United States Patent

Banks et al.

[15] **3,690,760**

[45] **Sept. 12, 1972**

[54] ELECTROSTATIC PRINTING SYSTEM

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[22] Filed: **April 5, 1971**

[21] Appl. No.: **131,311**

[52] **U.S. Cl.** **355/16**, 355/14

[51] **Int. Cl.** **G03g 15/00**

[58] **Field of Search** 355/3, 14, 16, 17

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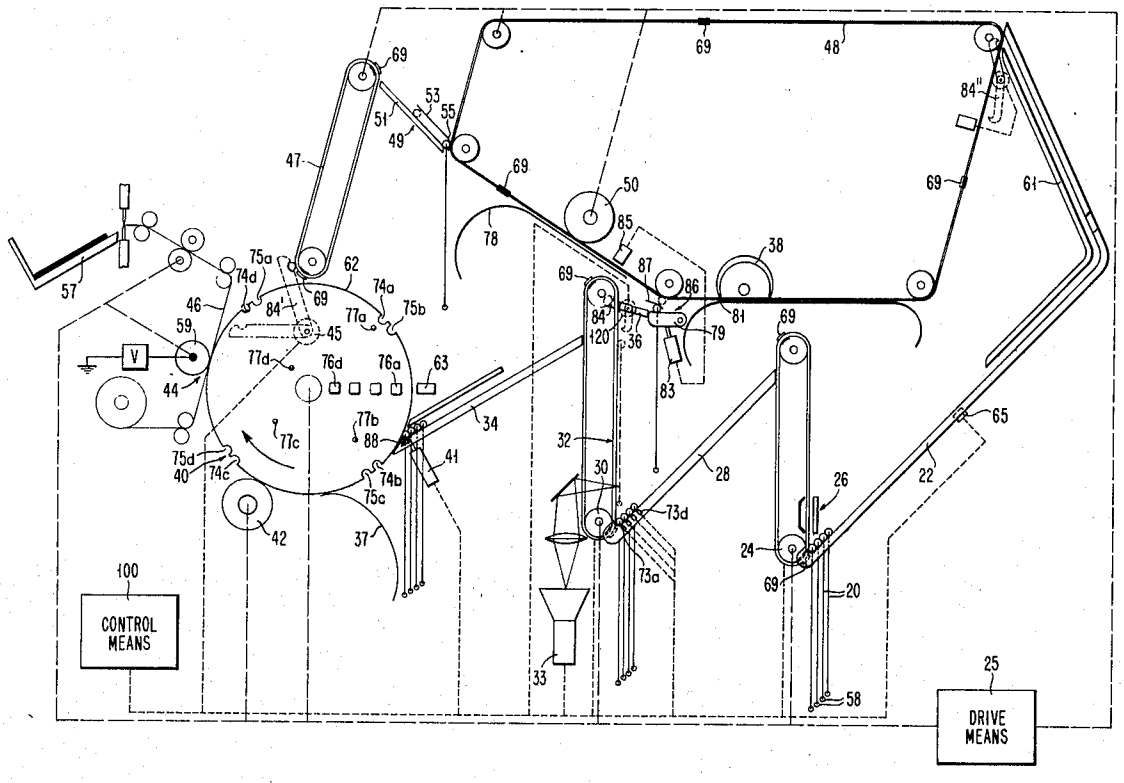
[57] **ABSTRACT**

An electrostatic printing apparatus wherein photoconductive elements are individually movable through process stations for charging, exposing and developing an electrostatic image, and wherein the photoconductive element is fed through a process buffer means between each of the stations so that asynchronous operation results. A plurality of the photoconductive elements with the electrostatic image are cycled a predetermined number of times through the development and transfer stations at a higher rate so that multiple copies can be printed from a single image deposition for each of the photoconductive elements without slowing the operation of the other parts of the system.

18 Claims, 12 Drawing Figures



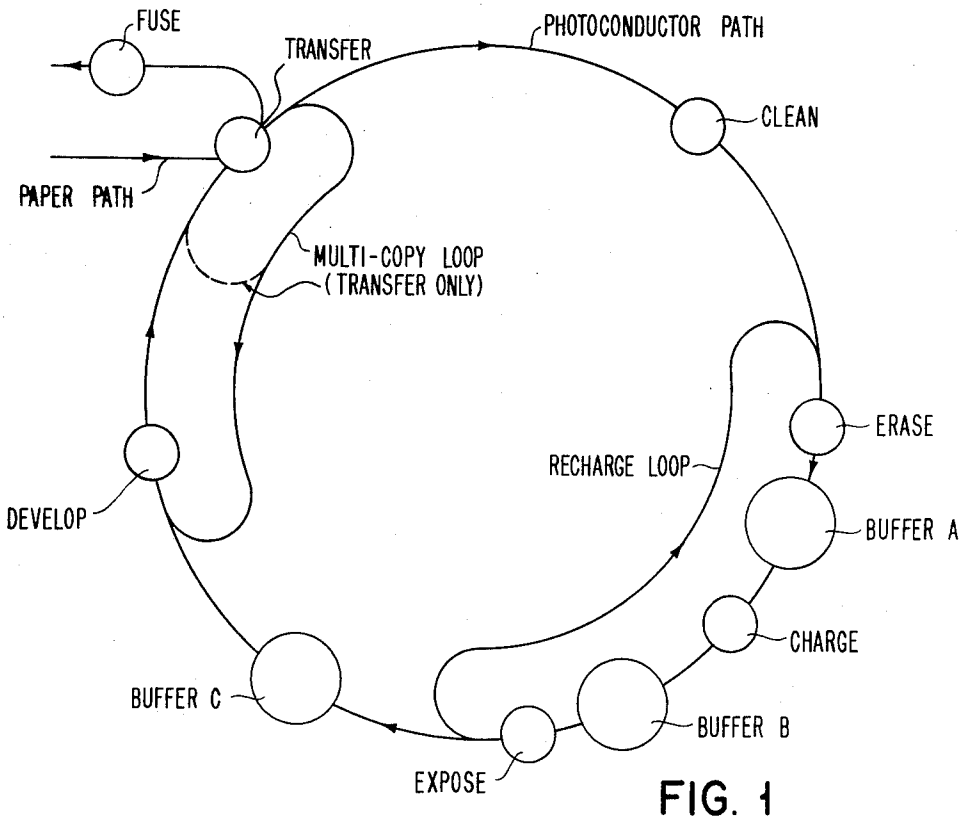


FIG. 1

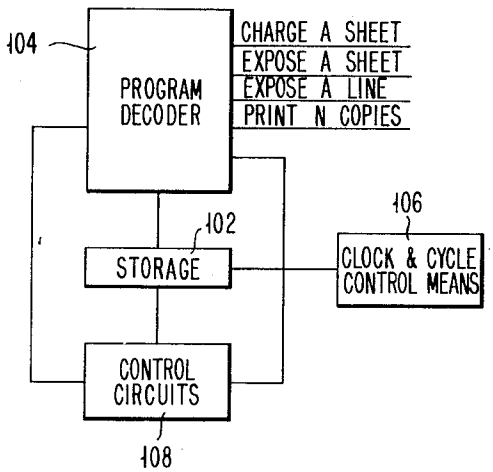


FIG. 3

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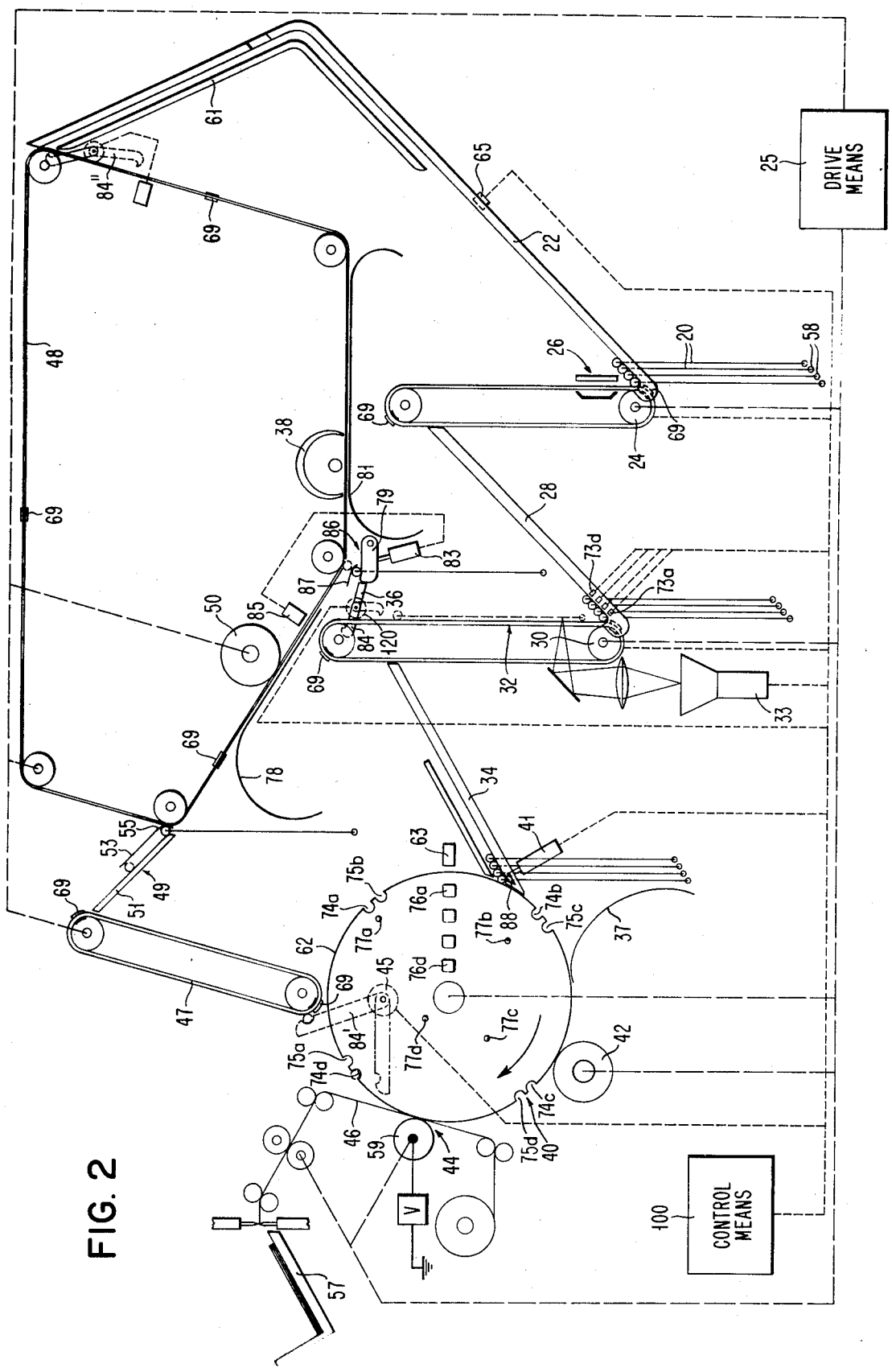

FIG. 2

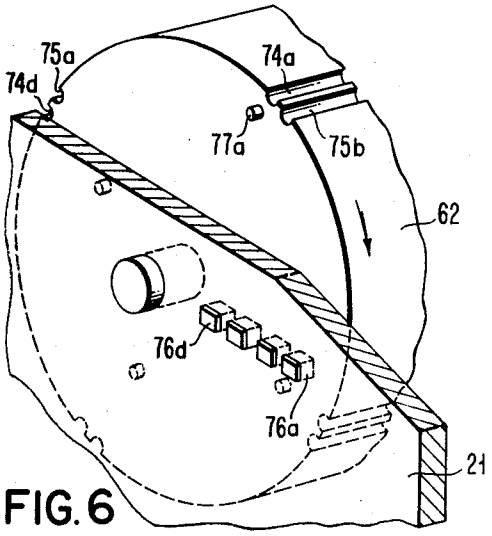

FIG. 6

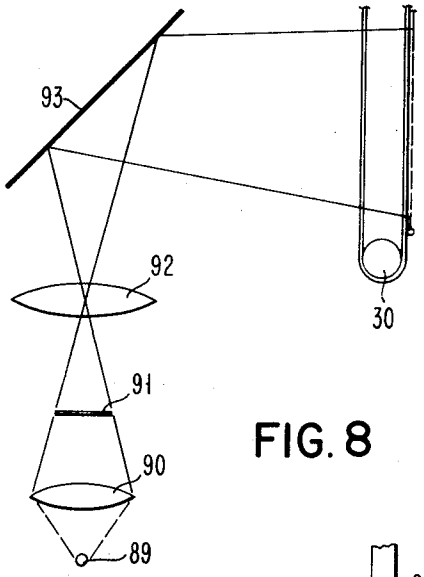

FIG. 8

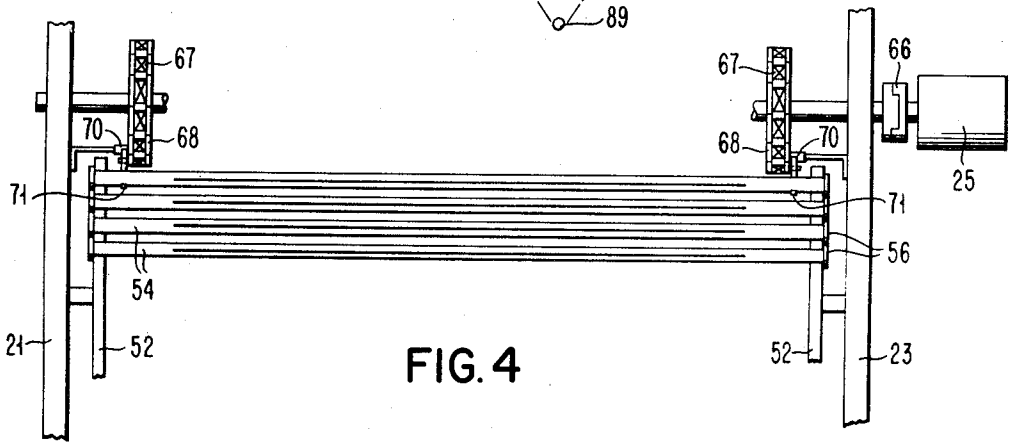

FIG. 4

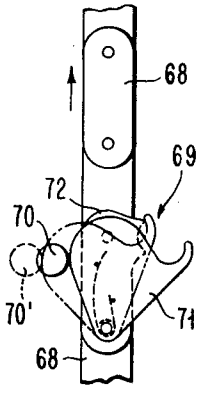

FIG. 5

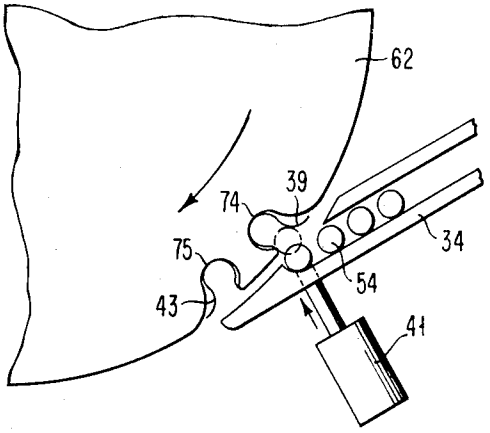

FIG. 7

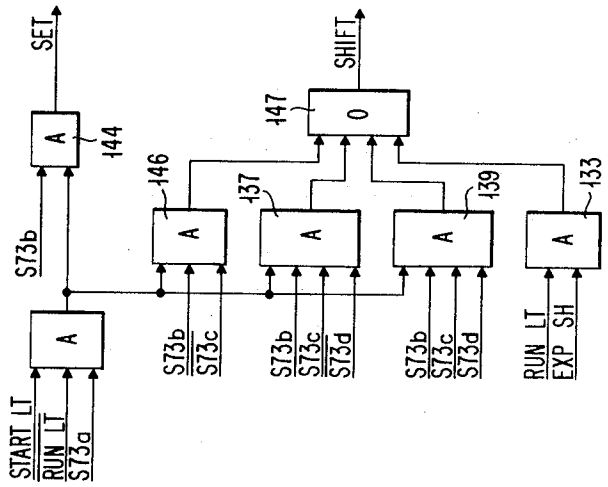
SET
SHIFT
144
146
137
147
139
133
A
0
S73b
START LT
RUN LT
S73a
S73c
S73d
RUN LT
EXP SH

FIG. 10

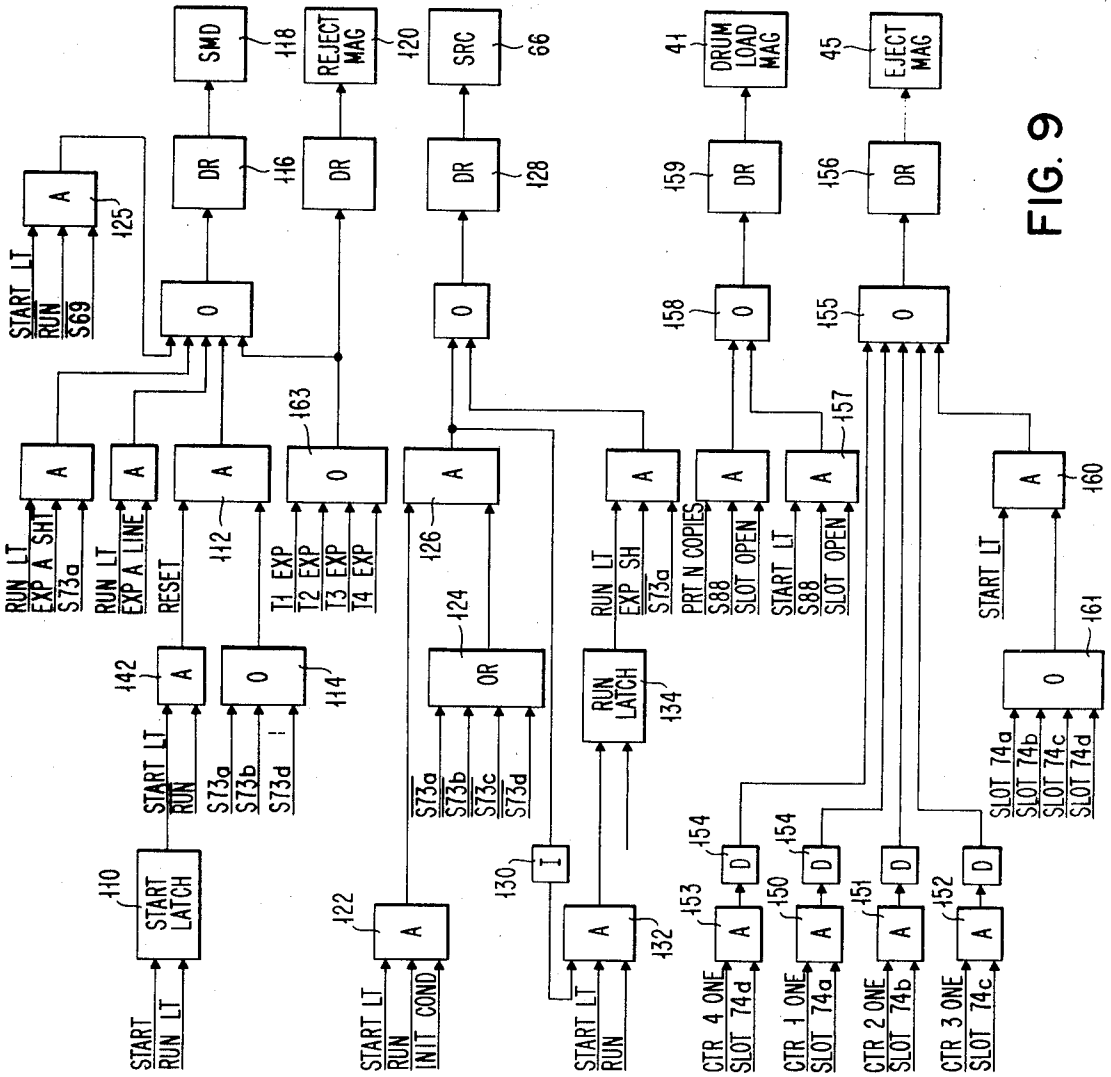
SMD
118
REJECT MAG
120
SRC
66
41
DRUM LOAD MAG
45
EJECT MAG
DR
116
128
159
156
125
START LT
RUN
S69
0
158
155
163
A
112
126
124
OR
RUN LATCH
134
130
I
122
110
START LATCH
142
114
RUN LT
EXP A SHT
S73a
EXP A LINE
RESET
T1 EXP
T2 EXP
T3 EXP
T4 EXP
PRT N COPIES
S88
SLOT OPEN
157
160
161
SLOT 74a
SLOT 74b
SLOT 74c
SLOT 74d
154
153
150
151
152
D
CTR 4 ONE
CTR 1 ONE
CTR 2 ONE
CTR 3 ONE
START
INIT COND

FIG. 9

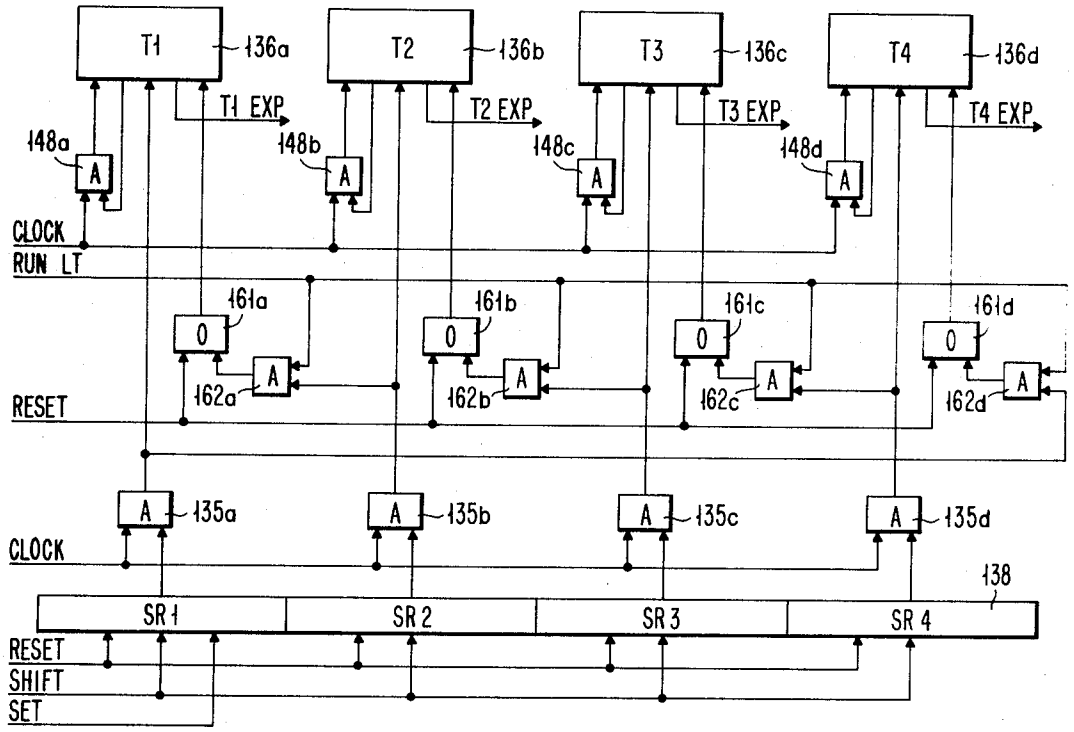
T1
136a
T2
136b
T3
136c
T4
136d
T1 EXP
T2 EXP
T3 EXP
T4 EXP
148a
148b
148c
148d
A
CLOCK
RUN LT
161a
161b
161c
161d
O
162a
162b
162c
162d
RESET
135a
135b
135c
135d
138
SR 1
SR 2
SR 3
SR 4
RESET
SHIFT
SET

FIG. 11

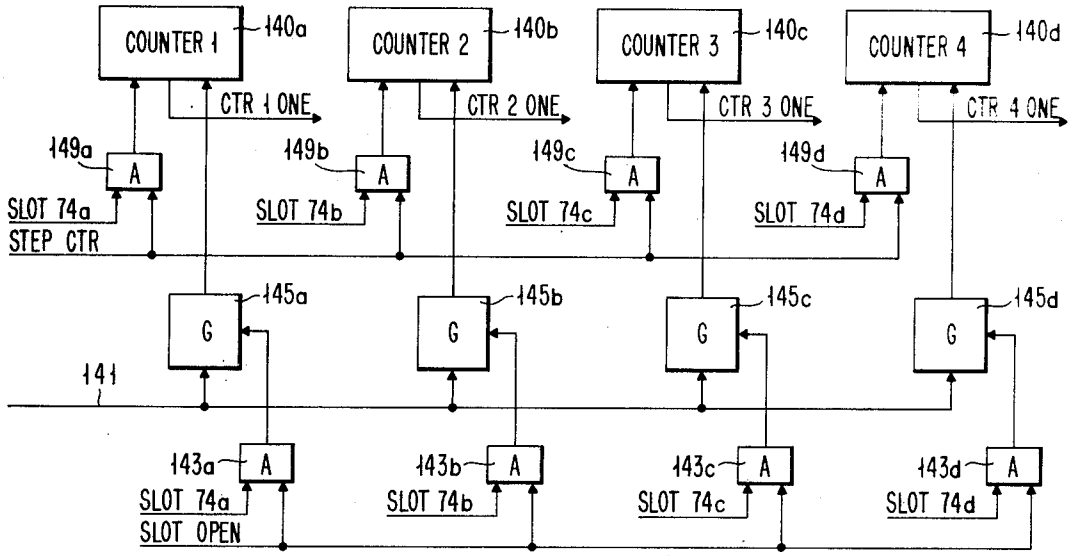
COUNTER 1
140a
COUNTER 2
140b
COUNTER 3
140c
COUNTER 4
140d
CTR 1 ONE
CTR 2 ONE
CTR 3 ONE
CTR 4 ONE
149a
149b
149c
149d
A
SLOT 74a
STEP CTR
SLOT 74b
SLOT 74c
SLOT 74d
G
145a
145b
145c
145d
141
143a
143b
143c
143d
SLOT 74a
SLOT OPEN
SLOT 74b
SLOT 74c
SLOT 74d

FIG. 12

ELECTROSTATIC PRINTING SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to electrostatic printing apparatus and more particularly to apparatus for asynchronously moving a photoconductive element through processing stations so that multiple copies can be printed from a single image deposition.

Prior art printing and copying apparatus normally uses continuous photoconductors in the form of drums or belts with the processing stations spaced along the surfaces of the photoconductors. The process by nature is continuous and synchronous and this operation produces one copy per cycle. Due to the synchronous operation, this apparatus does not permit individual process speeds within the total process to be tailored for optimum operation. In addition, the photoconductor has a limited life due to the continuous cycle of charging and cleaning the photoconductive surface. It is therefore the major object of this invention to provide apparatus which utilizes individually movable photoconductive elements in its operation.

It is another object of this invention to provide apparatus in which the station-to-station operation is asynchronous so that individual process stations can be tailored for optimum operation.

SUMMARY OF THE INVENTION

Briefly, according to the invention, there is provided electrostatic printing apparatus which utilizes individually movable photoconductive elements which are moved through the process stations on an asynchronous basis to charge, expose and develop an electrostatic image on the photosensitive member with each of these operations being separated by process buffer means wherein the photosensitive member can be temporarily stored. A plurality of the photosensitive members with the electrostatic image can be processed multiple cycles at a higher speed through the developing and transfer stations to provide multiple copies of the image without slowing the throughput of the system.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic view showing the possible paths of the photosensitive element through the printing apparatus;

FIG. 2 is a side diagrammatic view of the printing apparatus comprising the invention;

FIG. 3 is a schematic block diagram of control means **100** of the machine of FIG. 2;

FIG. 4 is a view showing the apparatus for pickup of the photosensitive element from one of the process buffer means;

FIG. 5 is a view showing in greater detail the means for moving the photosensitive elements along the transport path; and

FIG. 6 is a perspective view of drum member **62** showing the mounting of control members;

FIG. 7 is an enlarged view of the means for loading and retaining a sheet on drum member **62**;

FIG. 8 is an alternate embodiment for the exposure station utilizing flash exposure;

FIG. 9 is a schematic block diagram of the controls circuits for the printing apparatus;

FIG. 10 is a schematic block diagram of the control circuits for shift register **138**;

FIG. 11 is a schematic block diagram of the control circuits for timing means **136**;

FIG. 12 is a schematic block diagram of the control circuits for counting means **140**.

DETAILED DESCRIPTION OF THE EMBODIMENT

The electrostatic printing apparatus comprising the invention utilizes individually movable photosensitive elements. The movement of the sheets through the machine is controlled by a plurality of electromagnetic control means which are selectively energizable to select the proper mechanical device to perform the programmed printing function in the machine. A control means is provided to develop electrical signals to selectively actuate the electromagnetic control means according to both programmed functions and control signals from the mechanical devices.

Referring to FIG. 1 of the drawings, the printer comprises supply buffer A which holds a sufficient supply of sheets. Upon demand, a sheet or sheets are withdrawn and passed through a sensitizing station, CHARGE, at a relatively constant velocity to produce a uniform charge on the sheet, then to a holding station at buffer B. Subsequently a charged sheet is brought to the EXPOSE station for exposure to selectively discharge areas of the sheet to form a latent electrostatic image on the sheet of the image to be printed. The exposure operation may be either continuous or incremented as the application requires. Once through the EXPOSE station, the sheet with the latent image proceeds either to a holding station at buffer C, or is recycled back along the recharge loop to supply buffer A if required for any reason. From buffer C the exposed photoconductor proceeds to the DEVELOP and TRANSFER stations. Here the latent image is developed and transferred to a copy sheet after which the image is permanently fixed to the sheet at the FUSE station. At this point multiple copies can be made by recycling the exposed photoconductor back through the DEVELOP-TRANSFER station as many times as there are copies required. The process speed at this station may be faster than that at the previous or subsequent stations. Once the desired number of copies are produced, the photoconductive sheet is transferred through the CLEAN and ERASE stations back to the supply buffer A for subsequent reuse.

A plurality of electrical signals is generated in the machine and sent to control means **100** to permit the electrical control signals to be synchronized with the mechanical movement of the sheets through the machine. Control means **100** may comprise any suitable device for supplying control signals to perform the desired functions in accordance with the desired printing functions and the output from the sensing means located throughout the processing stations of the machine. Control means **100** may comprise the processor of an electronic data processing system if desired. The printer may also be operated as a stand-alone unit, in which case the machine would have its own control circuitry built in to cycle the machine through the desired steps to perform the processing function of the machine.

Referring to the embodiment of the invention shown in the drawings, the electrostatic printing apparatus utilizes individually movable photosensitive element **20**, a plurality of which are mounted in a supply process buffer means **22**. The process buffer means **22** and other components of the printer are mounted on suitable support means **21**, **23** at either side to provide a relatively open central area to facilitate the unimpeded movement of photosensitive elements **20** through the process stations of the printer. A selectively operable transport means **24** is utilized for moving the photosensitive element **20** from the supply buffer through a charging station **26** to place a uniform charge on the photosensitive member as it moves through the charging station to a second process buffer means **28**. Transport means **24** as well as other transport means in the system is provided motive power from a drive means **25** such as a motor, For example, through suitable belts or gears (shown by dashed lines in the drawings). A second selectively actuable transport means **30** is provided to move the photosensitive element through an exposure station **32** to expose the photosensitive element to a light image to produce a latent electrostatic image on the photosensitive element **20**. Transport means **30** is disposed to deposit photosensitive element **20** in a third process buffer means **34** preparatory to developing the electrostatic image. In the event that the photosensitive element is not to be used for the production of an image, a reject buffer means **36** is provided to temporarily store the photosensitive element **20** preparatory to moving element **20** through an erase station **38** by return transport means **48** to supply process buffer means **22** for reuse in the printing apparatus. A third transport means **40** is provided to move photosensitive element **20** through a predetermined number of cycles through a developing station **42** and a transfer station **44** to produce the predetermined number of copies. At each of these cycles the electrostatic image is made visible by the deposition of a development material commonly called toner which adheres to the photosensitive element **20** and an electric field is provided at transfer station **44** which facilitates the transfer of the developer material to a printing sheet **46** upon which the finished copy is produced. After the predetermined number of copies have been produced, photosensitive element **20** is moved by an eject transport means **47** for temporary storage in return buffer means **49**. Sheets are positioned for movement by return transport means **48** through a cleaning station **50** where any remaining particles of the developer material is removed. The sheet is then moved through the erase station **38** where any remaining electrostatic charge is discharged, and the sheet is then returned to supply process buffer means **22** for reuse in the printing apparatus.

In the embodiment shown in FIG. **3** the control means **100** for the machine comprises a storage means **102**, a program decoder **104**, clock and cycle control means **106** and control circuitry **108** to develop electrical signals to control electromagnets in the machine to perform the desired function. In the case where the processor of an electronic data processing system is used to control the machine, the first three stated elements of the control means are normally present and the instructions are included as part of the stored program. In the case where the machine is operated as a stand-alone unit, the storage device may comprise any suitable device capable of exhibiting two stable states such as a magnetic core storage system, an array of electronic bistable devices or any other memory device having the operating speed and capability necessary for the described operations. One type of control device suitable for use with the system is the type known as a read only memory. This device is designed for programming in a predetermined manner dependent upon the control manifestations entered into the memory at the start of operations. Cycling means are provided to read out sequential program steps to an external temporary storage device such as a register wherein a bit position of the register is coupled to control a particular electromagnet.

To make the printer ready to process data, a manually actuated start key is depressed to energize the start-up circuits. During start-up all sheets are returned to the supply buffer and all devices which require a specified time for reaching operating condition are made ready for operation. At the end of this time a sufficient number of sheets are charged so that the machine is then ready to run. Further operations of the machine are then controlled by program instructions which specify the operations to be performed on the sheets as they are moved through the process stations of the machine. The basic instructions for controlling the machine are CHARGE A SHEET, EXPOSE A SHEET, EXPOSE A LINE and PRINT N COPIES. In a CHARGE A SHEET instruction, a sheet from the supply buffer is moved past a charging device such as a corona discharge device so that a uniform charge is provided over the surface of the sheet. In an EXPOSE A SHEET instruction, a charged sheet is removed from the charge buffer and moved into position to expose an image on the sheet and the sheet is moved from the expose transport to the develop buffer. In an EXPOSE A LINE instruction, the expose drive is energized to move the sheet in position for having a line exposed. This operation is continued until a sheet is completed, at which time the sheet is ejected to the develop buffer. In a PRINT N COPIES instruction, the sheet is placed on a device which takes the sheets successively past a develop station and a transfer station at which point the developed image is transferred to a copy sheet to which the image is permanently fused as it is moved through a fusing station. The sheet is moved repetitively through these steps for N-cycles and the sheet is then ejected to the return transport. The sheet is then moved through the erase and cleaning stations as the sheet is moved in the return transport back to the supply buffer for further use in the machine.

Photosensitive element **20** may be any suitable device which can be selectively moved through stations of the process. In the embodiment of the invention shown in the drawings, the photosensitive element **20** comprises a flexible sheet of photoconductive material the length and width of which is somewhat greater than the maximum size of the desired output copy image. The element has fixed across one end an elongated support member **54** which extends outward from the edge of the sheet and terminates in enlarged end portions **56**. A support member **58** is fixed to the bottom of the sheet and extends a relatively small distance beyond

the edges of the sheet. Support **58** produces substantial rigidity in the lateral direction and also provides enough mass to the photosensitive sheet so that the sheets hang substantially vertically in the process buffer means.

The process buffer means has a capacity for storing a plurality of photosensitive elements **20**. Any suitable device can be utilized which is operable to store the photosensitive elements and permit the selection of one photosensitive element at a time on demand from the process control circuits. In the embodiment of the invention shown in the drawings, the process buffer means comprises a pair of spaced inclined rail members **52**. Rail members **52** are spaced a distance sufficient for end portions **56** of support member **54** to extend outside the rail members thereby laterally positioning the photosensitive sheet so that the sheet can be moved throughout the process stations without interference from the apparatus comprising the process buffer means or the associated transport means.

To insure that a sufficient quantity of the photosensitive sheets are present in the machine before the start of an operation, a sensing means **65** is provided. In the embodiment shown in the drawings, sensing means **65** comprises a micro switch which is attached to side rail **52** of buffer means **22** so that end portion **56** of photosensitive element **20** contacts the operative portion of the micro switch to generate an electrical signal which denotes to the control circuit that buffer **22** is loaded with a sufficient number of sheets.

Transport means **24** is provided for transporting the photosensitive sheet from supply buffer **22** past the charging station **26**. The embodiment of transport means **24** shown in the drawings comprises a chain and sprocket drive which has suitable placed gripper means for engaging support member **54** of the lowermost sheet in buffer means **22** and moving the sheet past the charging station to buffer means **28**. A charging operation is initiated by an electrical signal CHARGE A SHEET which is coupled to energize a single revolution clutch **66** to transmit power from the device motor to sprocket **67** which is meshed with chain **68**. Two sets of gripper means **69** are mounted at opposite points on chain **68** and these gripper means are operative to engage support means **54** of the sheet. At the start of a cycle of driving motion of clutch **66** one of the gripper means **69** is positioned to pick up a sheet from buffer means **22** and the other gripper means **69** is positioned to discharge a sheet into buffer means **28**. A fixed cam means **70** is provided which cams movable gripper jaw **71** from stationary gripper bar **72** so that gripper jaw **71** extends in the hopper means to engage the sheet (shown as full line position in FIGS. **4** and **5**). As the gripper means moves past the lower end of the buffer, the sheet is engaged by the gripper means to move the sheet in a vertical path past charging station **26** so that uniform charge is produced across the surface of the photosensitive sheet due to the constant velocity drive provided by transport means **24**. A second fixed cam means **70** is provided at the upper end of the transport so that the gripper means releases the charged sheet and gravity moves the sheet into buffer means **28**. When no sheet is in gripper means **69** the movable jaw **71** is spring biased to the dotted position shown in FIG. **5**. Solenoid actuated cam means **70'** are located in the inoperative position shown dotted in FIG. **5** when the solenoid is not energized. When the solenoid is actuated the cam means **70'** is moved to the operative position which is shown in full line in FIG. **5**.

Process buffer means **28** is similar in construction to process buffer means **22**; however, since photosensitive sheets **20** are utilized on demand, the capacity of this buffer is not as great since it is usually necessary to store only a few charged photosensitive elements at a time to meet the demands of the process. A large number of photosensitive materials are known which are suitable for use in constructing sheets **20**. The characteristics of the materials vary widely and the characteristics are subject to trade-offs to obtain the best combination of characteristics for the particular application. One limitation in the characteristics which may be present is a decay with time of the electrostatic charge, the rate of which depends upon the construction of the photosensitive sheet. To provide control over the number of charged sheets and the elapsed time that the sheets have been charged, a sensing means is provided. In the embodiment of the invention shown in the drawing, the sensing means comprises a micro switch **73** mounted on the side of the rails of buffer means **28** adjacent each of the sheets and positioned so that end portion **56** of the sheets will energize the switches to generate an electrical signal which designates to the control circuit that the corresponding sheet is present. To provide control over the time the sheet has been charged, a shift register is provided with a number of stages equal to the number of sensing switches **73** provided. Each time one of switches **73** is actuated the shift register is actuated to shift one position and a timing device is provided for each sheet to determine the time that the sheet has been charged. In the event that the predetermined time elapses before the sheet is exposed, transport means **30** is actuated along with eject means **84** to transport the sheet to reject buffer means **36** for return to the supply buffer **22** for reuse in the printer.

Transport means **30** is provided for moving a charged sheet through the exposure station to produce a light image on the sheet which is operable to selectively discharge the electrostatic charge on the photosensitive element to produce an electrostatic image. In the embodiment of the invention shown in the drawings, transport means **30** comprises a chain and sprocket drive which is selectively controllable to provide either continuous or incremental motion of the photosensitive sheet past the exposure station. This control is provided by a stepping motor drive. The stepping motor drive is operable to produce one increment of motion in response to an electrical signal or to produce continuous drive in response to a continuous series of electrical signals. The type of driving motion past the exposure station is dependent upon the type of exposure desired. The exposure station shown in FIG. **2** comprises a lens coupled cathode ray tube **33**. In this case, it is desired to expose the sheet to successive images of lines of printing coupled from the cathode ray tube **33** so that in this case an incremental drive is utilized. The embodiment of the exposure station shown in FIG. **8** comprises a flash exposure station. In this case, the sheet is moved to the proper exposure position and then stopped. The exposure is made by a

suitable light source **89** such as a flash lamp which is directed through condenser lens **90** to the micro image means **91** such as a microfilm slide for example. The image is projected by projection lens **92** and mirror **93** to the sheet **20** being held at the exposure station. The sheet is removed through the remainder of the exposure station where the sheet is ejected into buffer means **34**.

Transport means **40** is provided to selectively move the sheet from process buffer means **34** through developing station **42** and transfer station **44**. Developing station **42** may comprise any suitable means for rendering the latent image on sheet **20** visible. One suitable developing apparatus is a magnetic brush developer apparatus. A finely divided colored material commonly called toner is intermixed with and deposited on more coarsely divided iron filings. The toner and iron filings are electrostatically charged with respect to each other by triboelectric charging. The iron filings coated with toner are placed in a magnetic field and the filing form streamers extending along the magnetic lines of force constituting a brush-like mass. By rotating the magnet field producing means near the surface of the sheet **20**, the magnetic brush is placed in contact with and drawn across the surface bearing the electrostatic image. As the brush crosses an area of the image surface having an electrostatic charge, the charge on the surface exerts a greater attraction for the toner than the iron filings, thereby retaining a portion of the toner and separating it from the iron filings. As portions of the toner are electrostatically withdrawn from the brush, means are provided for replenishing the toner or for constantly exchanging the used iron filings for fresh filings coated with toner.

The sheet bearing the toned image is moved to the transfer station where suitable transfer apparatus is utilized to transfer the toned image to a copy member. In the embodiment shown, the transfer apparatus comprises a conductive roll **59** which feeds printing sheet **46** adjacent to sheet **20**. A charge is placed on roll **59** by power supply V of sufficient magnitude and of a sign opposite to the charge holding the toned image to sheet **20** so that the toned image is attracted to printing sheet **46**. As is known in the art, the voltage V on roll **59** is chosen to prevent distortion of the electrostatic image pattern on sheet **20** so that multiple copies of the image can be obtained. The image is then fused to printing sheet **46** (by means not shown) and the printed output is fed to output hopper means **57**.

In the embodiment of the invention shown in the drawings, transport means **40** comprises a drum member **62** which is utilized to remove the photosensitive sheet from process buffer means **34** under control of a proper electrical signal from the control circuits. Drum member **62** is provided with a slot **74** to receive the leading edge of photosensitive element **20** and a second slot **75** to receive the trailing edge of element **20**.

In the embodiment shown in FIGS. **2** and **7**, the apparatus for loading a sheet on drum member **62** comprises an electromagnet **41** on each side of the sheet positioned to push support member **54** of the sheet into leading edge slot **74** when electromagnet **41** is energized so that the support member **54** is retained in slot **74** by a spring retainer means **39**. The remainder of the sheet is drawn along by the drum and the trailing edge of the sheet follows guide members **37** which are spaced so that any contact with sheet **20** is in the non-image areas. The trailing edge of the sheet follows the curvature of guide **37** so that the bottom support member **58** is forced into trailing end slot **75** and retained there by spring retainer means **43**.

In the embodiment shown, four sets of slots **74***a–d*, **75***a–d* are provided so that four photosensitive elements **20** can be mounted on drum **62** simultaneously to produce a predetermined number of copies of the image stored upon photosensitive element **20**. A sensing means is provided to determine whether a particular slot is filled as the slot approaches the sheets in buffer means **34**. In the embodiment shown, the sensing means comprises a plurality of microswitches suitably mounted to the support means **21, 23**. Microswitch **63** is mounted to sense the presence of end portions **56** of photosensitive element **20** in a slot **74** of drum member **62**. When an element **20** is not present the switch remains open and an open switch at the sensing time causes an electrical signal SLOT OPEN to be generated. A set of microswitches **76***a–d* is mounted on the support means in a position to be operated by projections **77**. In the embodiment shown, each of projections **77***a–d* is radially positioned on drum **62** aligned with one of the switches **76** so that the designation of the approaching slot can be determined. In this manner, a particular sheet can be identified as being in a particular slot.

One counter is provided for each slot and when it is determined that, for example, sheet Y is in slot A, the number of copies of sheet Y is set in the counter associated with slot A. The count can be maintained in a hardware counter or the count can be maintained by the associated computer when the printer is operated as part of a data processing system. In the embodiment shown, each time the microswitch **76** is energized for a particular slot, the associated counter is decremented by one count. When the count reaches one, a signal is generated which is operable to eject the photosensitive element **20** after the next transfer operation is completed for that slot. Photosensitive element **20** is then picked up by eject transport means **47** which is operative to move the sheet to return buffer means **49**.

The apparatus for ejecting a sheet from drum member **62** comprises eject means **84'** which is actuated by a rotary solenoid **45**. When solenoid **45** is deenergized, eject means **84** is in the lower dotted position (FIG. **2**). When solenoid **45** is energized, eject means is moved from the lower dotted position to the upper dotted position and eject means **84** is returned to its original position when solenoid **45** is deenergized. The energization of solenoid **45** is timed so that eject means **84'** reaches the upper position when a gripper means is in position to receive the sheet.

Eject transport means **47** is similar in construction to the other transport means; however, the speed of transport means **47** is synchronized with the speed of drum **62** so that sheets can be removed from the drum without slowing the overall operation of the printer. The speed of drum **62** is normally greater than the transport speeds up to that point due to the requirement for producing multiple copies. The speed chosen for drum **62** is dependent on the projected number of

copies to be produced, the characteristics of the materials to be used, and the number of sheets that can be mounted on drum **62** at the same time. In a particular application the speed of drum **62** was chosen at three times the average transport rate for the charge and expose transport means so that the average number of multiple copies can be made without appreciably slowing the overall process.

Return transport means **48** is provided to move photosensitive elements **20** from return buffer means **49** and reject buffer means **36** to supply process buffer means **22** for reuse in the system. In the embodiment of the invention shown in the drawings, return transport means comprises a chain and sprocket drive which utilizes a plurality of gripper means **69** spaced on the chain member for picking up sheets from return buffer means **49** and reject buffer means **36**. Return buffer means **49** comprises a pair of rail members **51** spaced to receive sheets **20**. A spring member **53** is mounted over rail member **51** and spaced to permit free movement of the support members **54** to a position at which curved end portion **55** of spring member **53** stops the sheet. The sheet is then in position to be picked up by gripper means **69** on transport means **48**. Cam means **70** is mounted to open gripper means **69** so that a sheet is picked up as end portion **55** is deflected out of the path of the sheet. End portion **55** then retains the next sheet in a position to be picked up by the next gripper means on transport means **48**. The sheets which are picked up from buffer means **49** are moved through cleaning station **50** to remove any remaining developer particles. In the embodiment shown, cleaning station **50** comprises a rotating brush which is operative to remove the developer particles since guide means **78** functions to position the sheet close to the rotating brush. The developer particles removed in the cleaning station are collected for disposal.

To insure that sheets in the buffer means **36** do not interfere with sheets already being returned by transport means **48**, a sensing means is provided to sense whether approaching gripper means already carry a sheet **20**. When an empty gripper approaches, the loading means is actuated to permit one sheet **20** to move to position to be picked up by the approaching gripper means. In the embodiment shown, the sensing means comprises a microswitch means **85** mounted in a position so that the switch is operated by an end portion **56** of the sheet to close one contact and to close a second contact by the presence of the gripper means. Thus, loading means **86** is activated when only the gripper contact is closed to move one sheet **20** to the position to be picked up by the approaching gripper. A cam means is moved into position to open the gripper means to pick up the sheet. In the embodiment of the invention shown in the drawings, loading means **86** comprises a pivoted arm **79** mounted for movement by solenoid **83**. A sheet **20** is retained in position by spring member **87**, and the sheet is moved into position to be picked up by a gripper means. The end portion of arm **79** prevents a second sheet **20** in buffer means **36** from interfering with the pick-up of the sheet. The sheet is transported through erase station **38**, and guide means **81** positions the sheet for movement through the erase station **38**. The erase station may comprise a fluorescent lamp and this lamp is operable to remove any remaining electrostatic charge from the photosensitive sheet prior to the sheet being returned to supply process buffer **22** for reuse in the system. An eject means **84''** and a fixed cam means are utilized to eject the sheets into return guides **61** for return to supply process buffer means **22** for reuse in the system.

The control circuitry **108** comprises a start latch **110** which is energized by the electrical signal produced by depressing the START button of the machine. The start latch is combined in AND circuit **112** with the output of OR circuit **114** to actuate through driver **116** the stepping motor drive **118** to eject previously charged sheets from the charge buffer. This is accomplished by sensing the state of switches which form the inputs to OR circuit **114**. Deflector means **120** is also energized at this time to move the sheets to the reject buffer for return to supply buffer means **22**. AND circuit **125** is utilized to position gripper means **69** in a position to pick up a sheet **20**. When the start latch is on and a sheet is in the pre-develop process buffer means **34**, switch **88** is actuated which conditions AND circuit **157** to actuate drum load magnets **41** through OR circuit **158** and driver **159** to place the sheet in the first open slot on drum member **62**. The sheet is then ejected from drum member **62** by the signal generated by AND circuit **160** and OR circuit **161**. The sheets are then returned to the supply buffer means **22**. When the sheets have been returned to the supply buffer means **22**, the RUN signal is generated. When the initial conditions which relate to placing the components in a status ready for operation, AND circuit **122** is actuated. The output of AND circuit **122** and OR circuit **124** provide the inputs to AND circuit **126** to actuate, through driver **128**, the single revolution clutch **66** to energize the drive to charge a sheet. When all of the sheets are charged as sensed by OR circuit **124**, AND circuit **126** is deconditioned and this output through inverter **130** conditions AND circuit **132** to turn on RUN latch **134**. The machine then has a supply of charged sheets and is ready to execute instructions to produce a specified image.

The production of quality images is influenced by the uniformity and the level of the charge existing on the sheet **20** at the time of exposure to the image to be produced. The characteristics of the materials comprising sheets **20** are such that charge is dissipated over a period of time. For this reason it is desirable to sense the time which has elapsed since a particular sheet was charged. This is accomplished by providing a timing means **136** for each of the sheets in the charge buffer. In the embodiment shown in the drawings a supply of four charged sheets is maintained at charge buffer **28**. In this case timing means **136*a–d*** are provided to account for the time which has elapsed since the sheet was charged. The means for sensing the time comprises a shift register **138** which has a number of stages equal to the number of sheets to be charged which in the embodiment shown is four. When the first sheet is charged a 1-bit is set into the first stage of the shift register by the SET signal which is generated by AND circuit **144**. A clock pulse generator is provided to step timing means **136** and the timing means **136*a*** is started when the first sheet is charged. In the event that the sheet is not exposed prior to the expiration of the predetermined time set for timing means **136–*a***, the sheet is

ejected from the charge buffer since the charge may have deteriorated to the point that images of the desired quality can no longer be produced from that level of charge on sheet **20**. When the second sheet is charged, a SHIFT signal is coupled to shift register **138** so that the one bit is present in stage **2** of the shift register. The SHIFT signal is generated during start operations by AND circuit **146** and coupled through OR circuit **147**. This shift signal is connected to shift register **138** to shift the one bit by one position. The one bit signal is combined in AND circuit **135***b* with a clock pulse signal to start timing means **136***b* and the same operation is provided by AND circuits **137** and **139** with respect to the third and fourth sheets as the 1-bit in shift register **138** is shifted through the register. Shift register **138** is provided with an end around carry so that a ring is produced; therefore, when the one-bit is shifted from stage **4** the 1-bit is next shifted to the first stage of the shift register. During RUN operations the SHIFT signal is generated by AND circuit **133**.

To execute a PRINT N COPIES instruction, the sheet is placed on a transport means which moves the sheet past develop and transfer stations to produce a copy on a suitable copy receiving means such as plain paper. If one copy is produced per cycle as in conventional systems, then the total throughput of the system would be dependent on the number of copies required. To eliminate this dependence the speed of the printing transport means is faster than the other transport means and in addition the transport means functions to process several sheets at the same time for a printing operation. In the embodiment shown, the drum member **62** has provision for four sheets and the drum speed is three times the speed of the other transport means. The number of copies is included in the instruction and a counter **140** is provided to record the number of copies of each of the sheets on drum member **62**. The sheet **20** is placed on drum member **62** by drum load magnet **41** and this magnet is energized by sensing whether a slot is open as the drum approaches the buffer. When a SLOT OPEN signal is received, the drum load mechanism **41** is actuated. At the same time the signal which designates the number of slot is sensed and a coded signal representing the count is gated to line **141**. The SLOT OPEN signal and the corresponding slot signal condition the corresponding AND circuit **143***a–d* so that the count on line **141** is gated to the corresponding counter **140***a–d* by gate **145***a–d* so that the number of copies can be monitored. Counters **140***a–d* comprise count down counters so that a count signal is provided through AND circuit **149***a–d* each time a slot reaches the monitoring position. When the value in the counter reaches **1**, this designates that the last copy is to be made on the following cycle so that the eject mechanism **45** is actuated at the time when the appropriate slot is opposite the eject transport means **47**. The sheet is then ejected and returned to the supply buffer means for reuse in the machine. In the embodiment shown this control is provided by AND circuits **150–153** which sense counts in counters **140***a–d* respectively. When a counter reaches **1** the corresponding AND circuit is conditioned and a delay **154** is timed to provide a signal through OR circuit **155** and driver **156** to operate eject magnet **45** at the time when the support means of the sheet is opposite eject transport means **47**.

In the embodiment shown the control means for keeping track of the elapsed time since a sheet was charged comprises a shift register **138** which has a number of stages equal to the number of sheets to be charged. In the embodiment shown, four sheets are charged at one time; however, it will be recognized that the number could be different depending upon the process requirements and the characteristics of the materials being used. A timing means **136** is also required for each of the sheets. A clock pulse supplied by control means **106** is utilized to step timing means **136** at any suitable rate to provide a time interval of the required accuracy for the process. Both the shift register **138** and timing means **136** are reset to zero at the start of operations by a RESET signal which is generated from AND circuit **142**. A 1-bit is set into the first stage of shift register **138** concurrently with the first sheet being charged by the output from AND circuit **144**. The output from the first stage is combined with a clock pulse in AND circuit **135A** to produce a signal to start timing means **136A**. The subsequent clock pulse signals timing means **136A** is stepped in response to the output of AND circuit **148A** which senses when timing means **136A** stands at a count other than zero. In the event that the time expires before the sheet is used a TIME EXPIRED signal is operative to actuate through OR circuit **163** the drive means **118** to reject the sheet. In the event that the sheet is used before the expiration of the time the corresponding timing means **136** is reset by means of AND circuits **162***a–d*.

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

What is claimed is:

1. An electrophotographic reproducing apparatus wherein a plurality of resilient recording members are passed through a series of process stations for producing and transferring an image for reproduction on a copy sheet comprising:

a plurality of feeding means and a plurality of processing stations arranged to form a first and a second separate processing path;

a plurality of means selectively actuable at each of said processing stations for controlling said feeding means in moving the recording members through said processing stations;

a plurality of recording member position sensing means;

program means for providing a series of signals indicative of operations to be performed on said recording members in said machine; and

electronic control means operable under coincident control of said signals from said program means and said recording member sensing means to generate signals to selectively actuate certain of said controlling means to move said recording members along the selected processing path to perform the operations specified by said program means on said recording members at the selected ones of said processing stations.

2. The apparatus according to claim **1** wherein said first separate processing path includes a charging sta-

tion and an exposure station and said second separate processing path includes a developing station and a transfer station.

3. The apparatus according to claim 2 wherein said charging and said exposure operations are performed asynchronously at a first speed and said developing and transfer operations are performed continuously at a second speed which is a substantially greater speed than said first speed.

4. The apparatus according to claim 2 wherein said recording members are processed through said first processing path one at a time and said recording members are processed concurrently a predetermined number of operations through said second processing path.

5. An electrophotographic reproducing apparatus wherein a resilient recording member is passed through a series of process stations for producing and transferring an image for reproduction on a copy sheet comprising:

a plurality of feeding means and a plurality of processing stations arranged to form a first and a second separate processing path;

a plurality of means selectively actuable at each of said processing stations for controlling said feeding means in moving the recording members through said processing stations;

a plurality of recording member position sensing means;

program means for providing a series of signals indicative of operations to be performed on said recording members in said machine; and

electronic control means operable under coincident control of said signals from said program means and said recording member sensing means to generate signals to selectively actuate certain of said controlling means to sequentially move a plurality of said recording members along said first processing path to produce a predetermined electrostatic image to be copied on said recording members; and

electronic control means operable under coincident control of said signals from said program means and said recording member sensing means to generate signals to move a plurality of said recording members continuously through said second processing path a plurality of times to produce one copy of said image each time said recording member is moved through said second processing path.

6. The apparatus according to claim 5 additionally comprising signals from said program means for specifying the number of reproductions to be made of the image produced on each of said recording members;

means for recording the number of reproductions produced for each of said recording members moving through said second processing path; and

means for ejecting said recording member from said second processing path when said specified number of reproductions has been produced.

7. The apparatus according to claim 6 additionally comprising means for moving a recording member ejected from said second processing path to said first processing path.

8. The apparatus according to claim 7 additionally comprising means for moving the ejected recording member through a cleaning station and an erase station as said member is moved from said second to said first processing path.

9. An electrophotographic reproducing apparatus wherein a resilient recording member is passed through a series of process stations for producing and transferring an image for reproduction on a copy sheet comprising:

a plurality of temporary storage means each capable of storing a plurality of said recording members;

a first feeding means for moving a recording member from the first of said temporary storage means through a charge station to the second of said temporary storage means to produce a uniform charge on said recording member;

a second feeding means for moving a recording member from said second storage means through an exposure station to the third of said temporary storage means to produce an electrostatic image on said recording member;

a third feeding means for moving a recording member from said third temporary storage means through a developing and a transfer station to produce a reproduction of said image on a copy sheet;

a plurality of recording member position sensing means mounted adjacent to said temporary storage means;

program means for providing a series of signals indicative of operations to be performed on said recording members in said machine; and

electronic control means operable under coincident control of said signals from said program means and said record member position sensing means to generate signals to selectively actuate certain of said feeding means to move said recording members through the selected processing stations to perform the operations specified by said program means.

10. The apparatus according to claim 9 wherein said third feeding means comprises means for simultaneously mounting a plurality of recording members for movement through a continuous processing path.

11. The apparatus according to claim 10 additionally comprising means for separately sensing each of said recording members being moved by said third feeding means.

12. The apparatus according to claim 9 wherein said third feeding means comprises a continuously rotatably drum member.

13. The apparatus according to claim 11 additionally comprising:

means for receiving signals from said program means indicating the number of reproductions to be made from each of said recording members;

means for counting the number of reproductions produced from each of said recording members moved by said third feeding means; and

means for ejecting a recording member from said third feeding means when the predetermined number of reproductions has been produced.

14. The apparatus according to claim 13 additionally comprising means for moving said ejected recording member to said first temporary storage means.

15. The apparatus according to claim 14 additionally comprising:

a cleaning station;

an erase station; and

means for moving said ejected recording member through said cleaning station and said erase station when said recording member is being moved to said first temporary storage means.

16. The apparatus according to claim 9 additionally comprising:

timing means for timing the elapsed interval since a recording member has been moved through the charge station by said first feeding means;

means responsive to the passage of a predetermined interval, after charging a recording member, to generate a time expired signal;

an eject mechanism; and

means responsive to said time expired signal to energize both said second feeding means and said eject mechanism to move said recording member from said second to said first temporary storage means.

17. The apparatus according to claim 9 wherein said recording members comprise:

a resilient photoconductive sheet member;

a top support member extending laterally beyond said sheet member, said top support member being terminated in enlarged end portions.

18. The apparatus according to claim 17 wherein said temporary storage means comprises a pair of rail members, said rail members being spaced so that said enlarged end portions of said sheet support member laterally position the recording member in said temporary storage means.

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