Dec. 16, 1969 H. L. BYLAND 3,484,164

COPYING APPARATUS

Filed Feb. 27, 1963 2 Sheets-Sheet 1

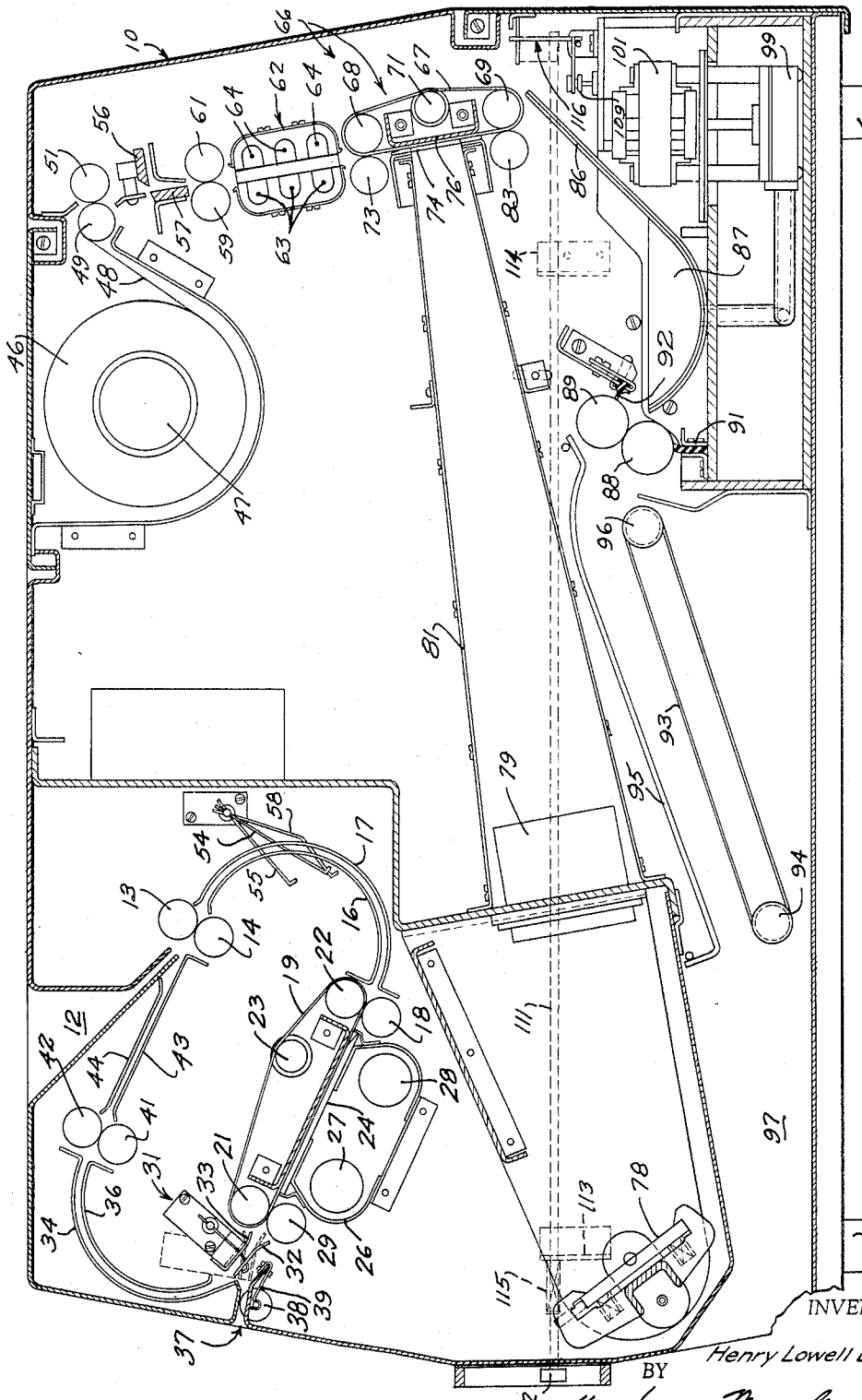


Fig 1

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COPYING APPARATUS

Filed Feb. 27, 1963 2 Sheets-Sheet 2

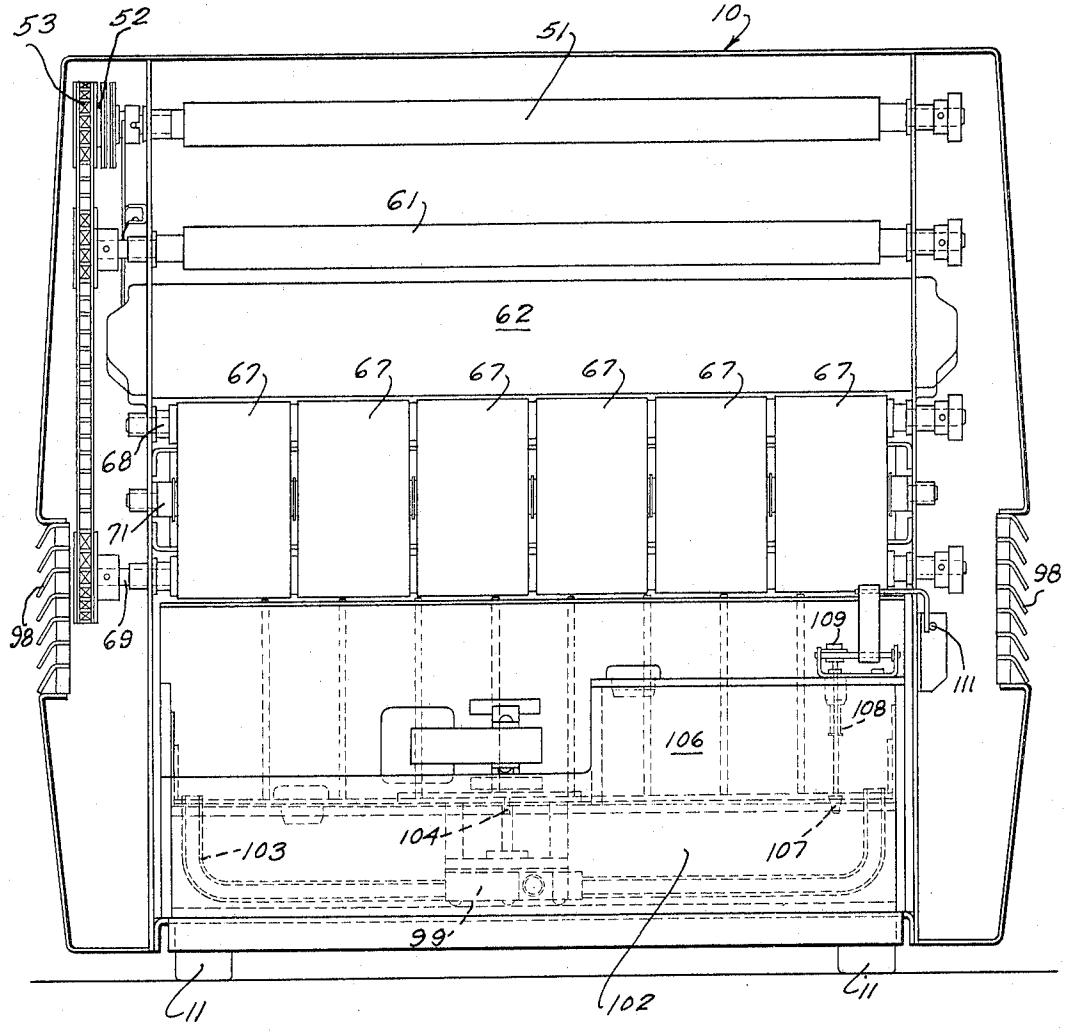


Fig 2

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3,484,164

COPYING APPARATUS

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Int. Cl. G03g 15/06
U.S. Cl. 355—8 21 Claims

The present invention relates to an improved copying apparatus of the xerographic type.

While there are a number of xerographic copying machines on the market presently, many of these are expensive to operate, require a large amount of floor space, and do not make multiple copies as quickly as would be desired. The copying apparatus of the present invention, therefore, seeks to overcome these difficulties by providing a copying machine which can be made relatively small, can be produced inexpensively, and produces multiple copies at a satisfactorily high rate.

The copying apparatus of the present invention is characterized by an endless loop transporting system for the sheet to be copied. The original is deposited on this endless loop and is moved to an exposure position where an illuminating source scans the original by virtue of the relative movement between the original being conveyed around the endless loop and the stationary illuminating source. The image thus produced is reflected into a reflex projection system which directs it to an exposure station at which a pre-charged photoconductive paper receives the image at the focal plane of the lens system. The movement of the copy paper is completely synchronized with the movement of the original through the endless loop. Specifically, switch means associated with the loop initiate operation of a drive system which takes off a continuous web of the photoconductive paper from a roll. Another switch means is actuated by the movement of the original about the endless loop to initiate operation of a cutting means which severs the continuous web being withdrawn from the roll into a sheet of the same size as the original. This sheet is then charged electrostatically to render it receptive to the image in the exposure station. After the image has been applied to the charged paper, the image is developed by passing through a developing station including a tray containing a suspension of toner particles in a carrier liquid, following which the print is passed through a pair of drying rolls and then is discharged from the machine.

An object of the present invention is to provide an improved copying apparatus capable of producing multiple copies rapidly.

Still another object of the invention is to provide a copying apparatus which can be made in a table top size.

Still another object of the invention is to provide an improved copying apparatus of the xerographic type in which the copy paper is supplied as a continuous web from a roll rather than as individual sheets as in the past.

Still another object of the invention is to provide a feed system for a copying apparatus employing an endless loop arrangement and a gating mechanism for directing the moving original either to the endless loop or to a discharge means in the machine.

Other objects and features of the present invention will become apparent to those skilled in the art from the following specific description of the attached sheets of drawings which illustrate a preferred embodiment of the invention.

IN THE DRAWINGS

FIGURE 1 is a cross-sectional view, partly in elevation, of a copying apparatus embodying the principles of the present invention; and

FIGURE 2 is an end view in elevation of the assembly of FIGURE 1.

AS SHOWN IN THE DRAWINGS

In FIGURE 1, reference numeral **10** indicate generally a housing for the copying apparatus of the present invention, the housing being supported on a plurality of legs **11**. As seen in FIGURE 1, the housing **10** has formed therein an inlet **12** for receiving sheet material which is to be reproduced. The sheet is deposited in the inlet **12** and then passes into the nip between a pair of driven rollers **13** and **14** which provide part of the motive power for transporting the sheet through an endless loop arrangement through which the sheet travels. Specifically, the driven rollers **13** and **14** pass the sheet between a pair of opposed, arcuately shaped guide ways **16** and **17** in spaced relation. The original then passes between the surface of a roller **18** and a conveyor belt **19** which extends between a pair of driven rolls **21** and **22**. Tension is supplied to the belt **19** by providing a tensioning roller **23** between the rolls **21** and **22**.

The original while disposed on the belt **19** passes by a slot **24** located in the housing **26** in which there is positioned a pair of illuminating bulbs **27** and **28**. Next, the sheet is delivered by the action of the belt **19** and a roller **29** past a gating mechanism generally identified at reference numeral **31** in the drawings. The gating mechanism **31** includes a pair of spaced guide ways **32** and **33** which can be selectively oriented to deliver the sheet either to a pair of arcuately shaped guide ways **34** and **36** constituting part of the endless loop, or to a discharge station **37** in which there is mounted a roller **38** supported on a resilient arm **39** and which functions to deliver the sheet through the discharge opening **37**.

In the event that multiple copies from the same original are desired, the gating mechanism **31** is disposed in the angular relationship illustrated in FIGURE 1, in which case the original passes between the guide ways **34** and **36** and then to the nip existing between a pair of driven rollers **41** and **42**. The sheet is then delivered between a pair of spaced guides **43** and **44** whereupon it then passes into the nip between the rolls **13** and **14** for another circuit through the endless loop.

Most copying apparatus presently in use involves separate sheets of copy paper and a manual or feeding mechanism for delivering individual sheets from a stack to an exposure station. The new assembly, on the other hand, employs a large roll **46** of photoconductive paper mounted on an arbor **47**. The paper may be, for example, coated with a photocnductive material such as zinc xide. A web **48** of the photoconductive paper is withdrawn from the roll **46** at a substantial constant lineal velocity by the action of a pair of driven rollers **49** and **51**, driven through a solenoid operated clutch **52** and a chain drive **53** illustrated in FIGURE 2. In order to apply a reasonable tension on the web **48** during playing out of the web, the arbor **47** may be provided with a slipping clutch assembly (not shown) so that the web **48** is drawn off at a constant velocity, regardless of the amount of paper wound about the arbor **47**.

The driving connection to the driven rolls **49** and **51** (by energization of the solenoid operated clutch **52**) is under the control of a feeler switch **55** which is arranged

to engage the leading edge of the original as it proceeds along the endless loop. Once the clutch **52** is energized, the constant speed rollers **49** and **51** deliver the continuous web **48** through a cutting mechanism including a reciprocable knife **56** which acts against a stationary cutting bar **57**. The knife **56** is also solenoid actuated, and its solenoid (not shown) is energized by operation of feeler arms **54** and **58**. With this arrangement, the size of the sheet which is severed from the web **48** by the cutting knife **56** corresponds exactly to the size of the sheet which is sensed by the feeler arms **54** and **58**.

Arm **54** constitutes a normally closed switch and arm **58** a normally open switch contact, the two switches being in series in the line energizing the solenoid operating the knife **56**. The original first contacts arm **54**, opening that switch. Then, the original engages arm **58** to close that switch, but since the switch controlled by arm **54** is now open, the circuit is still open to the solenoid. However, as the original advances its trailing edge beyond arm **54**, that switch closes and since the switch controlled by arm **58** is still closed, the circuit to the solenoid is completed, and the knife **56** operates. At the same time, the clutch solenoid **52** is deenergized terminating the feeding of the web. Finally, when the trailing edge of the original passes arm **58**, the circuit to the knife is broken, and the knife is ready for the next cycle.

The severed copy sheet then passes between a pair of driven rollers **59** and **61** and into charging unit shown generally at **62** where it is provided with a uniform electrostatic charge which conditions the photoconductive sheet for exposure to a photographic image. Although various charging devices could be employed, the exemplary charging unit **62** contains plural pairs of corona wires **63** and **64** which are maintained at a relative potential with respect to one another in order to provide a charging field for the photoconductive surface. Typically, the wires **63** and **64** are at a potential sufficiently high to provide a surface charge on the photoconductive surface of the sheet in excess of about 150 volts.

The charge sheet is then ready for an exposure station which is generally indicated at reference numeral **66** in the drawings. Specifically, the exposure station **66** includes endless belts **67** extending between a pair of rollers **68** and **69** and tensioned by providing tensioning rollers **71** intermediate the two driven rollers. The charged copy paper is delivered into the exposure station by the belts **67** and a cooperating roller **73**. In the exposure station **66**, the charged sheet passes between a glass plate **74** and a rigid backing **76** over which the belts **67** run.

The position of the charged sheet in the exposure station is at the focal plane of a reflex projection system. Scanning of the original is accomplished by moving the original past the slot **24** where it is illuminated by the illuminating bulbs **27** and **28**. The image is thereupon reflected by means of a tiltable mirror **78** through a lens **79** disposed in a light-tight housing **81** so adjusted that a perfectly focused image will be projected onto the charged sheet in the exposure station.

When the assembly is properly synchronized, the leading edge of the original will be at the leading edge of the slot **24** just as the leading edge of the copy paper arrives in the exposure station. A latent electrostatic image is thus produced in the photoconductive surface which represents a charge pattern corresponding to the material to be reproduced as scanned through the optical lens system. The exposed copy is then delivered by the belt **67** and a roller **83** to a developing station where the latent image is rendered visible by an appropriate developing technique. It will be appreciated that other forms of development could be employed such as a dry developer consisting of carrier particles and toner applied by means of cascade development or by brushing contact with a so-called magnetic brush. According to the present invention a liquid developer is employed wherein exposed copy paper is treated with a suspension of resin toner particles having triboelectric properties in a carrier liquid, such as a liquid hydrocarbon. To this end, the exposed copy paper is delivered onto a trough or tray **86** having a dispersion **87** of toner particles in the carrier liquid. The copy paper in following the contour of the tray **86** comes into contact with the toner suspension and the toner particles affix themselves to the sheet in the form and disposition of the latent image, thereby rendering the image visible. In order to permanently affix the developed image on the copy sheet the toner treated sheet passes between a polished hard roller **89** and a rubber covered roller **88** where the pressure is sufficient to fix the particles to the sheet. A pair of synthetic rubber wipers or squeegees **91** and **92** engage the peripheries of the rollers **88** and **89** to wipe off excess liquid. The sheet, with the image permanently fixed thereto, is then received on a conveyor belt **93** extending between a pair of rollers **94** and **96** which deliver the completed copy sheet to an outlet generally identified at reference numeral **97** in the drawings. A wire form guide **95** is positioned above the belt **93** to guide the copy onto the belt **93** without marring its surface.

To vent any vaporized liquid and to provide for air circulation for the assembly, the casing **10** may be provided with louvers **98** as indicated in FIGURE 2.

The toner suspension, containing the resin particles dispersed in a suitable liquid carrier, is constantly circulated by means of a pump **99** driven by a motor **101**. The bulk of the toner suspension is stored in a tank **102** from which it is pumped by the pump **99** into the tray **86** through a line **103**. The suspension is constantly being drained from the tray **86** by means of a return line **104**, leaving a predetermined amount of suspension in the tray at all times. A concentrate of the toner particles in the carrier liquid is contained in a toner concentrate tank **106** located above the toner storage tank **102**. Communication between the two tanks is provided by means of a valve **107** which is normally biased into its closed position by means of a spring **108**. The valve element **107** is located on a rod which has a headed portion **109**. Opening of the valve **107** is controlled by a rod **111** having an operating button **112** extending beyond the housing **10**. The rod **111** extends between a pair of brackets **113** and **114**, and spring **115** normally biases the rod **111** into a position in which the valve **107** is closed. Movement of the rod **111** against the action of the spring **115** opens the valve **107** by the operation of a bell crank lever **116** having one end operated by the rod **111**, and the other end connected to the headed end portion **109** of the valve stem.

From the foregoing it will be seen that the copying apparatus of the present invention provides a compact but highly efficient device for securing multiple copies of originals. The machine is simple to operate even by inexperienced personnel since it is completely automatic.

It should be evident that various modifications can be made to the described embodiments without departing from the scope of the present invention.

I claim as my invention:

1. In a copying apparatus, means defining an endless loop of generally elongated shape along which a sheet to be copied is adapted to be fed, said endless loop defining means including opposed, substantially parallel, spaced, fixed sheet guide means between which at least a portion of said loop is defined, roller means arranged to engage a sheet in said loop and feed said sheet along said loop, inlet means for invariably delivering a sheet to be copied into said loop, and means, associated with said loop, adjustable to at least two positions, said sheet following a path along the loop if the adjutable means is in one of said positions and following a path discharging it from the loops at a discharge station if the adjustable means is in the other of said positions, said adjustable means being effective in at least one of its positions to deflect the sheet to follow the corresponding path, said adjustable means being adjacent said discharge station,

means defining a feed path for copy paper onto which said sheet is to be copied, said feed path being completely independent of said endless loop, and means for imaging on said copy paper at least a portion of said sheet in said endless loop, said imaging means including illuminating means outside said loop.

2. The combination according to claim 1, wherein said roller means comprises at least one pair of cooperating feed rollers between which and with respect to which said sheet is fed along said endless loop.

3. The combination according to claim 1, wherein said adjustable means forms a part of said endless loop.

4. A copying apparatus comprising: means defining an endless loop; means for moving a sheet to be copied in said endless loop; means, associated with said loop, adjustable to at least two positions, said sheet following a path along the loop if the adjustable means is in one of said positions and following a path discharging it from the loop if the adjustable means is in the other of said positions, said adjustable means being effective in at least one of its positions to deflect the sheet to follow the corresponding path; means outside said loop for light scanning said sheet during a portion of its travel in said loop; a roll of photoconductive copy paper; means synchronizing withdrawal of a web of copy paper from said roll with movement of said sheet in said loop; means for applying an electrostatic charge to said copy paper; severing means responsive to movement of said sheet in said loop to sever a length of copy paper from the web; an exposure station receiving the charged copy paper; a reflex projection system arranged to apply an image from said sheet to the charged copy paper in said exposure station during a portion of the travel of said sheet in said loop; means for developing the image on said copy paper; the path of movement of said copy paper being completely independent of said endless loop; said endless loop defining means including opposed, substantially parallel, spaced, fixed sheet guide means between which at least a portion of said loop is defined.

5. The combination according to claim 4, wherein said sheet moving means comprises roller means arranged to engage a sheet in said loop and feed said sheet along said loop.

6. The combination according to claim 5, wherein said adjustable means forms a part of said loop.

7. The combination according to claim 1, wherein said imaging means further includes a reflex projection system including at least one mirror means.

8. The combination according to claim 1, wherein said imaging means further includes a reflex projection system including at least one lens means.

9. The combination according to claim 1, wherein said imaging means further includes a reflex projection system including at least one mirror means and one lens means.

10. The combination according to claim 1, wherein said adjustable means is effective in the other of its positions to deflect the sheet to follow the path corresponding to said other position.

11. The combination according to claim 1: said copy paper comprising a roll of photoconductive copy paper; drive means for paying out a continuous web of copy paper from said roll; a first switch means actuated by said sheet during its travel in said loop to initiate operation of said drive means; a charging unit arranged to place an electrostatic charge on said web; a second switch means actuated by said sheet in its travel in said loop; a cutting means controlled by said second switch means and arranged to sever a length of copy paper from said web; an exposure station receiving the severed copy paper; said illuminating means being arranged to scan said sheet during a portion of its travel along said endless loop; said imaging means comprising, in addition to said illuminating means, a reflex projection system arranged to transmit an image from said sheet during its illumination; said projection system having a focal plane coinciding with the charge surface of said copy in said exposure station; and means for developing the resulting image on said copy paper.

12. The combination according to claim 1: said copy paper comprising a roll of photoconductive copy paper; drive means for paying out a continuous web of copy paper from said roll; cutting means arrange to cut a length of copy paper from said web; switch means actuated by movement of a sheet in said endless loop and connected to said cutting means to operate the same; charging means arranged to place an electrostatic charge on the copy paper; an exposure station receiving the charged web of copy paper; said illuminating means being arranged to illuminate said sheet during its travel along said endless loop; said imaging means comprising, in addition to said illuminating means, a reflex projection system arranged to transmit the image of the illuminated sheet to said exposure station; and developing means for developing the image thus produced on the copy paper.

13. The combination according to claim 12: wherein said developing means includes a tray containing toner particles in suspension in a liquid, into which the exposed paper is inserted; and a pair of pressure rolls which receive the developed paper from said tray.

14. The combination according to claim 1: said copy paper comprising a roll of photoconductive copy paper; means synchronizing withdrawal of a web of copy paper from said roll with movement of said sheet in said loop; means for applying an electrostatic charge to said copy paper; severing means responsive to movement of said sheet in said loop to sever a length of copy paper from the web; an exposure station receiving the charged copy paper; said illuminating means being effective to light scan said sheet during a portion of its travel in said loop; said imaging means including, in addition to said illuminating means, a reflex projection system arranged to apply an image from said sheet to the charged copy paper in said exposure station during a portion of the travel of said sheet in said loop; and means for developing the image on said copy paper.

15. An electrophotographic machine comprising a main housing having an upper front entry opening receptive of a document to be coupled, a document exit opening adjacent to and below said entry opening, means defining a document path from said entry opening to said exit opening and including document transporting means and a document scanning aperture, exposure lamp means and lamp housing means mounted in the main housing adjacently below said exit opening and trained toward said scanning aperture, a reflecting mirror below said lamp housing means and lamp means and scanning each document traversing said scanning aperture, a projection tunnel having projection optics therein and leading from said mirror generally upwardly and rearwardly and terminating in an exposure aperture, a copy paper supply means in the top of said housing, a paper charging corona discharge device between said supply means and said exposure aperture, means operative to feed paper from the supply means through the corona discharge device and then through said exposure aperture, a liquid toner receptacle below said exposure aperture receptive of the exposed paper after it leaves the exposure aperture, squeeze rollers engageable with the developed copy paper on leaving the liquid toner receptacle, a copy receptacle accessible from the front of the main housing and located below said mirror, and means providing a copy discharge path beneath said projection tunnel leading to said copy receptacle in a forward and downward direction relative to said squeeze rollers and including overlying means for limiting upward movement of a sheet entering said discharge path and guiding said sheet onto the base of said path.

16. The combination according to claim 15, wherein said projection tunnel includes a bottom wall for preventing light from said tunnel from striking a sheet in said

discharge path, and wherein said guiding and limiting means is effective to prevent said sheet from coming into marring contact with at least portions of said bottom wall of said projection tunnel.

17. The combination according to claim **16**, wherein said means providing a copy discharge path includes conveyor means for conveying a sheet to said copy receptacle.

18. The combination according to claim **17**, wherein said conveyor means comprises a belt.

19. The combination according to claim **16**, wherein said guiding and limiting means comprises a wire form guide.

20. An electrophotographic machine comprising a housing having an upper front entry opening receptive of a document to be copied, a document exit opening immediately below said entry opening, means defining a document path from said entry opening to said exit opening and including document transporting means and a document scanning aperture, an exposure lamp and reflector mounted in the housing adjacently below said exit opening and trained toward said scanning aperture, a reflecting mirror below said reflector and lamp and scanning each document traversing said scanning aperture, a projection tunnel having projection optics therein and leading from said mirror generally upwardly and rearwardly and terminating in an exposure aperture, a copy paper supply magazine in the top of said housing, a paper charging corona discharge device between said magazine and said exposure aperture, means operative to feed paper from the magazine through the corona discharge device and then through said exposure aperture, a liquid toner receptacle below said exposure aperture receptive of the exposed paper after it leaves the exposure aperture, squeeze rollers engageable with the developed copy paper on leaving the bath, a copy receptacle accessible from the front of the housing and located below said mirror, and means defining a copy discharge path leading downwardly and forwardly from said squeeze rollers to said copy receptacle, said path defining means including means providing a downwardly and forwardly inclined base surface and further including overlying downwardly facing shield means along the bottom of the light tunnel defining the upper side of said discharge path.

21. A machine as defined in claim **20**, in which said shield means include longitudinal downwardly projecting spacer means.

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JOHN M. HORAN, Primary Examiner

U.S. Cl. X.R.

355—14, 51, 102, 109

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(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,484,164 Dated December 16, 1969

Inventor(s) H. L. Byland

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In column 2, line 55, "photocnductive" should read --photoconductive--.

In column 2, line 55, "xide" should read --oxide--.

In column 6, line 43, "coupled" should read --copied--.

SIGNED AND
SEALED
JUL 21 1970

SEAL
Attest:

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Attesting Officer

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Commissioner of Patents