United States Patent [19]

Hildenbrandt

[11] E **Re. 29,017**

[45] **Reissued Oct. 26, 1976**

[54] **ILLUMINATION SYSTEM FOR COPIER MACHINES ARRANGED TO MINIMIZE GLARE WITH RESPECT TO AN OPERATOR**

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

[22] Filed: **Apr. 16, 1975**

[21] Appl. No.: **568,753**

Related U.S. Patent Documents

Reissue of:

[64] Patent No.: **3,758,774**
Issued: **Sept. 11, 1973**
Appl. No.: **264,093**
Filed: **June 19, 1972**

[52] **U.S. Cl.** .... **240/41.35 R;** 240/103 R; 355/67

[51] **Int. Cl.**[2] **F21S 1/00;** G03B 27/54

[58] **Field of Search** .... 355/67, 66, 49, 8, 51; 353/50, 98; 240/103, 41 R, 41.35; 350/6

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Attorney, Agent, or Firm—John W. Girvin, Jr.; D. Kendall Cooper

[57] **ABSTRACT**

The present case is directed to a number of illumination systems making use of lamps and reflectors having predetermined optical configurations and arranged to insure minimal glare in the eyes of an operator using the equipment in which the illumination systems are incorporated. A first version involves a stationary paraboloid reflector cooperating with a moving parabolic cylinder reflector to illuminate an original document during a copying operation. In a second version, the moving reflector is split into two reflectors each having distinct parabolic configurations and different focal lengths. In still another version, only a single reflector is arranged for movement during scanning of an original document to project a line of light and has a predetermined configuration which is paraboloid in one direction and substantially elliptical in a direction transverse to the first direction.

7 Claims, 9 Drawing Figures

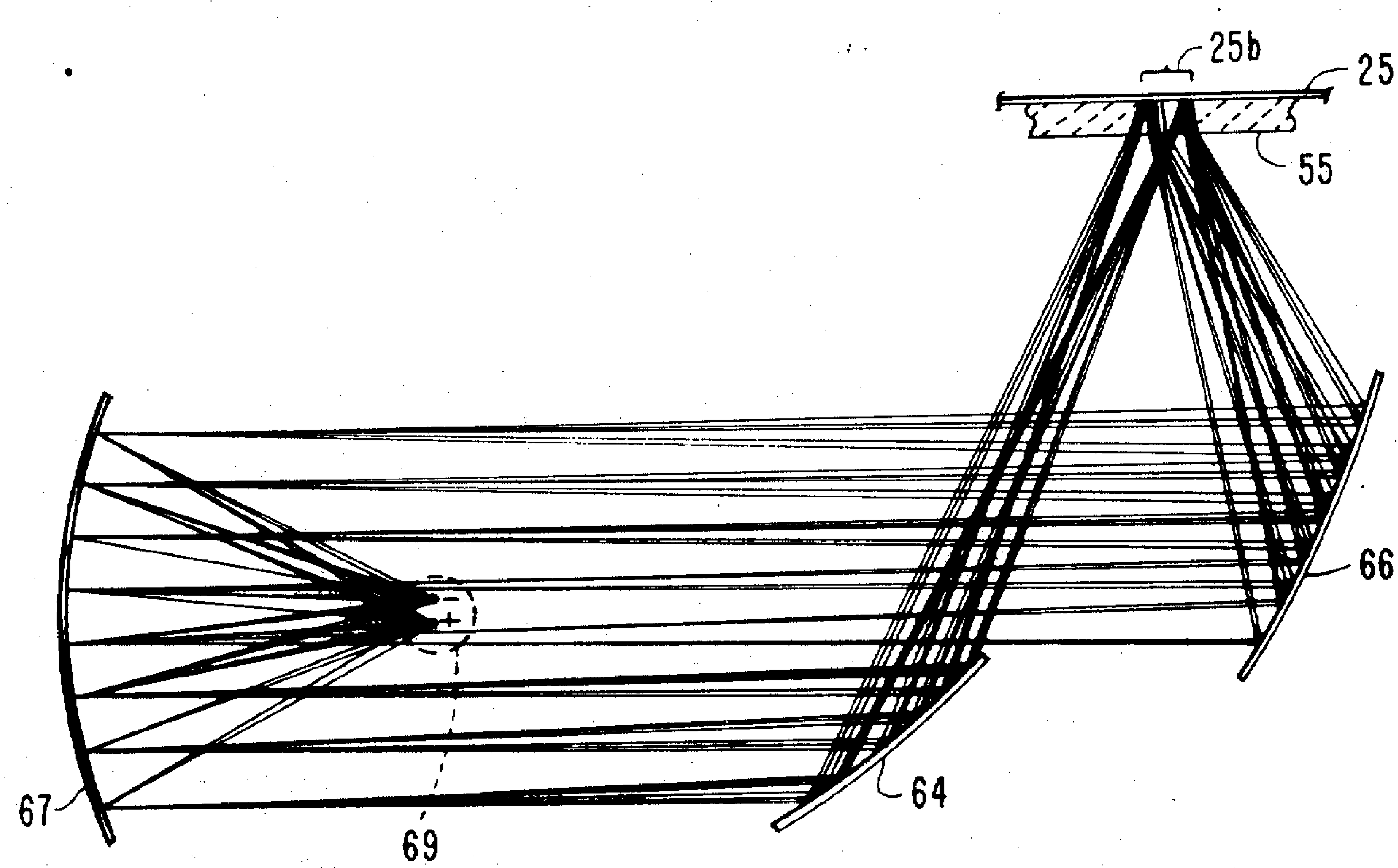


FIG. 1

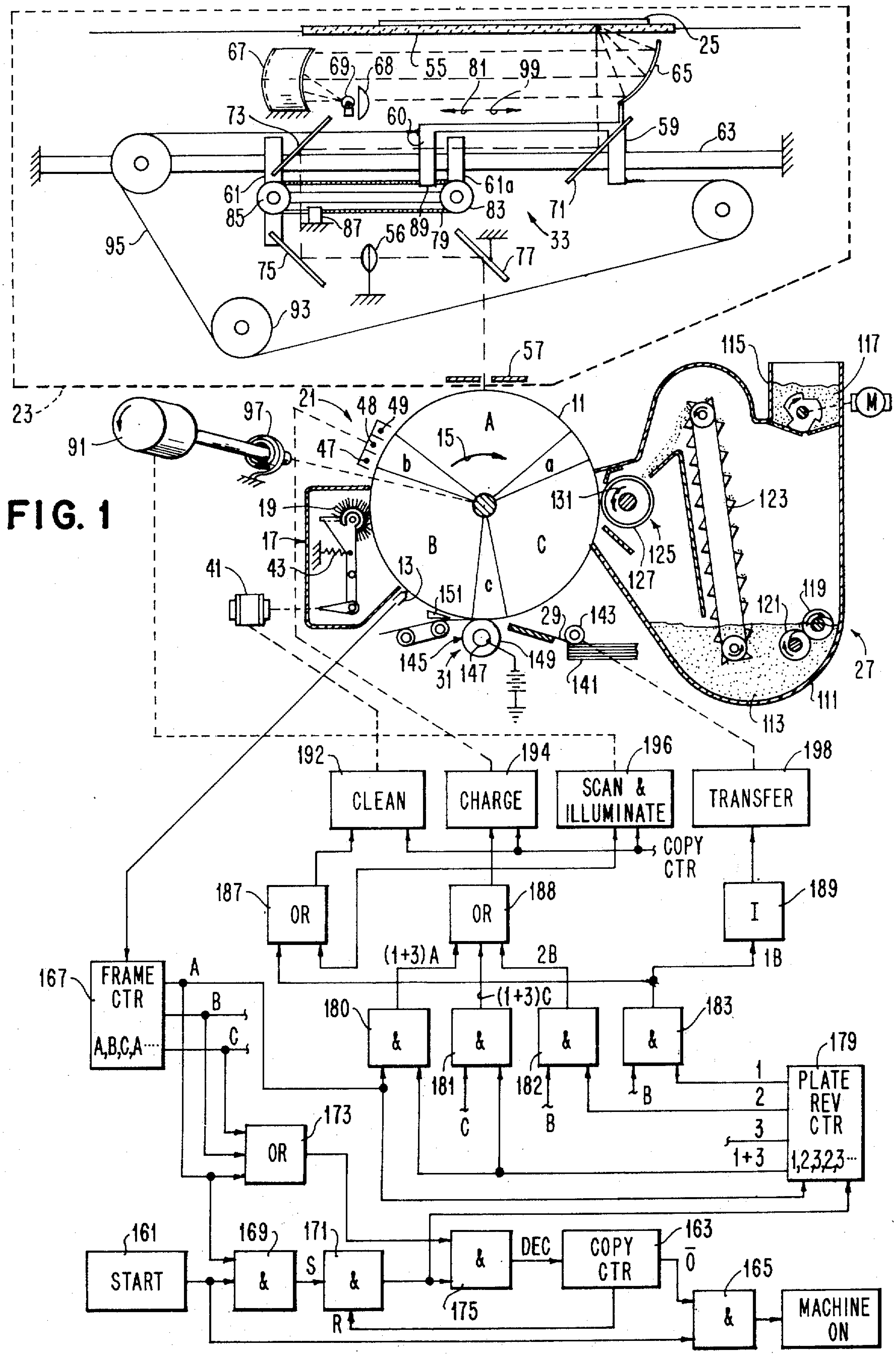

CLEAN
CHARGE
SCAN & ILLUMINATE
TRANSFER
COPY CTR
OR
OR
I
FRAME CTR
A,B,C,A···
&
PLATE REV CTR
1,2,3,2,3···
START
COPY CTR
MACHINE ON
DEC

FIG. 2a

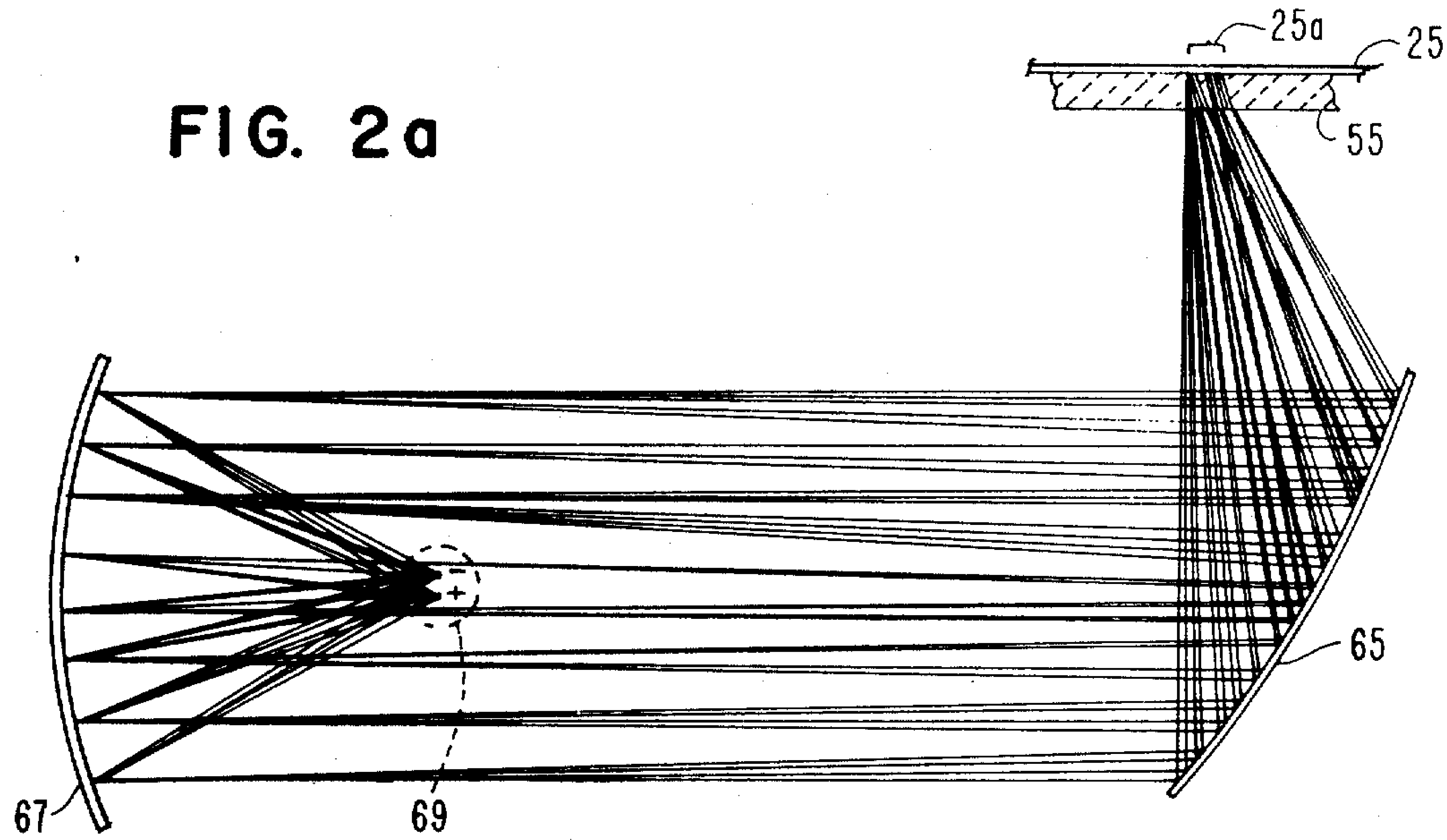


FIG. 2b

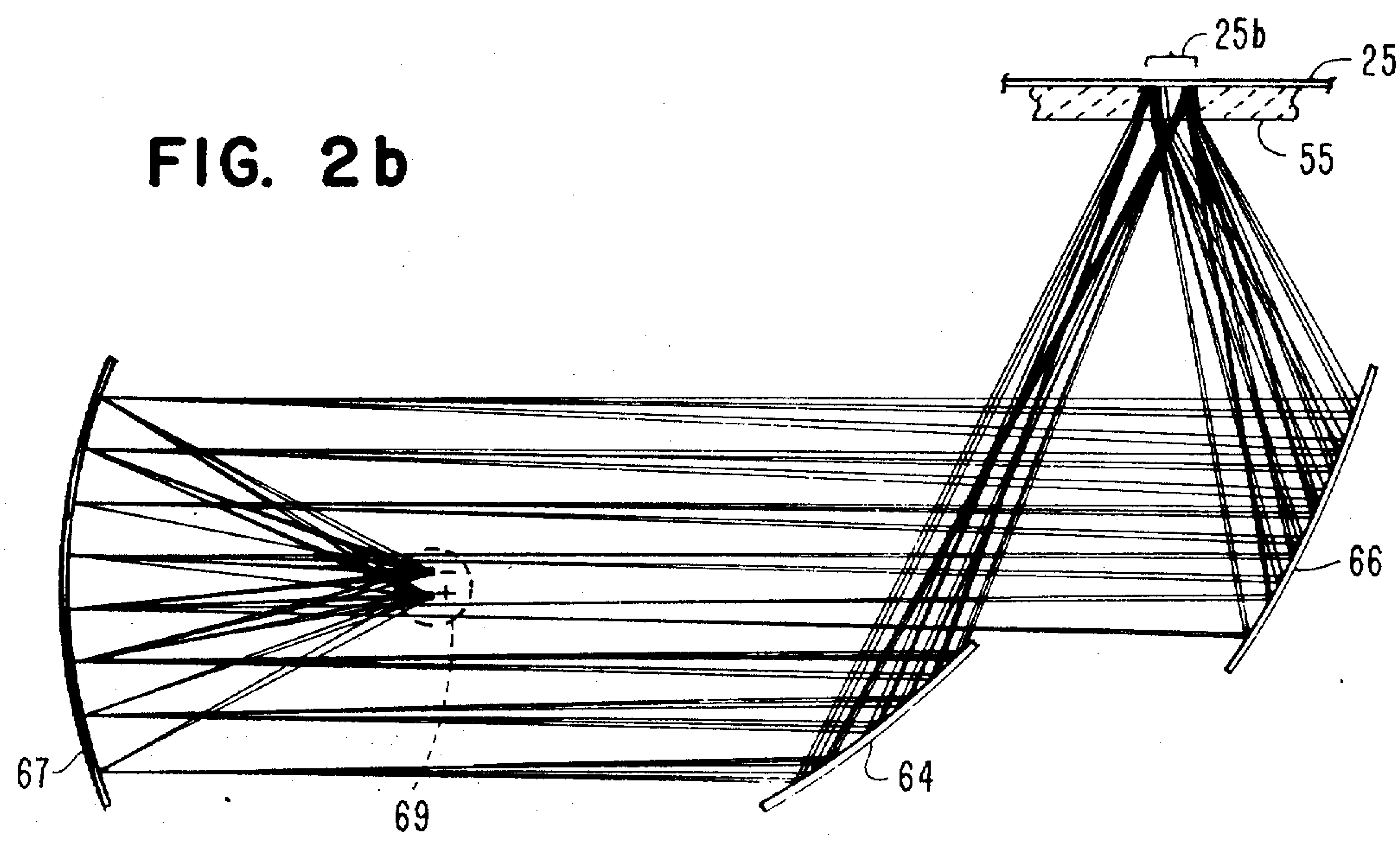


FIG. 3a

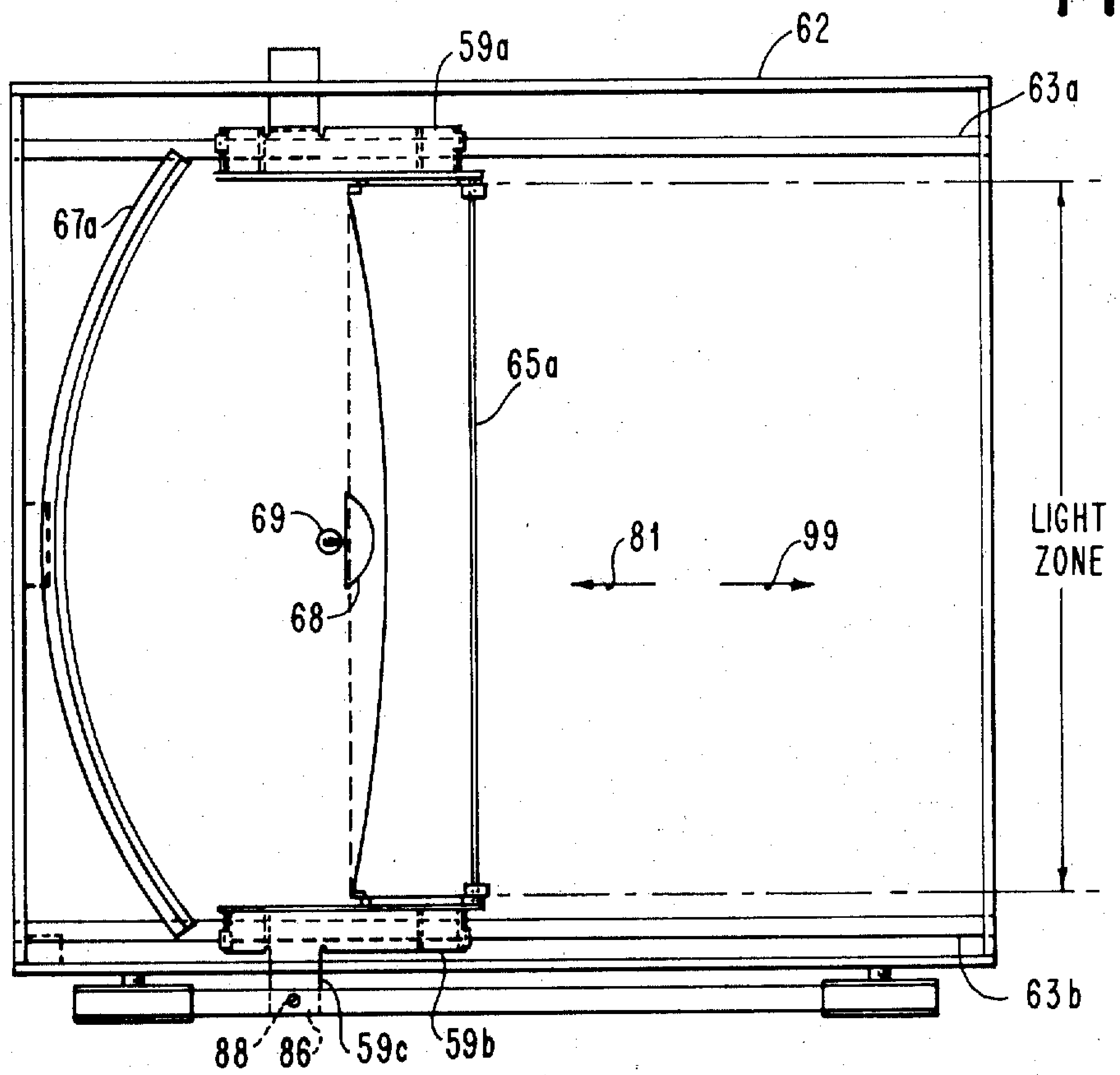


FIG. 3b

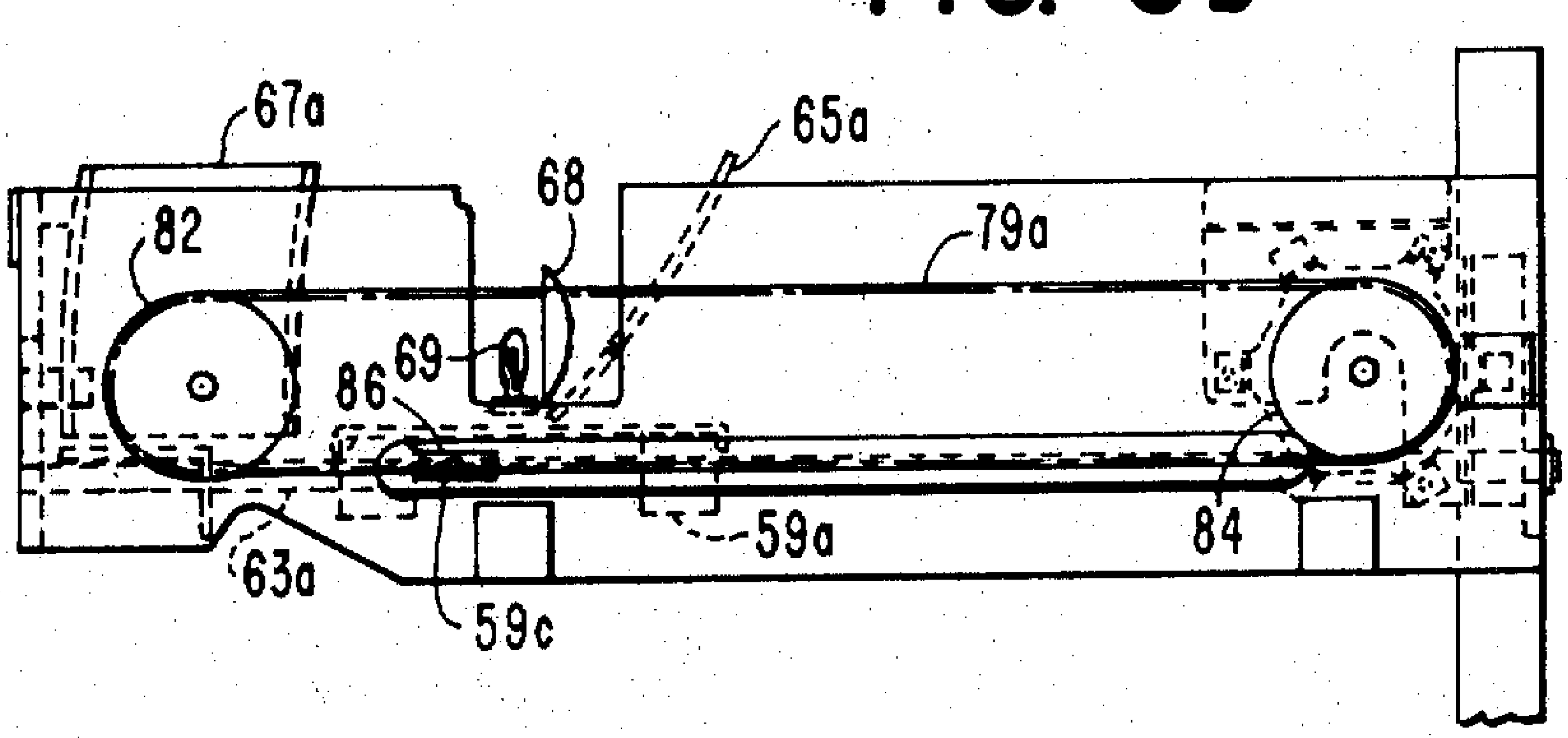


FIG. 3c

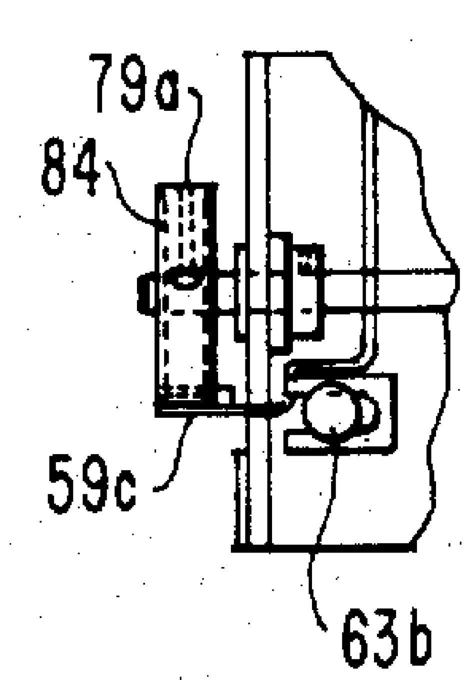


FIG. 4 PRIOR ART

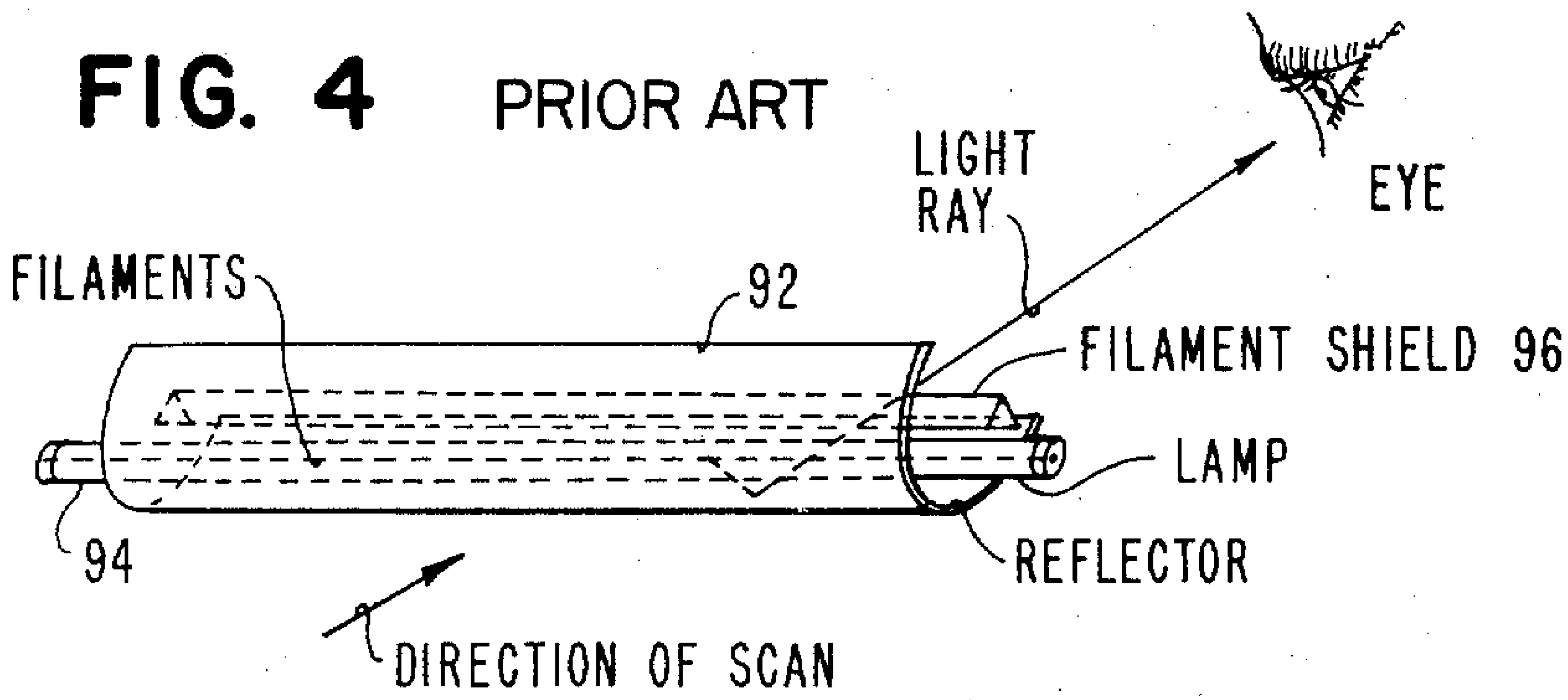


FIG. 5a

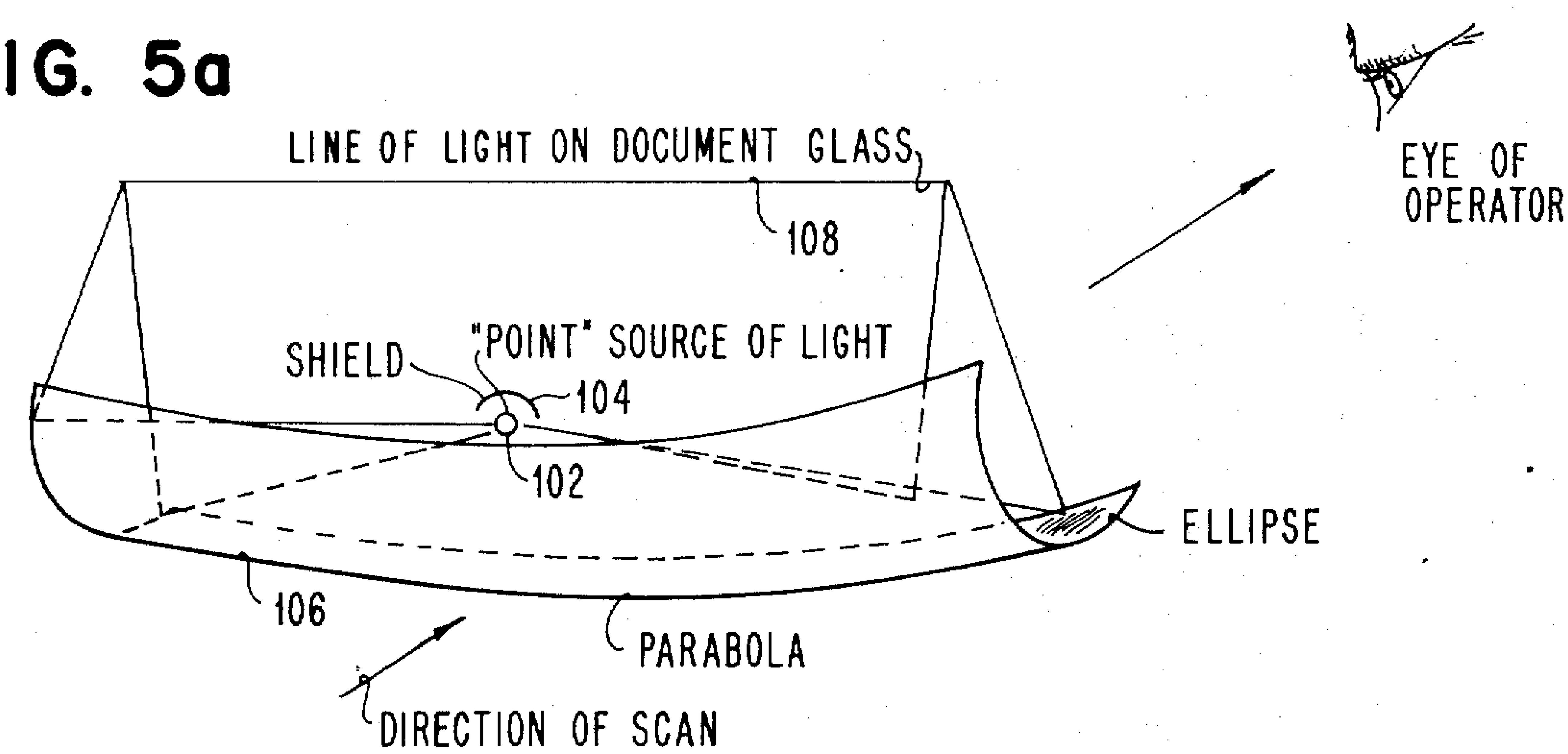
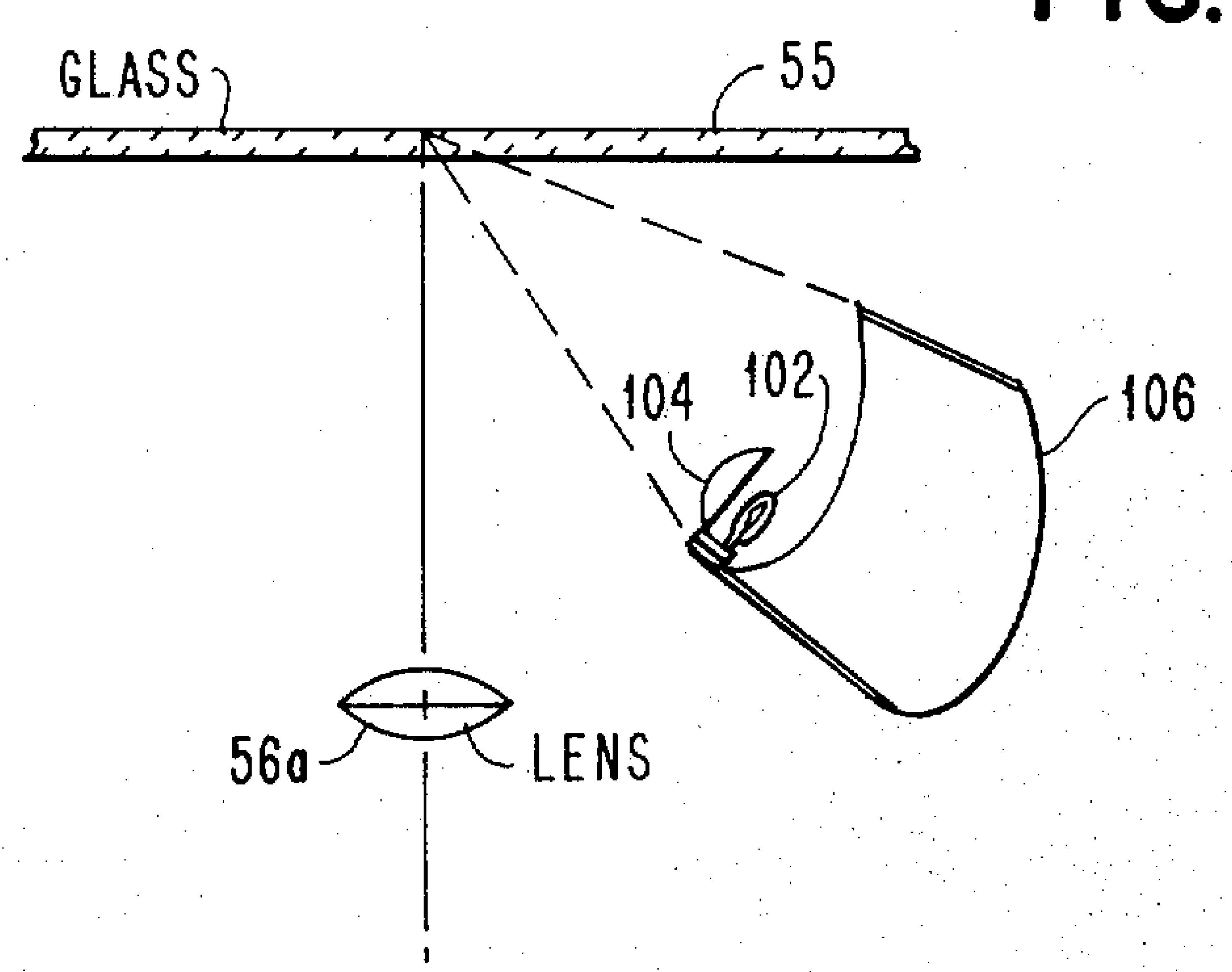


FIG. 5b



ILLUMINATION SYSTEM FOR COPIER MACHINES ARRANGED TO MINIMIZE GLARE WITH RESPECT TO AN OPERATOR

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.

REFERENCES TO PATENTS, PENDING APPLICATIONS, AND PUBLICATIONS OF INTEREST

Book: Calculus With Analytic Geometry having Angus E. Taylor and Charles J. A. Halberg, Jr. as authors; copyright 1969, published by Prentice-Hall, Inc. Note pages 85–91.

U.S. Pat. application Ser. No. 209,326, filed Dec. 17, 1971; having R. V. Davidge, et al., as inventors; and entitled: "Reproduction Apparatus Incorporating Alternate Redevelopment and Reimaging Cycles for Multiple Copies."

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

BACKGROUND OF THE INVENTION, FIELD, AND PRIOR ART

A variety of illumination schemes have been provided in the prior art ranging all the way from simple aperture lamp arrangements, making use of no reflectors to more complex systems making use of a linear lamp position within an elliptical reflector and, in some cases, making use of additional reflecting members to achieve projection of the light in a preferred direction. In some cases, a multiplicity of lamps have been arranged to illuminate an original document cooperating with a closely positioned reflector element that is coextensive with the lamps. Ordinarily, in any copier machine, when a flat document, such as original letters, and the like, are placed in position for copying purposes, little or no light is projected from the illumination system toward the operator's eyes. However, under circumstances where the original comprises a book or comparable original requiring special positioning or handling, prior systems are prone to project light toward the operator's eyes. This is due to the fact that the book or comparable original is positioned on the copy machine with the document lid in an open condition thereby permitting light to escape from the interior of the machine during the copying operation.

SUMMARY OF THE INVENTION

In accordance with the present invention, various illumination arrangements are provided that establish light patterns within pre-selected light boundaries not normally encountered by the operator of the machine. More specifically, reflector elements are provided in the illumination systems set forth therein that cooperate in various respects to establish an original document illumination pattern that is characterized as a directed column of light, also referred to as collimated in nature. With this arrangement, the chance that an operator of the machine will see the light emanating from the machine under normal conditions is extremely unlikely. This is true when original documents such as letters and the like are being copied with a document cover in place as well as under circumstances when books or other relatively large documents are being copied with the document cover moved out of position thereby exposing the illumination system. The principles set forth herein are applicable even when a very small original document is positioned for copying, or when in fact no document is in place but the illumination system happens to be on. The latter condition might occur, for example, during test procedures or the like.

As previously indicated, the invention is illustrated in several versions. In a first version, the illumination system includes a stationary paraboloid reflector having an associated light source that is preferably of compact design. Further, the first version includes a single parabolic cylinder scanning reflector arranged adjacent the original document for projection of a line of light during copy operations. The moving reflector receives collimated light from the stationary paraboloid reflector and focuses it to a line of light. In the second version, a stationary paraboloid reflector is also made use of but cooperates with a split parabolic scanning mirror arrangement, comprising two parabolic cylinder reflectors each having different focal lengths but focusing to the same line during scanning operations. An objective of this arrangement is to insure that light is provided from two directions, thereby minimizing or eliminating shadow effects that otherwise might be encountered with three-dimensional original objects.

In a third version, the illumination system includes a single moving reflector having both paraboloid and substantially elliptical characteristics. In this version, the reflector is preferably formed with a parabolic characteristic in one direction transversely to the direction of scanning with respect to the original document and that is substantially elliptical in cross-sections that are parallel to the direction of scanning.

Reference is made to the Taylor and Halbert book for some discussion of paraboloid and parabolic cylinder elements.

OBJECTS

A primary object of the present invention is to provide an illumination system that substantially eliminates glare projected toward the eyes of an operator in proximity to the system.

Another object of the invention is to provide an illumination system incorporating cooperating elements of compact design and achieving a more efficient illumination of objects.

Another object of the present invention is to provide an illumination system for projecting a line of light onto an original document in a copying machine.

A further object of the present invention is to provide an illumination system having a minimum of moving elements but producing a highly efficient light output for scanning of an original document in a copier machine.

Also, an object of the present invention is to provide an illumination system with some measure of control of light distribution in the system.

A still further object of the present invention is to provide an illumination system based on a unique arrangement of paraboloid and parabolic reflector elements.

An additional object of the present invention is to provide an illumination system having non-glare characteristics and utilizing a single reflector means for controlled light distribution.

An object of the present invention is to provide an illumination system that produces a more effective illumination pattern for particular use with three-dimensional objects.

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

IN THE DRAWINGS

FIG. 1 is a schematic diagram of an electrostatic transfer reproduction apparatus incorporating a cyclic control unit for automatically effecting alternate redevelopment and reimaging cycles, and incorporating illumination means predicated on the principles of the present invention.

FIG. **2a** represents tracings of light rays from an original light source to a stationary paraboloid reflector to a moving parabolic reflector, thence through a document glass to an original document.

FIG. **2b** is similar to FIG. **2a** but is representative of light ray traces where a split reflector scheme is used involving two parabolic cylinders arranged for movement during scanning. This also illustrates the light being projected to an original document from two different angles to minimize shadow effects.

FIGS. **3a, 3b,** and **3c** together represent a first version of the illumination scanning arrangements previously referred to and particularly making use of a moving parabolic cylinder reflector.

FIG. 4 represents a typical illumination arrangement of the prior art utilizing an elliptic cylinder reflector with a linear light source.

FIGS. **5a** and **5b** represent a third version of an illuminating scheme according to the principles of the present invention making use of a single moving reflector serving the same objective of the other versions, that is controlling the light from a substantially compact or near-point source of light to maintain the light within predetermined light projection boundaries in order to minimize or eliminate glare that might otherwise occur. In doing this, light is collimated as viewed in one plane and focused in a perpendicular plane.

GENERAL DESCRIPTION

Referring now to FIG. 1 of the drawings, a continuously operating electrostatic transfer reproduction apparatus incorporating a first version of an illumination system is depicted. Although illustrated in conjunction with a particular copier apparatus, as taught in the Davidge, et al case, the illumination systems of the present invention are adaptable to many kinds of copiers and scanning systems.

Before discussing the illumination system, a general description of the copier apparatus shown is in order. The copier apparatus comprises a plurality of processing stations located about a cylindrically shaped photosensitive electrostatic plate of drum member **11.** Drum member **11** 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. Member **11** 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 place 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 plate 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 surface 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 member **11** rotating thereunder. The projection of the light image onto the sensitized electrostatic plate creates a latent electrostatic image thereon which rotates with member **11** 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 intact (that is, not being disturbed at the cleaning station **17** or the charging station **21** or re-exposed 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 an 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 telescopic fashion on a common track means **63** for reciprocal movement. The first carriage **59** supports a parabolic reflector **65** which cooperates with a stationary paraboloid reflector **67** to direct light from a lamp **69** upon an original document **25** through document mounting means **55** to thereby illuminate a segmental portion of the master **25**. Lamp **69** has an associated reflector **68** for intensifying and directing light toward reflector **67**. The arrangement is such that a moving line of light is projected onto document **25** during scanning. 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 stationary mirror **77** through the 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 arrow **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 **60** 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 **69** and reflector **65** 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** retreates 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 **65** 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 tone 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. Counter-rotating 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 surfaces 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 facilities 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 imaging cycles and deactuated prior to redevelopment cycles. The following table summarizes a suggested cyclic operation of the cleaning, charging, imaging, and transfer stations.

TABLE I

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

TABLE I-continued

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

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 again to FIG. 1 of the drawings, the machine 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-numbered 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 inverter **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 **69** 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 **69** 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 inverter **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 timed 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.

ILLUMINATION SYSTEMS

The arrangement of the illumination elements in all three versions of the present invention is such that a line of light is projected toward an original document, or object, the line of light having a predetermined finite length confined within a light zone not normally encountered by an operator of the equipment. The principles may be best understood by reference to the detailed drawings **2a–5b.**

FIRST VERSION

In the first version, a stationary paraboloid reflector element **67** receives light from lamp **69,** projects the same toward parabolic reflector **65** which in turn reflects the light toward the original document. The two reflector elements **65** and **67** cooperate in such a manner that a line of light of finite width and length is obtained. The typical tracings of light from source **69** are shown in FIG. **2a.** The light is projected toward paraboloid reflector **67** that serves to collimate the light as it is directed toward parabolic reflector **65.** Parabolic reflector **65** in turn, is designed with a focal line that produces a line of light of predetermined width in area **25a** of document **25.** Further understanding of the first version may be had by reference to FIGS. **3a, 3b,** and **3c** representing a top elevation, side elevation, and partial end elevation of an illumination scheme similar to that shown in FIG. **1** but differing in a number of aspects. Where appropriate, identical reference numerals are used in FIGS. **3a–3c** that correspond, respectively, with numerals in FIG. **1.** When illumination of a document is required, lamp **69** is energized and light is projected toward paraboloid reflector **67a** that is stationarily mounted in the apparatus. Spherical reflector **68,** which has a reflective inner surface, serves to prevent direct light emanating from lamp **69** from going into the light zone, and also improves the efficiency of the system by re-directing light back toward lamp **69.** The reflector **67a** serves not only to collimate the light within predetermined vertical dimensions as shown in FIG. **2a** as it is projected toward reflector **65,** but further collimates the light from lamp **69** so that it remains substantially within the light zone in a horizontal plane, particularly shown in FIG. **3a.** Thus, the shape of paraboloid reflector **67a** is such that collimated light is produced in a two-dimensional sense, that is both vertically and horizontally. The dimensions of the arrangement are such that a relatively uniform level of illumination is maintained throughout the scanning range of movement of parabolic reflector **65,** or **65a,** as the case may be. As previously discussed in connection with FIG. **1,** reflector **65** is mounted for travelling movement on carriage **59,** more specifically designated as members **59a** and **59b** in FIG. **3a.** Only so much of the driving and travelling mechanisms of FIG. **1** as are believed necessary for an understanding of the illumination system are shown in FIGS. **3a–3c.**

The two-dimensional collimated light projected from reflector **67a,** FIG. **3a,** travels toward parabolic reflector **65a,** throughout its range of movement. As shown in FIG. **3a,** reflector **65a** is in the home position and from such position travels toward the right within the bounds of frame number **62.** As previously indicated in connection with FIG. **1,** this is effected by sliding reciprocating movement of bearing members **59a** and **59b** on rods **63a** and **63b,** respectively. Also, as described in FIG. **1,** the movement is evidenced by arrows **81** and **99.**

While many of the elements shown in FIGS. **3a–3c** are similar to those in FIG. **1,** some differences exist. As an example, in FIGS. **3a–3c,** carriage member **59b** has an extension **59c** extending into the path of movement of a drive belt **79a.** Drive belt **79a** is mounted on pulleys **82** and **84** for reciprocating movement as pulleys **82** and **84** are rotated. Ordinarily, a drive means, not shown, is connected to one of the pulleys **82** or **84** to rotate the same and drive belt **79a** in a reciprocating fashion, evidenced by arrows **81** and **99.** Belt **79a** is provided with regularly spaced driving teeth, best seen in FIG. **3b,** that engage correspondingly shaped segments on a clamp element **86.** Clamp element is firmly interconnected to extension **59c** with a portion of belt **79a** passing therebetween through a screw connection **88.** Due to the connections just described, reciprocating motion of reflector member **65a** is effected.

It is evident that the arrangement of the first version, as well as others to be described, provides a highly efficient illumination system wherein light from a light source is controlled to produce a line of light having a finite width and finite length. If it is assumed that the top elevation of FIG. **3a** conforms to the orginal document supporting area of a copy machine, it is readily understood that an operator while using the machine, would be standing under normal circumstances in a position that is on one or the other side of the light zone indicated in FIG. **3a.** This being the case, the operator ordinarily sees no light emanating from the zone and glare is thereby eliminated. If per chance, as during testing procedures, the illumination system is operated and reflector element **65a** reciprocated as indicated by arrows **81** and **99** with no original document in place and an associated document cover, not shown, out of the way, the operator would see only low intensity scattered light as scanning takes place.

SECOND VERSION

FIG. **2b** illustrates a second version of the illumination system wherein the parabolic reflector **65** is replaced by a pair of parabolic reflections **64** and **66.** Reflectors **64** and **66** receive collimated light from paraboloid reflector **67** but as can be observed in FIG. **2b,** reflector **66** receives the upper portion of the collimated light while reflector **64** receives the lower portion of the collimated light. The positional relationships and preselected curvatures and angles of reflectors **64** and **66** are such that the collimated light is re-directed through document glass **55** to original document **25** and confined in an area **25b** on document **25.** The arrangement is such that better light distribution of a three-dimensional object in the area **25b** can be achieved in this manner. In this case, it is understood that document **25** is representative of a three-dimensional object.

TYPICAL PRIOR ILLUMINATION SYSTEM

To further illustrate the advance represented by the present inventive arrangements, a prior illumination arrangement is illustrated in FIG. **4.** This includes a reflector member **92,** lamp **94** and filament shield **96.** The direction of scan is also indicated. Although there is a filament shield **96** that prevents a direct path for light to project from the filament to the eye of an operator, the reflector **92** establishes a multitude of paths that are reduced in intensity only slightly, such as by one reflection loss level. Attempts to shield this kind of reflected light severely reduces the net illumination to a document or requires greater power to the lamp to achieve sufficient illumination.

THIRD VERSION

The problems encountered with the prior illumination arrangement of FIG. **5** are readily eliminated by use of the illumination arrangements taught herein, including the first and second versions. They may also be eliminated by use of the third version illustrated in FIGS. **5a** and **5b.** In this case, a compact source of light **102** cooperates with a shield **104** and a specially shaped reflector **106** to produce the line of light or light footprint shown on the line **108** having a finite width and finite length. The special characteristics of the reflector **106** are that it has a curvature that is parabolic when viewed in the scan direction indicated in FIG. **5a.** The configuration of reflector **106** in a direction transverse to the scan direction is substantially elliptical. It is noted that substantially elliptical curvatures need not be maintained in this plane. That is this curvature could be straightened out more and made essentially flat, but whatever the shape of the reflector **106** in this plane, no light goes in the operator's eyes. A substantially elliptical curvature is desired however to produce a narrow light. Any light going toward the reflector **106** is directed straight up to the footprint area on line **108** with light not going toward reflector **106** being intercepted by shield **104.** This light is either absorbed or reflected back toward the source **102.** The side view of reflector **106** is shown in FIG. **5b** as it might be incorporated in a copier.

Advantages of this version, as well as the others include the fact that all light emanating from the illumination system is radiated in a perpendicular fashion with respect to the scan direction and no light is radiated obliquely toward an operator or someone else standing at the side of a machine. With respect to the third version in FIGS. **5a** and **5b,** as well as the other versions, a compact source of light is advantageous since this permits the use of high-intensity discharge lamps or the more efficient projector type of lamp, such as a tungsten lamp. This also permits easier focusing since only one compact light source need be positioned. By proper variation of the width of the reflector, the light intensity may be controlled to any desired distribution, for example, in order to compensate for the Cosine Fourth Power Law diminution of light in the system. Also, for versions one and two, a specially contoured mask may be positioned in the path of the collimated beam of light from reflector **67** to **65.** The characteristic of the reflectors in all versions enables the establishment of a narrow line of light without using apertures. The systems described herein may be positioned in any direction of scan relative to the operator, and still keep light from the eyes of the operator. As an example, this would apply to someone standing at the side of a front to back scanning machine. It is noted that the reflector elements may be formed of heat transmitting material thereby keeping heat off of the

document area. In addition, the spectral characteristics of the light going to the document may be tailored to the specific requirements of the application.

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

What is claimed is:

1. An illumination system for establishing a line of light substantially coextensive with a linear exposure station having a predetermined finite length within a light zone, comprising:

a light source;

a paraboloid reflector formed to receive light from said source and to project in a first light path a beam of light of substantially rectangular cross-section having a relatively long first dimension and a relatively short second dimension, said relatively long dimension corresponding to said predetermined finite length;

a parabolic reflector formed to receive said substantially rectangular beam of light and to project a line of light therefrom corresponding to said predetermined finite length;

first means mounting said light source and said paraboloid reflector in order to project said substantially rectangular beam of light to said parabolic reflector in said first light path and within said light zone; and

second means mounting said parabolic reflector to re-form and re-direct along a second path said substantially rectangular beam of light as a line of light of said predetermined finite length and to project said line of light to said exposure station, whereby light is confined essentially within said light path and light scattering is minimized.

2. The system of claim **1** wherein exposure is required in an exposure plane and wherein said first means mounts said paraboloid reflector to direct said beam of light in a light path that is parallel to said exposure plane, and further comprising:

moving means for reciprocating said mounted parabolic reflector in said first light path and in a substantially parallel plane with respect to said exposure plane, in order to move said line of light in said exposure plane during reciprocation of said parabolic reflector.

3. The system of claim **2** wherein said exposure plane accomodates an original document in a copier and wherein reciprocation of said parabolic reflector is performed in order to scan said original document and project information from said document for copying purposes.

4. The system of claim **1** wherein said parabolic reflector comprises a pair of parabolic reflectors and further comprising:

means mounting said pair of parabolic reflectors for reduction of light to said exposure station at different angles to minimize shadow effects.

5. An illumination system for establishing a line of light substantially coextensive with a linear exposure station having a predetermined finite length within a light zone, comprising:

a light source;

a paraboloid reflector formed to receive light from said source and to project in a first light path a beam of *light of substantially rectangular cross-section having a relatively long first dimension and a relatively short second dimension, said relatively long dimension corresponding to said predetermined finite length;*

a second reflector formed to receive said substantially rectangular beam of light and to project a line of light therefrom corresponding to said predetermined finite length;

first means mounting said light source and said paraboloid reflector in order to project said substantially rectangular beam of light to said second reflector in said first light path and within said light zone; and

second means mounting said second reflector to reform and re-direct along a second path said substantially rectangular beam of light as a line of light of said predetermined finite length and to project said line of light to said exposure station, whereby light is confined essentially within said light path and light scattering is minimized.

6. The system of claim 5 wherein exposure is required in an exposure plane and wherein said first means mounts said paraboloid reflector to direct said beam of light in a light path that is parallel to said exposure plane, and further comprising:

moving means for reciprocating said mounted second reflector in said first light path and in a substantially parallel plane with respect to said exposure plane, in order to move said line of light in said exposure plane during reciprocation of said second reflector.

7. The system of claim 6 wherein said exposure plane accomodates an original document in a copier and wherein reciprocation of said second reflector is performed in order to scan said original document and project information from said document for copying purposes.

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