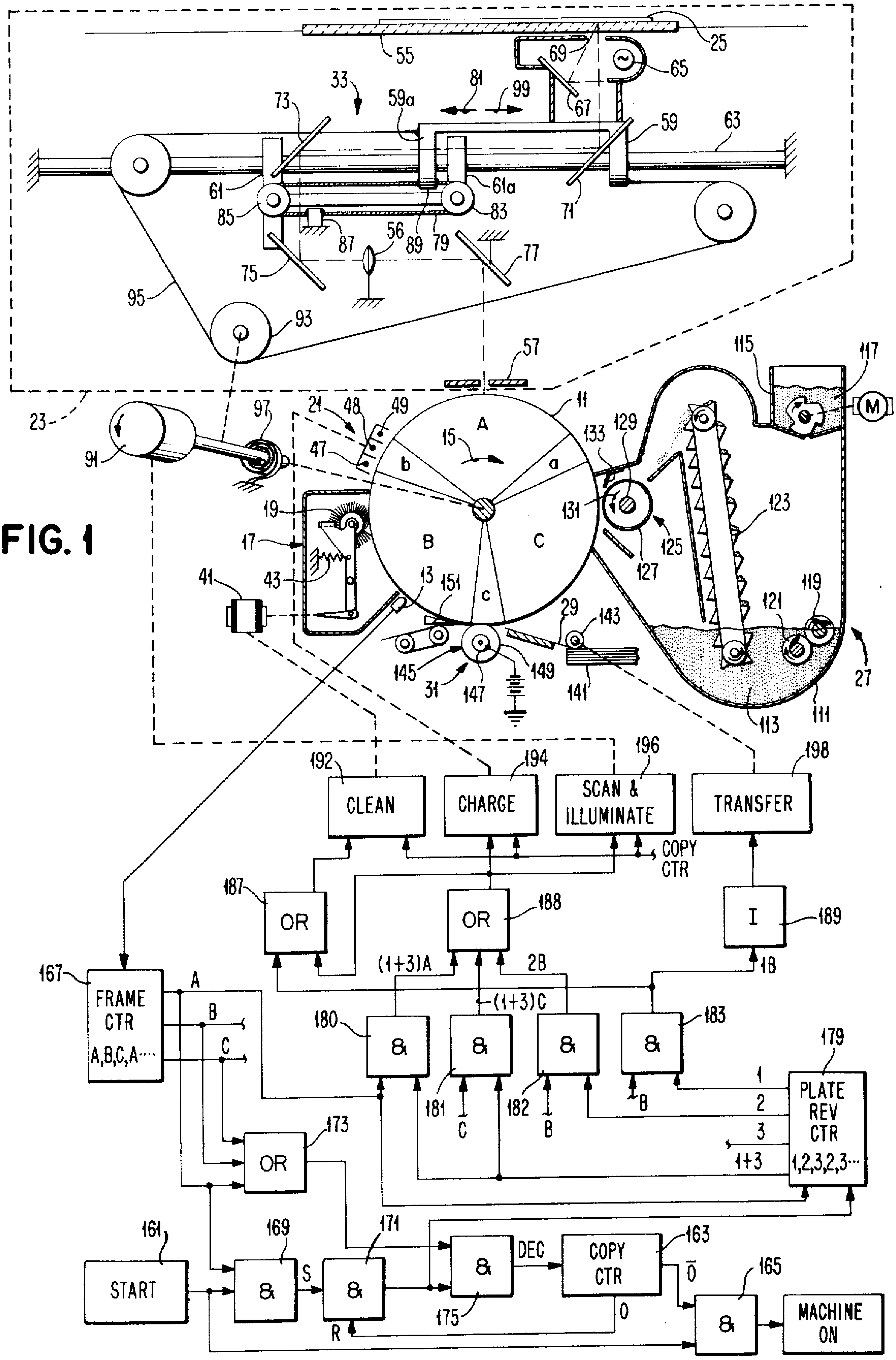
[57] **ABSTRACT**

A continuously operating transfer reproduction apparatus includes a cyclic control unit which automatically effects alternate redevelopment and reimaging cycles when reproducing multiple copies of the same master. An electrophotographic plate travels in a closed loop past a moving optical system which images the plate with a light image of the master creating a latent electrostatic image on the plate. The latent image is developed at a developing station and transferred to a substrate at a transfer station as the plate travels therepast. Increased throughput speed is achieved by effecting a fixed number of redevelopment cycles while the moving optical system is resetting. Thus, the plate continues its travel past the resetting optical system to the developing station where the latent image is redeveloped and thence to the transfer station for transfer of the developed image to a second substrate. The plate is then cleaned and charged prior to being reimaged with the light image of the same master, and the process continues until the requisite number of copies have been reproduced. In one embodiment, multiple imaging areas, preferably an odd number thereof, are located on the plate facilitating rapid alternate imaging and redevelopment cycles.

13 Claims, 1 Drawing Figure




CLEAN
CHARGE
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TRANSFER
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I
FRAME CTR A,B,C,A···
(1+3)A
2B
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1+3
OR
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MACHINE ON
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FIG. 1

REPRODUCTION APPARATUS INCORPORATING ALTERNATE REDEVELOPMENT AND REIMAGING CYCLES FOR MULTIPLE COPIES

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

CROSS REFERENCE TO RELATED APPLICATIONS

The following application is assigned to the same assignee as the present application.

U.S. patent application Ser. No. 209,039 entitled "Electrophotographic Development Apparatus," Allison H. Caudill, inventor, filed Dec. 17, 1971.

BRIEF BACKGROUND OF INVENTION

1. Field

This invention relates to an electrostatic transfer reproduction apparatus and, more particularly, to an improved control device thereof for effecting rapid operation thereof.

2. Description of the Prior Art

In well-known continuous electrostatic printing processes, a photoconductive surface is continuously moved in a closed loop past various processing stations. Often, such systems include an imaging station which incorporates a moving optical projection system which projects a light image of a master onto the moving plate thereby creating a latent electrostatic image thereon. The moving optical projection system scans the master in the direction of plate travel so that the plate "sees" a continuous image of the master as it moves past the imaging station. The latent image on the plate is thereafter developed at a developing station, and the image is transferred to a substrate at a transfer station. When making multiple copies of the same master with such prior devices, it has been necessry for the system to wait for the optical system to return to its initial position prior to automatically initiating the second reproduction cycle. As devices have been constructed with ever increasing processing speeds, the delay time has accounted for a substantial portion of each reproduction cycle.

Prior attempts to avoid the delay introduced by the resettng optical projection system have suggested redeveloping the electrostatic image without reimaging the master. While such systems operate continuously without a delay thereby occasioning a marked increased in throughput, the quality of the reproduced copies rapidly degrades as the number of such redeveloped copies increase. That is, when a large number of copies are required, the first several copies produced by redeveloping the latent image without reimaging have virtually the same quality as the first copy produced by the system. However, each transfer operation and each redevelopment operation tends to degrade the electrostatic latent image on the plate thereby causing subsequent redeveloped copies to degrade in quality. Accordingly, the use of such a prior system would require operator intervention to reinitiate the system when image quality degraded below that which the operator thought was good image quality, thereby losing the time efficiencies of the redevelopment process. Accordingly no commercially successful system utilizing redevelopment has been introduced since such systems are only effective for producing a relatively small number of high quality copies of the same master.

SUMMARY

In order to overcome the above-noted shortcomings of the prior art and to provide a continuously operating electrostatic transfer reproduction apparatus having increased throughput speed when reproducing multiple copies of the same master without degrading the quality of the output copy, the present invention incorporates a cyclic control unit which automatically effects alternate redevelopment and reimaging cycles when reproducing multiple copies of the same master. In those embodiments of the invention wherein an odd number of image areas are located on the photoconductive plate, the cyclic control unit initiates alternate imaging and redevelopment cycles. Thus, a given image area on the plate is first exposed to the light image of the master by the moving optical projection system and thereafter developed. The developed image is then transferred to a substrate and the image area passes the imaging station while the optical projection system is resetting. The original electrostatic image is redeveloped and the redeveloped image transferred to produce a second copy. The image area is then cleaned and charged prior to again receiving the light image from the same master for producing a third and fourth copy. The process continues until the Requisite number of copies have been reproduced. When an even number of image areas are located on the plate, the latent image is developed three times (redeveloped twice) for each image exposure. Accordingly, the number of redevelopment cycles are automatically held to a minimum thereby assuring high quality copy output. Further, no delay times are introduced by the resetting optical projection system since a redevelopment cycle is automatically taken while the optical projection system resets. Thus, both increased throughput speed and good reproduction output quality are attained without necessitating operator intervention or judgement.

Accordingly, it is the primary object of the invention to automatically increase the throughput speed of a continuously operating electrostatic transfer reproduction apparatus without causing an appreciable degradation of output image quality.

A further object of the present invention is to provide a system of this nature which rapidly reproduces a multitude of copies of the same master without noticeable variations in image quality.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of the preferred embodiment of the invention as illustrated in the accompanying drawing.

In the drawings:

FIG. 1 is a schematic diagram of a continuously operating electrostatic transfer reproduction apparatus incorporating a cyclic control unit for automatically effecting alternate redevelopment and reimaging cycles.

DESCRIPTION

Referring now to FIG. 1 of the drawings, a continuously operating electrostatic transfer reproduction apparatus incorporating a cyclic control unit is depicted.

The reproduction apparatus comprises a plurality of processing stations located about a cylindrically shaped photosensitive electrostatic plate **11**. The cylindrical plate comprises a layer of photoconductive material superimposed over a conductive backing. A suitable photoconductive material is disclosed in U.S. Pat. No. 3,484,237, issued Dec. 16, 1969. The cylindrical plate is divided into three segments or frames designated A, B, and C. The frames are separated from one another by interframe or intersegment gaps, a, b, and c.

A sensing device **13** senses permanently recorded signals within the interframe gap portion of the electrostatic plate and supplies logical signals to a cyclic control apparatus to be described hereinafter indicating the positional relationship of the various frames with respect to the various processing stations, as the electrostatic plates rotates in the direction of arrow **15** past the processing stations. The electrostatic plate **11** first passes a cleaning station **17** having an actuable cleaning member **19** located therein. When actuated, the cleaning member **19** brushes the surfaces of the electrostatic plate **11** removing any foreign material including developer material therefrom. The plate then passes an actuable charging station consisting of a corona generating device **21** which sensitizes the electrostatic plate **11** as it rotates therepast. Thereafter, the electrostatic plate passes an imaging station **23** which, when actuated, projects a light image of a master **25** onto a frame segment of the electrostatic plate **11** rotating thereunder. The projection of the light image onto the sensitized electrostatic plate creates a latent electrostatic image thereon which rotates with the plate as it passes the developer station **27.** At the developer station **27,** multicomponent developer material including an electrostatically charged toner is applied to the surface of the electrostatic plate containing the electrostatic image thereon. The charged toner particles are preferentially attracted to the latent image on the plate **11** and are subsequently transferred to a substrate surface **29** at the transfer station **31.**

As will be described hereinafter, the frame containing the latent electrostatic image which had been imaged at the imaging station **23** is not cleaned at the cleaning station **17** as it again rotates therepast, nor is it charged at the actuable charging station **21** as it again rotates therepast. Further, as will be described, the imaging station **23** incorporates a moving optical projection system **33** which is reset to its initial position as the previously imaged frame rotates past the imaging station **23.** Since the initial latent electrostatic image remains basically in tact (it not being disturbed at the cleaning station **17** or the charging station **21** or reexposed at the imaging station **23**), the image is redeveloped at the developing station **27** and the thusly redeveloped image is transferred to a second substrate surface at the transfer station **31.** Thereafter, the segment containing the image is cleaned at the cleaning station **17,** charged at the charging station **21** and imaged with the same master **25** at the imaging station. The operation thus proceeds alternately imaging and redeveloping a previously imaged segment until the requisite number of copies of the master **25** have been produced.

In the description immediately following, the detailed operation of each of the processing stations located about the periphery of the electrostatic plate **11** will be described. Thereafter will follow a description of the cyclic control logic which effects the sequential operation of each of the stations as the electrostatic plate **11** rotates therepast.

The sensing device **13** senses indicia permanently recorded on the edge portion of the electrostatic plate **11** at the interframe gaps a, b and c. For example, this device could comprise a magnetic head adapted to read magnetic signals recorded on the edge surface of the plate. The output signal of this device is utilized to control the sequencing of the various stations to be described hereinafter.

The cleaning station **17** incorporates as actuable cleaning member **19** which moves from a position of close adjacency to the electrostatic plate **11** to a second position remote from the electrostatic plate **11.** The cleaning member could, for example, comprise a cleaning brush well known in the art which intimately contacts the surface of the electrostatic plate **11** and rotates there against, thereby removing foreign material including toner from the surface of the plate when in its position of close adjacency thereto. The magnet and armature assembly **41** is actuated to drive the actuable cleaning member against the plate and the spring **43** returns the cleaning member to a position of nonadjacency to the plate when the magnet and armature assembly is deactuated. When in its position of nonadjacency to the plate, the actuable cleaning member **19** does not contact the surface of the plate, and therefore, the plate rotates therepast without interference therefrom.

The actuable charging station **21** comprises three corona generating wires **47, 48,** and **49** which are sequentially turned on and off as the interframe gaps of the electrostatic plate **11** rotate therepast. For example, when the actuable charging station is turning on, the corona generating wire **47** is first energized as the first portion of an interframe gap rotates therepast. The corona generating wire **48** is then turned on as the same leading edge portion of the interframe gap rotates therepast, and thereafter, the corona generating wire **49** turns on as the leading edge portion of the interframe gap rotates therepast. Thus, any discontinuities in charge levels effected by turning on the corona generating wires appear within the interframe gap portions of the electrostatic plate **11.** The same magnetic signal which is sensed by the sensing device **13** may also be utilized to actuate magnetically actuable switches to effect the sequential turn on and turn off of the corona generating wires **47, 48** and **49.** The turn off sequence of the actuable charging station is identical to the turn on sequence.

The imaging station **23** comprises a fixed transparent document mounting means **55** onto which the master **25** to be copied is placed. A moving optical projection system **33** projects a progressive light image of the master **25** through the stationary lens **56** and aperture member **57** onto the electrostatic plate **11** rotating therepast. The moving optical projection system **33** includes a first carriage **59** and a second carriage **61,** both mounted in telescope fashion on a common track means **63** for reciprocal movement. The first carriage **59** supports a lamp **64** and mirror **67** which direct light upon the master **25** through the slot **69** and document mounting means **55** to thereby illuminate a segmental portion of the master **25.** A scanning mirror **71** is also mounted on the first carriage **59** for receiving the image of the master thus illuminated.

The second carriage **61** supports a pair of compensating mirrors **73** and **75** which receive the image as reflected by the scanning mirror **71** and redirect the image to the stationary mirror **77** through the stationary lens **56** from whence the image is reflected through the stationary aperture member **57** onto the moving electrostatic plate **11.** The first carriage **59** and the second carriage **61** are mechanically interconnected through a closed loop flexible cable **79** to cause the movement of the second carriage **61** to be one-half of that of the first carriage **59.** By thusly moving the second carriage **61** by an amount equal to one-half the distance moved by the first carriage **59,** a constant optical path from the document mounting means **55** through the mirrors **71, 73,** and **75** to the lens **56,** mirror **77** to the electrostatic plate **11** is maintained during the motion of the first carriage **59,** and the second carriage **61** in the scanning direction of arrows **81.** The flexible cable **79** is mounted on rollers **83** and **85** carried by the second carriage **61.** A ground clamp **87** makes one point on the flexible cable **79** stationary at all times. The first carriage **59** is connected to an intermediate point of the cable **79** at point **89.**

The motion in the scanning direction of arrow **81** is imparted to the first carriage **59** by the actuable drive motor **91** which is connected to the capstan **93** which is in turn connected to the cable system **95.** As described heretofore, motion of the first carriage **59** in the direction of arrow **81** effects motion of the second carriage **61** through the flexible cable **79** so that the second carriage moves one-half the distance of movement of the first carriage. Upon completion of motion in the scanning direction of arrow **81,** the first carriage **59** and the second carriage **61** are returned to their initial home positions by the spring motor **97** which effects rotation of the capstan **93** in an opposite direction thereby causing the cable system **95** to move the first carriage **59** in the direction of arrow **99.** The second carriage **61** is returned by the action of member **59a** of the first carriage **59** pulling the member **61a** of the carriage **61** to its home position.

Summarizing, the scanning mirror **71** and an illumination system including lamp **65,** mirror **67,** and slot **69** are driven by the capstan **93** in synchronism with the rotation of the electrostatic plate **11.** As the scanning mirror **71** approaches the compensating mirror **73** thus tending to shorten the optical path, the compensating mirror **73** retreats at one-half the speed of the scanning mirror **71.** Additionally, the compensating mirror **75** also moves with the compensating mirror **73** thereby creating a folded optical path which compensates for the tendency to shorten the optical path and maintains a constant optical path during the scanning operation. Accordingly, a light image of the master **25** is progressively projected onto a frame of the electrostatic plate **11** rotating past the aperture **57** creating a latent electrostatic image thereon. Once a complete frame section has been exposed, the lamp **64** is turned off and the first carriage **59** and the second carriage **61** are then driven to their home position under the control of the cable system **95.** During the time that the optical system is returning and awaiting a new scan cycle, the next frame of the electrostatic plate **11** rotates past the aperture **57.**

As the electrostatic plate **11** passes the developer station **27,** electrostatically charged toner is applied thereto thereby developing the latent electrostatic image existing on the surface of the electrostatic plate **11.**

The operation of the developer station **27** is generally described in the aforereferenced copending application of Allison H. Caudill. The developer station includes a sump portion **111** containing multicomponent developer material **33.** The principle components of the developer material are electroscopic toner and a carrier material. Suitable materials for use as toners are well known in the art and generally comprise finely divided resinous materials capable of being attracted and held by electrical charges. Many well-known suitable carrier materials can be utilized, the carrier particles generally being between 50 and 1,000 microns in size. The carrier materials which are utilized for the developer station depicted must be ferromagnetic or capable of being attracted and held by a magnetic field. Such a carrier material could comprise a magnetic bead coated with a material which triboelectrically interacts with the selected toner to produce a desired charge on the toner in order to provide good imaging quality.

A toner dispensing unit **115** is provided to dispense toner particles **117** into the multicomponent developer material **113** located in the sump portion **111** of the developer station **27.** Counterrotating augers **119** and **121** stir the freshly added toner with developer material to assure complete mixing thereof.

A bucket conveyor **123** rotates through the sump portion **111** of the developer station **27** and scoops up quantities of developer material **113** for delivery to the magnetic brush unit **125.** The magnetic brush unit includes a conductive, nonmagnetic, rotatable, cylindrical member **127** having located therein a magnetic field producing means **129.** Since the core material of the carrier particles consists of a ferromagnetic material the carrier particles are caused to be magnetically attracted to the surface of the cylindrical member **127** and held thereon by magnetic forces produced by the magnetic field producing means **129.** The cylindrical member **127** rotates in the direction of arrow **131** under a doctor blade **133** which governs the amount of developer material located on the surface of the cylindrical member **127** as it rotates to a position adjacent the electrostatic plate **11.** As described in the aforereferenced copending application of Allison H. Caudill, the magnetic field producing means **129** creates a normal magnetic field at approximately the 9 o'clock position of the cylindrical member **127** causing the magnetic carrier particles in the developer material **113** to form in bristle-like arrays emanating from the surface of the cylindrical member **127.**

The small toner particles of the developer material **113** are held onto the surface of the relatively large carrier particles by electrostatic forces, which develop from the contact between the toner and the outer surface of the carrier particles which produces triboelectric charging of the toner and carrier material to opposite polarities. A potential source (not shown) is connected to the cylindrical member **127** thereby biasing the cylindrical member to a fixed potential. As the magnetically formed bristles of carrier material containing toner triboelectrically attracted thereto rotate past and in contact with the electrostatic plate **11,** the triboelectrically charged toner particles are attracted to the electrostatic latent image on the plate **11** and adhere thereto. The potential on the cylindrical member correctly orients the electrical field in which the charged toner particles move to produce a uniformly developed image on the surface of the plate **11.** The electrostatic plate **11** containing a toned or developed image continues its rotational movement past the developer station **27** and continues to the transfer station **31.** The carrier particles and the unspent toner particles attracted thereto are retained on the surface of the cylindrical member **127** until it reaches its approximate 6 o'clock position whereupon they are released into the sump portion **111** for subsequent mixing and reuse.

As the developed image on the electrostatic plate **11** moves from the developer station **27** toward the transfer station **31,** a substrate surface such as paper is fed from the hopper **141** by the picker roll **143** which is actuated in timed relation to the rotational movement of the electrostatic plate **11.**

The substrate surface **29** is fed over a feed path to the transfer roller **145.** The transfer roller comprises a conductive core **147** and a dielectric outer layer **149.** The conductive roll is biased so that the positively charged toner particles will separate from the electrostatic plate **11** and transfer to the support substrate **29.** That is, an electric field is created between the grounded conductive backing member of the electrostatic plate **11** and the biased core **147** through the photoconductive surface of the electrostatic plate **11** and the insulating material **149** of the transfer roller **145.** The toner particles move within this field to the support substrate **29** located between the electrostatic plate **11** and the transfer roller **145.** Thereafter, the support substrate is removed from the surface of the electrostatic plate **11** by the pickoff means **151.** The pickoff means **151** can comprise any of the well-known pickoff devices utilized in the duplicator art such as timed air puffs, stationary guide members, or movable guide members. The thusly separated substrate surface **29** containing a toned image is thereafter transported to a fuser station (not shown) where the toner is fused to the substrate in a well-known manner.

The description immediately preceding has related to the operation of each of the processing stations located about the rotating electrostatic plate **11.** As described heretofore, various ones of these stations are sequentially actuated in accordance with the positional rotational relationship of the electrostatic plate **11** with respect to the fixed sensing device **13.** The sequential actuation of the various stations facilitates alternate imaging and redevelopment cycles. By utilizing such alternate imaging and redevelopment cycles, the throughput speed of the reproduction apparatus is increased since there is no longer a requisite delay time occasioned by the moving optical projection system **33** which must reset to an initial condition. Further, by limiting the number of redevelopment cycles, high quality output images are maintained.

When utilizing an electrostatic plate having three segments such as that depicted in FIG. 1 of the drawings, alternate segments are first imaged on the first rotation of the electrostatic plate and the electrostatic latent images created thereby are not thereafter substantially altered, thus allowing the latent image to be redeveloped on the second revolution of the electrostatic plate. The cleaning member and the charging station are actuated prior to image cycles and deactuated prior to redevelopment cycles. The following table summarize the cyclic operation of the cleaning, charging, imaging, and transfer stations.

TABLE I

Plate Rec.	Frame	Clean	Charge	Image	Transfer
	A	Yes	Yes	Scan (image)	Yes
1	B	Yes	No	Return (no image)	No
	C	Yes	Yes	Scan	Yes

TABLE I-continued

Plate	Frame	Clean	Charge	Image	Transfer
				(image)	
	A	No	No	Return (no image)	Yes
2	B	Yes	Yes	Scan (image)	Yes
	C	No	No	Return (no image)	Yes
	A	Yes	Same as	Same as	Yes
3	B	No	Rev 1	Rev 1	Yes
	C	Yes			Yes
	A	Same as	Same as	Same as	Same as
4	B	Rev 2	Rev 2	Rev 2	Rev 2
	C				

As can be seen from Table I, the operation on all even numbered plate revolutions is the same. After the first plate revolution, the operation of the device is the same for all odd-numbered plate revolutions, the only difference between plate revolutions **1** and **3** being the operation of the cleaning and transfer stations with respect to the B segment which does not go through a redevelopment cycle on the first plate revolution.

Referring once agin to FIG. **1** of the drawings, the machine cycle control logic which effects the cyclic operation of the cleaning, charging, imaging and transfer stations is depicted in block form. The reproduction apparatus is started upon operator depression of a start control **161.** The operator also sets a copy counter **163** indicating the number of reproductions of the master **25** which are desired. Assuming that a number of copies is specified, the copy counter **163** provides an output signal to the And gate **165** which provides a machine on signal. The machine on signal initiates the rotational movement of the electrostatic plate **11** in the direction of arrow **15** and initiates the various processing stations in a well-known manner (e.g., the bucket conveyor **123** is rotated). When the indicia located in the interframe gap, a, of the rotating electrostatic plate **11** is sensed by the sensing device **13,** the frame counter **167** provides an output signal to the And gate **169** which, in turn, sets latch **171.** The frame counter **167** also provides an output signal to the Or gate **173** upon sensing the indicia located in the interframe gaps a, b, and c as they rotate past the sensing device **13.** The output signal of the Or gate **173** and of the latch **171** are provided to the And gate **175** which, in turn, provides a signal to the copy counter **163** causing that counter to be decremented. Thus, the copy counter is decremented as each segment rotates past the sensing device **13.** It should be noted that the copy counter is initially set with a number which exceeds the number specified by the operator by four. This is to insure that the first rotational pass of segment B, which produces no copy, is not counted and that the last counted segment rotates fully around to the transfer position. Thus, when the copy counter reaches a count of zero, the requisite number of copies have been reproduced and the machine is cycled off. It should further be noted that the output signal of the copy counter is utilized to prevent charging and scanning during the runout of the last copy.

The frame counter **167** also provides an output to the plate revolution counter **179** each time the interframe segment, a, passes the sensing device **13.** The plate revolution counter provides an output signal indicating whether the electrostatic plate is in its first revolution past the sensing device **13** and, thereafter, whether the plate is in an even or odd-number revolution. The output signals of the plate revolution counter **179** and of the frame counter **167** are applied to the And gates **180–183** which, in turn, are applied to the Or gates **187** and **188** and the invertor **189**. The output signal of the Or gate **187** is applied to the cleaning control **192**. The cleaning control **192** is further provided with an input signal (not shown) indicating the precise rotational relationship of the electrostatic plate **11** with respect to the cleaning station **17**. As a segment of the plate to be cleaned rotates past the actuable cleaning member **19**, cleaning control **192** provides a signal to the magnet and armature assembly **41** causing the cleaning member to contact the electrostatic plate **11**. The signal remains on until the entire segment has passed the cleaning member at which time the output signal of the cleaning control **192** is removed.

In a similar manner, the output signal of the Or gate **188** is provided to the charge control **194** which is also supplied with a timing signal (not shown) indicating the exact positional relationship of the interframe segment with respect to the actuable charging station **21**. The charge control provides an output signal which effects the turn on or turn off of the corona generating wires **47, 48, 49** as the interframe segment rotates therepast.

The output signal of the Or gate **188** is also provided to the scan and illuminate control **196**. This control is also provided with a timing signal indicating the exact positional relationship of the rotating electrostatic plate past the imaging station **23**. The output signal of this device is supplied to the drive motor **91** which effects movement of the moving optical system in the scanning direction of arrow **81**. Additionally, the output signal of the scan and illuminate control turns on the lamp **65** thereby illuminating the master **25**. At the completion of a scan, the output signal of the scan and illuminate control is dropped, thereby causing the lamp **65** to be extinguished and the enabling signal to be removed from the drive motor **91**. The spring motor **97** effects the return of the moving optical projection system **33** in the direction of arrow **99**.

The Invertor **189** provides an output signal to the transfer control **198** which is also provided with a signal indicating the positional relationship of the electrostatic plate **11** with respect to the transfer station **31**. The output signal of the transfer control **198** effects the rotational operation of the picker roller **143**, thereby causing a substrate surface **29** to be fed from the hopper **141** in time relationship to the arrival of a developed image at the transfer station **31**.

As described heretofore, the copy counter **163** provides a signal to the charge control **192** and to the scan and illuminate control **194** preventing, respectively the charging and scanning of unwanted segments during a runout cycle. The same signal is provided to the cleaning control **192** which effects cleaning of those segments which rotate past the cleaning station during a runout cycle.

It should be noted that the timing signals indicating the exact positional relationship of the electrostatic plate **11** with respect to the various stations supplied to the cleaning control **192**, the charge control **194**, the scan and illuminate control **196**, and the transfer control **198** may be provided by sensing devices similar to the sensing device **13** located at each station or by logic responsive to the sensing device **13** or by mechanical logic (e.g., cams, etc.) well known in the art. Further, the output signal of the cleaning control **192** may be held on through an appropriate electronic delay device or by a mechanical delay. Additionally, the charge control is depicted as being responsive to logic which turns on the actuable charging station **21**. It should be noted that the absence of a signal from the Or gate **188** effects the turn off of the actuable charging station as an appropriate interframe segment passes thereunder.

While the above description has related to a three segment electrostatic plate, it is, of course, recognized that a single segment plate could be utilized. In such an embodiment, the moving optical projection system would be actuated during a first revolution of the rotating plate and would return to its home position as the plate rotated past the imaging station during its second revolution. The cleaning member and the charging station would be deactuated during the second pass of the plate therepast in order to facilitate redevelopment of the original image.

It should be further recognized that an even number of segments can be utilized by effecting two redevelopment cycles for every imaging cycle. Table II, set forth below, indicates the sequential operation of the various stations for a two-segment electrostatic plate.

TABLE II

Drum Rev	Frame	Clean	Charge	Image	Transfer
	A	Yes	Yes	Scan (image)	Yes
1	B	Yes	No	Return (no image)	No
	A	No	No	Stationary (no image)	Yes
2	B	Yes	Yes	Scan (image)	Yes
	A	No	No	Return (no image)	Yes
3	B	No	No	Stationary (no image)	Yes
	A	Yes	Yes	Scan (image)	Yes
4	B	No	No	Return (no image)	Yes

From the above table, it can be seen that the moving optical projection system remains stationary every third imaging cycle thereby allowing a second redevelopment of a previously exposed latent image. The operation of the reproduction apparatus for drum revolutions 5–7 would be identical to drum revolutions 2–4 and so on.

OPERATION OF THE INVENTION

Referring once again to FIG. **1** of the drawings, an operator places a master **25** onto the document mounting means **55** and specifies a number of copies of the master to be reproduced by setting the copy counter **163**. Thereafter, the operator depresses a start control **161** which gates the And gate **165** which in turn effects the rotational motion of the electrostatic plate **11** in the direction of arrow **15**. As the interframe segment, a, passes the sensing station **13**, the frame counter **167** provides an output signal effecting the decrementing of the copy counter **163** and effecting the resetting of the plate revolution counter **179**. The output signals of the frame counter **167** and the plate revolution counter **179** are provided to combinational gating circuits which in turn provide signals to the cleaning control **192**, the charge control **194**, the scan and illuminate control **196**, and the transfer control **198**. These units, respectively, control the sequential operation of the cleaning station **17**, the actuable charging station **21**, the imaging station **3**, and the transfer station **31**. Additionally, the developer station **27** is actuated to provide a continuous flow of developer material **113** to the magnetic brush unit **125** which is continuously operated to develop electrostatic latent images on the surface of the electrostatic plate **11** as the plate rotates adjacent to the cylindrical member **27**.

After the interframe segment, a, passes the sensing device **13**, it thereafter passes an actuable cleaning member **19** which is actuated by the cleaning control **192** to a position of close adjacency to the surface of the electrostatic plate **11**. Thereafter, as the segment A passes the actuable cleaning member **19**, residual toner existing thereon is swept therefrom.

As the interframe sector, a, passes the actuable charging station **21**, the magnetic indicia located thereon sequentially actuates the corona generating wires **47**, **48** and **49** so that the charging station **21** applies a uniform charge to the segment A as it thereafter rotates therepast. When the interframe sector, a, reaches the imaging station **23**, the scan and illuminate control **196** provides a signal to drive motor **91** and to the lamp **65**. The drive motor **91** effects the movement of the first carriage **59** and the second carriage **61** in the direction of arrow **81** in timed movement with the movement of the segment A on the electrostatic plate **11** past the aperture member **57**, thereby projecting a light image of the master **25** onto the surface of the electrostatic plate **11**. The electrostatic latent image thus produced is developed at the developing station **27** as the segment A rotates therepast. The transfer control **198** initiates the feeding of a support surface **29** in timed relation to the rotational movement of the segment A past the transfer station **31**. The developed image on the sector A is transferred to the support surface **29** at the transfer station **31**.

As the interframe sector, a, again rotates past the sensing device **13**, it provides a signal to the frame counter which in turn provides a signal that is utilized by the logic depicted to cause the cleaning control 192 to deactuate the cleaning member 19 so that the cleaning member does not engage the surface of the electrostatic plate **11** as the segment A rotates therepast. Additionally, the charge control **194** causes the corona wires **47, 48** and **49** to be turned off as the interframe segment a rotates therepast. As segment A of the electrostatic plate 11 rotates past the imaging station **23**, the signal is removed from the drive motor **91** thereby allowing the spring motor **97** to effect the return movement in the direction of arrow **99** of the first carriage **59** and the second carriage **61** of the moving optical projection system **33**. The lamp **65** is turned off thereby insuring that the electrostatic image still remaining on the electrostatic plate 11 remains undisturbed. Thereafter, the segment A passes the developing station where the latent image is again developed and the transfer station where the transfer control **198** effects the feeding of a second substrate surface **29** to receive the developed image. Continued rotation of the electrostatic plate 11 results in alternate imaging and redevelopment of the segment A.

The segment B of the electrostatic plate 11 which rotationally follows the segment A is imaged by the moving optical projection system during those revolutions of electrostatic plate **11** that the image on the segment A is redeveloped. In a similar manner, the segment B is redeveloped on those revolutions of the electrostatic plate during which the segment A is imaged or scanned. The segment C following the segment B is imaged and redeveloped in a manner identical to that of the segment A on any given revolution. As can readily be appreciated, for any given plate revolution except the first revolution, three copies of the master **25** are produced. When the requisite number of copies have been reproduced, the copy counter **163** provides a signal causing the reproduction apparatus to turn off.

It should be noted that FIG. **1** is a schematic illustration and is not drawn to scale. Thus, in actuality, the segment A is of a length equal to the length of travel of the moving optical projection system (assuming a 1:1 magnification ratio of the optical system). Additionally, the interframe segments are shown exaggerated in size for illustrative purposes. The interframe segment is not sufficiently large to allow return of the optical projections system as the interframe segment rotates therepast. In fact, with an assumed processing speed of 20 inches a second, and for the optical system depicted. the interframe segment must be approximately six times as large as the one required for corona and cleaning station switching in order to "hide" the flyback time of the optical system. Further, by utilizing a thicker photoconductive layer, the requisite charging area can be reduced thereby further diminishing the width of the intersegment gap.

While the present invention has been described with respect to an optical projection system incorporating moving mirror carriages, it will be understood that the invention is equally applicable to those projection systems utilizing rotational mirrors, travelling lenses, moving master document holders, and moving masters, each of which must be returned to an initial position prior to initiating a second image projection of the mounted master.

Further, as is understood by those skilled in the art, various charging, developing, transfer, and cleaning stations, per se, well known in the art could be utilized without departing from the spirit and scope of the present invention. Thus, for example, a cascade or screen-type development system could be utilized. The cleaning station could also incorporate an actuable preclean corona and/or erase lamp which are actuated in the same sequence as the cleaning member described. Further, it has been found that, when utilizing a wiper cleaning member, the latent image remains sufficiently undisturbed by the cleaning member to produce a limited number of high quality copies even though the cleaning member continuously remains in contact with the plate. Further, pressure and heat transfer techniques can be utilized, it being only important that the electrostatic image on the electrostatic plate be relatively undisturbed by the transfer operation.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it should be understood by those skilled in the art that the foregoing and other changes in form and detail may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. An electrostatic transfer reproduction apparatus incorporating an electrophotographic plate having at least one image area thereon which travels in a first direction in a closed loop past a plurality of processing stations comprising:

mounting means for mounting a master for optical projection;

an imaging [processing] station for projecting a light image of said mounted master onto said image area of said plate as said image area travels therepast creating a latent image on said image area, said imaging [processing] station including;

an actuable moving optical projecting system for projecting said light image while moving in said first direction from a home position;

actuable drive means for moving said optical projection system in said first direction from said home position and for returning said optical projection system to said home position;

a developer [processing] station for applying electrostatically charged developer material onto said image area thereby developing said latent image whenever said image area travels therepast;

a transfer [processing] station for transferring each developed image from said image area onto a substrate when said image area travels therepast;

an actuable [processing] station actuable for removing a latent image on said image area as said image area travels therepast;

position sensing means for sensing the position of said at least one image area with respect to said processing stations;

cycle control means responsive to said sensing means for actuating said optical projection system and said drive means when said image area travels past said imaging [processing] station on a first pass thereby creating a latent image of the mounted master on said image area, for deactuating said actuable [processing] station and said optical projection system when said image area travels past said actuable [processing] station and said image [processing] station on at least one next subsequent pass following said first pass thereby retaining said latent image created during said first pass and for actuating said actuable [processing] station and said optical projecting system and drive means when said image area travels past said actuable [processing] station and said imaging [processing] station following said at least one next subsequent pass thereby creating a further latent image of said mounted master on said image area, the latent image on said at least one image area being developed at said developer [processing] station and transferred at said transfer [processing] station at least two times before removal thereof at said actuable [processing] station.

2. The electrostatic transfer reproduction apparatus set forth in claim **1** wherein said electrophotographic plate having an odd number of image areas thereon and wherein said cycle control means alternately actuates and deactuates said actuable [processing] station and said optical projection system when an image area travels past said actuable [processing] station and said imaging [processing] station.

3. The electrophotographic transfer reproduction apparatus set forth in claim **2** wherein said electrostatic plate having an odd plural number of image areas thereon.

4. The electrostatic transfer reproduction apparatus set forth in claim **1** wherein said actuable [processing] station includes:

an actuable charging station for charging said image area of said electrophotographic plate when said image area travels therepast, said charging station being located prior to said imaging station in said first direction of plate travel;

said cycle control means actuating and deactuating said charging station in the same actuation-deactuation sequence applied to said optical projection system when the image area travels past said charging station.

5. The electrostatic transfer reproduction apparatus set forth in claim **1** wherein said actuable processing station includes:

an actuable cleaning station for cleaning residual developer material from said image area of said plate when said image area travels therepast, said cleaning station being located prior to said imaging station in said first direction of plate travel;

said cycle control means actuating and deactuating said cleaning station in the same actuation-deactuation sequence applied to said optical projection system when the image area travels past said cleaning station.

6. The electrostatic transfer reproduction apparatus set forth in claim **1** wherein said drive means moves said optical projection system in a second direction opposite said first direction when return said optical projection system to said home position:

at least one of said at least one image areas travelling past said imaging [processing] station during the movement of said optical projection system in said second direction.

7. The electrostatic transfer reproduction apparatus set forth in claim **6** wherein said electrophotographic plate having an odd number of image areas thereon and wherein said cycle control means alternately actuates and deactuates said actuable [processing] station and said optical projection system when an image area travels past said imaging [processing] station.

8. The electrostatic transfer reproduction apparatus set forth in claim **7** wherein said electrophotographic plate having an odd plural number of image areas thereon.

9. The electrostatic transfer reproduction apparatus set forth in claim **6** wherein said mounting means retains said master in a stationary position and wherein said optical projection system includes a movable carriage for scanning said mounted master.

10. In electrostatic transfer reproduction incorporating an electrophotographic surface which travels cyclically around a closed loop past an imaging station where the image of a master document is projected onto said electrophotographic surface, past a developing station for developing said projected images with electrostatically charged developer material, past a transfer station for transferring the developed image from the electrophotographic surface to a substrate, past a cleaning station for cleaning developer material from the electrophotographic surface, and past a charging station for charging the electrophotographic surface to a predetermined charge in preparation for the imaging station, apparatus for hiding flyback time occurring at the imaging station comprising:

means for sensing the position of frame on the electrophotographic surface relative to said stations;

means responsive to said sensing means for indicating cycles of the electrophotographic surface about the closed loop;

optical projection means mounted with relative movement between said projection means and the master document, said optical projection means responsive *to said position sensing means and said cycle indicating means for projecting at the image station an image of the master document on frames separated by at least one frame to allow said optical projection means time to fly back so that in a given cycle of the electrophotographic surface around the closed loop imaged frames are followed by at least one non-imaged frame;*

said developing and transferring stations responsive to said position sensing means and said cycle indicating means for developing and transferring the image from each imaged frame and each non-imaged frame carrying a latent image from a previous cycle of the electrophotographic surface;

said cleaning and charging stations responsive to said position sensing means and said cycle indicating means for cleaning and charging the non-imaged frames carrying a latent image during the cycle of the electrophotographic surface in which the latent image is developed and transferred for the last time before the frame is again imaged on the next cycle whereby a frame on the electrophotographic surface is imaged in one cycle, and is passed over by the flyback of the projection means in another succeeding cycle.

11. The apparatus of claim 10 wherein said electrophotographic surface contains an odd number of frames in the closed loop and each frame becomes an imaged frame and a non-imaged frame in alternate cycles of said electrophotographic surface around the closed loop.

12. Method for hiding the flyback time of an optical system used in an electrostatic transfer reproduction apparatus wherein said apparatus has a charging station, an imaging station, a developing station, a developed image transfer station, and a cleaning station past which an electrophotographic surface moves cyclically in a closed loop, said electrophotographic surface being of a predetermined size having an odd numer of image frames consuming substantially all of the electrophotographic surface except for small interframe gaps to separate the frames, and said optical system and a master document to be projected mounted with relative movement therebetween, the method comprising the steps of:

sensing the cylindrical position of the frames relative to each of said stations;

actuating the optical system at the imaging station to image the master document on a first frame and every other frame thereafter and to fly back during an immediately succeeding frame and every other frame thereafter;

developing and transferring a developed image from said first frame and every other frame thereafter during the first electrophotographic-surface cycle and from each frame during each cycle after the first cycle of the electrophotographic surface through the closed loop;

cleaning and recharging a frame in the electrophotographic-surface cycle during which the frame was not imaged whereby each frame is imaged once and developed and transferred twice during two cycles of the electrophotographic surface through the closed loop and each frame is moved past the image station during optic system flyback time, cleaned and recharged once during two cycles of the electrophotographic surface in the closed loop.

13. Method for hiding flyback time of an optical system used in an electrostatic transfer reproduction apparatus wherein said apparatus has a charging station, an imaging station, a developing station, a developed image transfer station, and a cleaning station past which an electrophotographic surface moves cyclically in a closed loop, said electrophotographic surface being of a predetermined size having an even number of image frames consuming substantially all of the electrophotographic surface except for small interframe gaps to separate the frames, and said optical system and a master document to be projected mounted with relative movement therebetween, the method comprising the steps of:

sensing the cyclical position of the frames relative to each of said stations;

actuating the optical system at the imaging station to image the master document on a first frame and every third frame thereafter and to fly back during at least one frame intermediate the imaged frames;

developing and transferring a developed image from each frame during the first cycle of the electrophotographic surface around the closed loop in which said frame is imaged and thereafter in each successive cycle;

cleaning and recharging a frame in the second electrophotographic-surface cycle during which the frame was not imaged whereby each frame is imaged once and developed and transferred three times during three cycles of the electrophotographic surface through the closed loop and each frame is moved past the image station twice without being imaged, cleaned and recharged once during three cycles of the electrophotographic surface in the closed loop.

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