

[54] **PAPER FEED AND EXPOSURE SYNCHRONIZER**

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Related U.S. Application Data

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abandoned.

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355/108

[51] Int. Cl. **G03b 27/00**

[58] Field of Search **355/3, 16, 99, 100,**
355/102, 104, 106-110

[56] **References Cited**
UNITED STATES PATENTS

3,521,950	7/1970	Gardner et al.	355/3
3,182,578	5/1965	Limberger	355/107
3,259,047	7/1966	Berman et al.	355/109
3,416,863	12/1968	Ralston	355/110 X

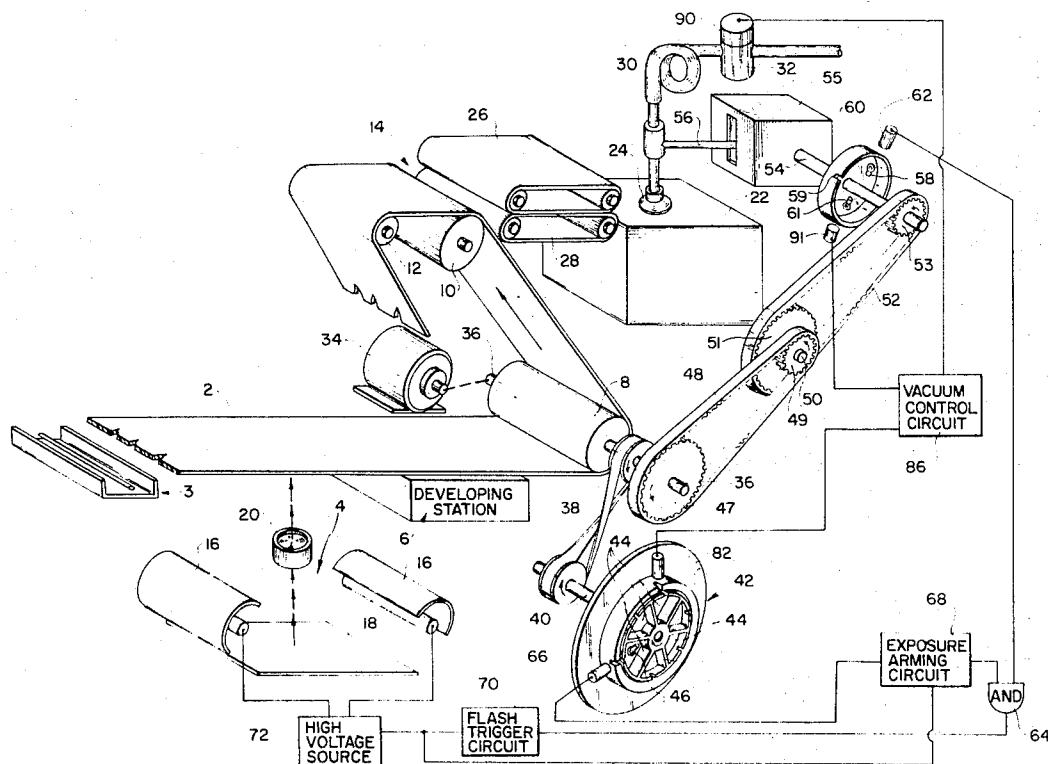
3,419,328 12/1968 Klosky et al. 355/110 X

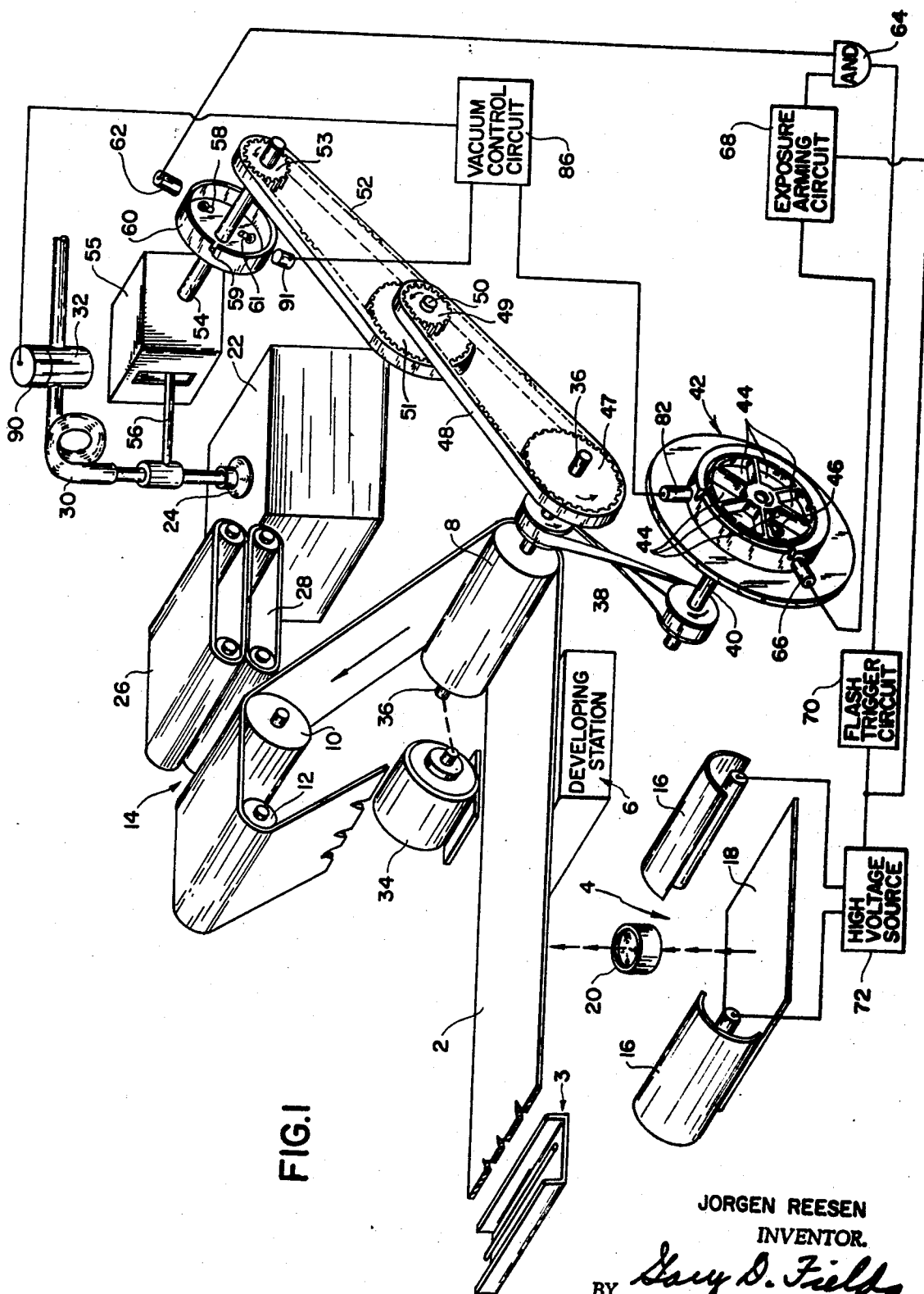
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[57] **ABSTRACT**

A synchronizer for an electrophotographic device is provided wherein an electronic flash exposure is initiated in response to the position of a movable photosensitive surface to be exposed and the position of a paper feed device for feeding receiver sheets onto which a toned image is to be placed. The paper feed device operates cyclically during movement of the photosensitive surface but is enabled to feed paper only in response to the proper position of an image on the photosensitive surface and is disabled in response to position of the paper feed device itself. This invention is particularly applicable in an electrophotographic device in which an endless photoconductive web is used to form a toner image which image is transferred in proper time relation to a receiver sheet fed by the paper feeding device.

8 Claims, 3 Drawing Figures





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FIG.2

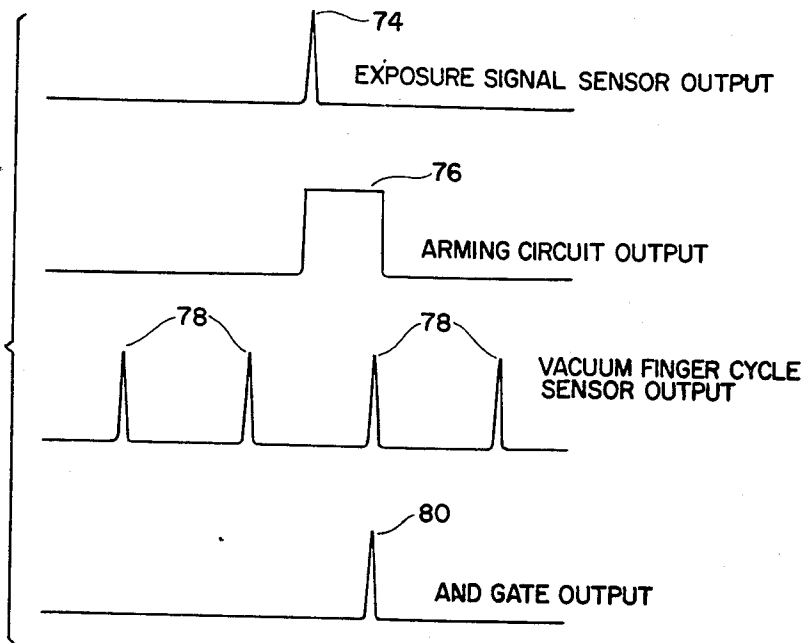
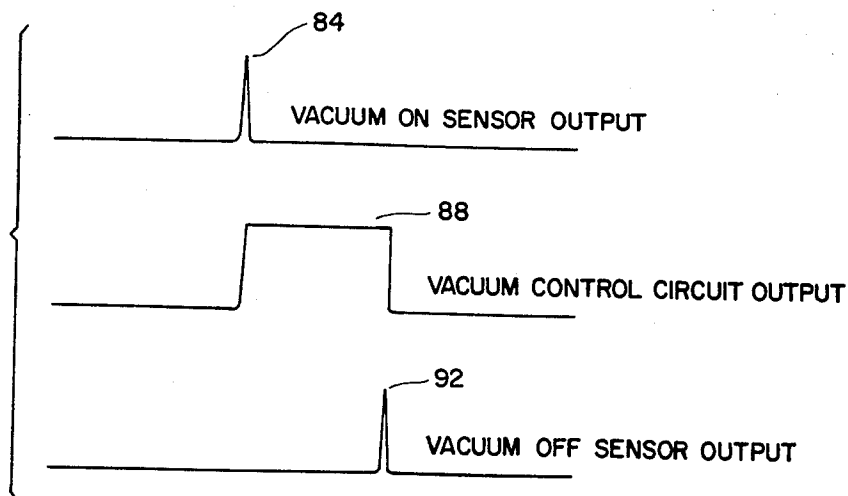


FIG.3



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PAPER FEED AND EXPOSURE SYNCHRONIZER

This application is a continuation of application Ser. No. 23,705 filed 3/30/70 now abandoned.

CROSS-REFERENCE TO RELATED APPLICATIONS

Reference is made to copending, commonly assigned U.S. Application Ser. No. 19,999, entitled "MACHINE PROGRAMMER" to Lional R. Hickey and Ellsworth J. McCune and U.S. Application Ser. NO. 19,644 entitled "MAGNETICALLY CONTROLLED MACHINE PROGRAMMER" to Lional R. Hickey, both filed Mar. 16, 1970.

BACKGROUND OF THE INVENTION**1. Field of the Invention**

This invention relates to a synchronizer and more particularly to a device for synchronizing flash exposure and paper feed operations so that an image may be formed on a photosensitive member and transferred in proper time relation to a receiver sheet for accurate registry.

2. Description of the Prior Art

In one form of electrophotographic process, an endless photoconductive member, such as a drum or an endless web moves continuously through a series of electrophotographic stations to form a toner image from an original, which toner image is transferred to a receiver sheet to make a copy of an original. Typically, the photoconductive member first is advanced past a charging station which places a generally uniform electrostatic charge on the photoconductive member, such as by corona discharge. Next it passes an exposure station where it is exposed to a pattern of radiation corresponding to an original to be copied. This discharges a photoconductive member in the exposed areas to form an electrostatic latent image. This image is toned at a developing station to form a toner image. As a photoconductive member continues along its endless path, the toner image can be utilized in any one of several ways but is commonly transferred to a receiver sheet at a transfer station to form a copy of the original. At a subsequent station any residual toner particles remaining on the photoconductive member are cleaned therefrom so that the photoconductive member may be recycled through the stations just described.

With such electrophotographic apparatus, it is clear that the operation of each station along the path of the photoconductive member must be perfectly synchronized with the movement of the photoconductive member so that each function is performed at the proper time and in the proper sequence to make a satisfactory print. If any one function is advanced or retarded slightly with respect to movement of the photoconductive member, the resulting image may be imperfectly registered on the receiver sheet. Such synchronization can be accomplished by use of the shift register disclosed in commonly assigned, copending U.S. Application Ser. No. 19,999, entitled "MACHINE PROGRAMMER" and U.S. Application Ser. No. 19,644, entitled "MAGNETICALLY CONTROLLED MACHINE PROGRAMMER", both filed on Mar. 16, 1970. In the prior art, various attempts have been made to synchronize sheet feeding with the movement of the photoconductive surface. For example, U.S. Pat. Nos. 3,060,108; 3,062,109; 3,187,651 and 3,256,009 each disclose an electrophotographic apparatus in which a

copy sheet is fed in synchronization with rotation of a photoconductive drum. In U.S. Pat. No. 3,148,601 the document feed, as well as the copy sheet feed, is operated in timed relation with the rotation of an electrophotographic drum. U.S. Pat. No. 3,223,008 sheet feed, is operated in time relation with the rotation of an electrophotographic drum U.S. Pat. No. 3,223,008 discloses synchronization of feeding a web of photoconductive copy paper with the operation of a flash exposure station wherein the web may be fed at variable speeds to control spacing between images.

In each instance the exposure is made and the copy sheet is fed in accordance with respective preselected positions of the photoconductive member. This method does not provide adequate registry of image and copy sheet unless the inaccuracies inherent in or developing during use of the aforementioned shift register or equivalent control devices are strictly minimized.

In prior art devices it is necessary to provide both complex exposure control devices to expose the image in accurate location on the photoconductive member, and complex paper feed the control means provides a third signal as an output signal to activate the flash. In addition, means are provided to enable the paper feed mechanism so that it feeds a sheet of receiver paper during a subsequent cycle so that the receiver sheet reaches the transfer station at the same time as a toner image. The paper feed mechanism is subsequently disabled in response to the position of the paper feed mechanism in its cycle.

More particularly, in a preferred embodiment signals in response to the position of a photoconductive web, movable along an endless path, are provided by a shift register such as those disclosed in either of the above-mentioned, commonly assigned, copending U.S. Applications. When a charged portion of the photoconductive web approaches a proper position for exposure, the shift register provides a signal to an arming circuit which in turn provides a first signal to an AND gate. When a paper feed mechanism, such as a vacuum or suction finger is in the exact position with respect to the charged portion of the photoconductive web it provides a second signal to the AND gate. The AND gate now sends an output signal to a flash trigger circuit which in turn provides an output signal to trigger the electronic flash. The output signal of the flash trigger circuit also resets the exposure arming circuit. The shift register also causes the constantly operating paper feed means to be enabled, as by providing a vacuum to the vacuum finger for separating individual receiver sheets from a stack for feeding seriatim to the transfer station. This is accomplished by an output signal from the shift register to a vacuum control circuit which operates a solenoid valve connected to a vacuum source. The vacuum is turned off when the suction fingers reach the appropriate position for feeding the paper to the transfer station by a signal to the vacuum control circuit in response to the position of the vacuum finger which causes the valve to close so that the vacuum at the finger is interrupted at precisely the right time. This reduces the possibility of paper jams and permits the use of lighter weight paper.

Thus, the invention provides an improvement in accuracy of registry between exposure and copy sheet. Also, if the relation of phase between web drive and paper feed should change somewhat by wear of belts, gears or the like, or through service disassembly and

reassembly, replacement of parts or the like, exposure and paper feed will be delayed or advanced by equivalent amounts, thereby maintaining accurate registry of image and copy sheet.

Additional advantages of this invention will become more apparent from the description which follows and taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic, fragmentary, perspective view of an electrophotographic device showing details of the synchronizer of this invention;

FIG. 2 is a series of energy-time curves showing the time relationship between various signal pulses for synchronization of the electronic flash and paper feed mechanism of FIG. 1; and

FIG. 3 is a series of energy-time curves showing the time relationship between the signal sensors for enabling the paper feed mechanism and for disabling it.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In accordance with this invention a synchronizer is provided so that different electrophotographic operations are performed on a photoconductive member in proper sequence and in timed relation. A photoconductive member, such as a photoconductive belt 2, moves along an endless path past a charging station 3, an exposure station 4, a developing station 6, around a drive roller 8 and past support rollers 10 and 12 at a transfer station 14. The belt then can continue past a cleaning station (not shown), if desired, then be recycled past the stations previously described.

Exposure of a charged portion of photoconductive web 2 is made, as by a pair of electronic flash units 16 which are positioned to reflect an image from an original 18 through a lens 20 onto the charged portion. The charge is dissipated in the exposed areas to form an electrostatic image. This image then passes through developing station 6 to form a toner image and then proceeds to transfer station 14. A supply of receiver sheets 22 are sequentially fed from a stack, as by a reciprocal vacuum finger 24, to a pair of transport belts 26 and 28 which bring the sheet 22 into contact with the toner image on web 2 to transfer the image to the receiver sheet. After transfer, the receiver is separated from the web (by means not shown) and the toner image thereon may be fused, if necessary. Vacuum finger 24 is connected to a flexible hose 30 to a source of vacuum (not shown). Hose 30 includes a valve 32 for intermittently connecting vacuum finger 24 to the source of vacuum in a manner to be described. For convenience of illustration, only one vacuum finger has been illustrated, but it should be understood that a plurality of vacuum fingers can be provided to handle any width receiver sheets.

Photoconductive web drive roller 8 is driven by a power source, such as a motor 34, connected to shaft 36 which in turn is connected by means of belt 38 and shaft 40 to shift register 42, such as the type disclosed in the above-mentioned commonly assigned copending U.S. Applications. Conveniently, the drive ratio between shift register 42 and motor 34 is such that the shift register makes one revolution for each advancement of one print sector of the photoconductive web through each of the stations along the endless path. As used herein the term "print sector" is that portion of

the photoconductive member required for making a single print. As more fully disclosed in the above mentioned, commonly assigned patent applications, the shift register is divided into a plurality of sectors 44 each of which includes a lamp, such as lamp 46, which is energized to light the sector, by means shown in the copending applications, to sequentially initiate the electrophotographic operations on each print sector as the print sectors move through the various stations. A plurality of sensors are provided around shift register 42 to initiate each of the operations, most of which have been omitted in FIG. 1 for clarity of illustration. Drive roller 8 is mechanically connected to vacuum finger 24 which moves through a cyclical path in response to movement of the photoconductive web. Conveniently, the ratio of the drive connection which couples the web to the vacuum finger is such that the vacuum finger goes through one cycle for each advancement of a print sector through the exposure station whether paper is fed or not, as described below. A mechanical connection is illustrated which includes a relatively large timing gear 47 on shaft 36 which through timing belt 48 drives a smaller timing gear 49 mounted on shaft 50. A large timing gear 51 is driven by shaft 50 and through timing belt 52 drives timing gear 53 to rotate shaft 54. The rotation of the shaft 54 is converted into a reciprocal motion within drive box 55 which may include a bell crank (not shown) which is connected by an arm 56 to suction finger 24, as shown.

Electronic flash units 16 must be operated in proper time sequence with the reciprocal movement of vacuum finger 24 so that the electrostatic image formed on the print sector is developed and received at transfer station 14 at the same time that a receiver sheet 22 reaches the transfer station so that a toner image is properly positioned on the receiver sheet. To this end, a lighted sector 44, upon rotation of the shift register and advancement of the web to a position somewhat in advance of the point of exposure, is aligned so that a sensor 66 provides a signal to exposure arming circuit 68 which in turn provides a continuous signal to AND gate 64. By way of example, the exposure arming circuit 68 may include a flip-flop which switches to a first state to apply a high level signal to the AND gate 64 in response to an input signal from the sensor 66 and switches to a second state to apply a low level signal to the AND gate 64 in response to a reset signal from the flash trigger circuit 70. Additionally, photoelectrical signal means, such as sensor 62, located peripherally to disc 60 on shaft 54 is activated by a signal from a light 58 shining through a slot 59 in the sidewall of disc 60 at the appropriate position of finger 24, to provide a signal pulse to AND gate 64.

If the shift register were to have a sensor to directly trip the exposure, variations in accuracy of manufacture of the sector rotor, as well as variations between the individual sector light bulbs flux due to individual bulb and circuit characteristics, would cause advancement or retardation of sensor pulse as each individual sector activated the sensor. The result would be a cyclically repetitive set of registry errors, aggravated by the slower angular rotation of the shift register compared to the synchronizer. The same is true of the vacuum cut-off.

Upon receiving both signals, AND gate 64 provides an output signal to flash trigger circuit 70. The output from flash trigger circuit 70 activates a high voltage

source 72 to energize electronic flashes 16 and also provides a signal back to exposure arming circuit 68 to reset it for the next cycle. Thus, the electronic flash is controlled by both the position of the photoconductive member and the position of the vacuum finger to assure that exposure occurs when both the photoconductive web and the vacuum finger are in the proper positions.

A better understanding of the signal sequences may be had by looking at FIG. 2. Each time a print sector of photoconductive web 2 is in proper position for exposure, shift register 42 is positioned so that a lighted sector 44 causes sensor 66 to provide output signal 74 which is a short pulse as shown in FIG. 2. This signal causes arming circuit 68 to provide a longer and continuous output high level signal 76 to AND gate 64. For each cycle of reciprocal vacuum finger 24 sensor 62 provides an output signal 78, and this is true whether or not a vacuum is being applied to the vacuum finger. One of these pulses 78 occurs during an output signal 76 of arming circuit 68 which causes AND gate 64 to give an output signal 80. Thus the output signal causing the exposure occurs when the paper feeding mechanism is at a point in its cycle corresponding to later delivery of a copy sheet to a position on the photoconductive web congruent with the location of the exposure made.

A vacuum-on sensor 82 provides an output signal when the corresponding lighted sector 44 of the shift register has rotated to be aligned with that sensor. As shown in FIG. 3, an output signal in the form of a pulse 84 is provided to a vacuum control circuit 86 which in turn provides an output signal 88. Circuit 86 has its own internal holding device and remains on after the signal pulse 84 disappears. The circuit 86 may include a flip-flop which switches to a first state to energize a solenoid 90 in response to an input signal from the sensor 82 and switches to a second state to de-energize the solenoid 90 in response to a signal from the sensor 91. The vacuum-on sensor is aligned with respect to the rotating shift register 42 to turn on the vacuum to the feed finger 24. The timing of signal 84 is not critical and will be sufficiently accurate as long as vacuum is established during the downward travel stroke of the paper feed vacuum finger. The vacuum control circuit by means of output signal 88 energizes a solenoid 90 to open valve 32 so that a vacuum appears at vacuum finger 24. As stated above, the feed finger goes through its cycle repetitively, once per print sector advancement of the belt, and if valve 32 is opened it picks up a sheet of receiver paper 22 when it is at the bottom of its stroke. During upward motion of the feed finger a sheet of receiver paper is delivered to paper transport belts 26 and 28. A sensor 91 is positioned adjacent disc 60 so that as soon as the leading edge of the receiver sheet 22 which is being fed is firmly held by belts 26 and 28, slot 59 is positioned so that a light 61 shines on sensor 91. An output signal 92 from sensor 91 deactivates vacuum control circuit 86 to close valve 32 to shut off the vacuum. Precise shut-off of the vacuum avoids exertion of reverse forces on the receiver paper at the most critical point in the paper feeding cycle. Thus, registry can be improved; creasing or buckling of the paper can be avoided, reducing the risk of paper jams and allowing the use of lighter weight paper.

From the foregoing, the advantages of this invention are readily apparent. A synchronizer has been provided in an electrophotographic apparatus for causing expo-

sure of a charged portion of a photoconductive web in proper sequence with the cyclical movement of a paper feeding device such as a vacuum feed finger. Furthermore, the vacuum to the feed finger is turned on in accordance with the position of the advancing electrostatic image on the web and is turned off in accordance with the position of the feed finger itself so that it occurs at a time when the leading edge of the receiver sheet being fed is gripped by a separate transport means. This reduces the possibility of paper jams and permits the use of lighter weight paper. Also, accurate registration is provided even though there is wear of gears, belts, replacement of parts, etc.

The invention has been described in detail with particular reference to a preferred embodiment thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

I claim:

1. In electrophotographic apparatus having an electrophotosensitive web, means for charging a plurality of spaced image receiving portions of the web and adapted to have a plurality of electrostatic images of an original formed thereon respectively, the web being movable along a first predetermined path, and means adapted to transfer information contained in each such electrophotostatic image to receiver sheets in image transferring relation therewith respectively, the combination comprising:
 - a. a plurality of work stations disposed adjacent said first path including means for charging a portion of the web, an actuable exposure station operative when actuated for exposing such charged portion of the photosensitive web to a light image to form an electrostatic image on the web, a developing station for contacting such electrostatic image with a medium which adheres to the web in a configuration defined by such electrostatic image to form a toner image and an actuable sheet feeder movable through a predetermined sheet feeding cycle and operative when actuated for feeding a receiver sheet into an image transferring relation with respect to toner image on the web for permitting the transfer of at least a portion of the medium in an image configuration to such receiver sheet;
 - b. means defining a second predetermined path;
 - c. means coupled to said web moving means and movable along said second path for sequentially (1) providing a first signal when a charged portion of the web moves to a position wherein it is capable of being exposed in said exposure station, and (2) actuating said sheet feeder, in timed relation to movement of the web past predetermined positions along said first path; and
 - d. exposure station actuating means comprising:
 - i. means coupled to said sheet feeder for providing a second signal in response to said sheet feeder being in a predetermined position in said sheet feeding cycle; and
 - ii. means responsive to said first and second signals for actuating said exposure station causing said exposure station to expose a charged portion of the web to an image, whereby image exposure on the web is synchronized with the operation of said sheet feeder.
2. The invention as claimed in claim 1 wherein sequential means includes:

means for producing a third signal indicative that a charged portion of the web has entered said exposure station; and
 exposure arming means effective in a first condition in response to said third signal to provide said first signal and in a second condition to prevent said exposure arming means for producing said first signal.

3. The improvement claimed in claim 1 wherein: said third signal providing means is an AND gate.

4. The invention as claimed in claim 1 further including:
 a flash trigger circuit responsive to said third signal from said AND gate to expose an image of an original on the web and to produce a further signal to said arming means causing it to be in said second condition.

5. In electrophotographic apparatus having an electrophotosensitive member having a plurality of discrete electrostatic images of an original formed thereon in predetermined spaced relationship with respect to each other, and means adapted to transfer information contained in such electrostatic images to receiver sheets, the combination comprising:
 a. a plurality of work stations including a charging station for charging a portion of the member, an actuatable exposure station operative when actuated for exposing a charged portion of the member to a light image of an original for forming an electrostatic image of such original on the member, a developing station for contacting such electrostatic image with a medium which adheres to the member in a configuration defined by such electrostatic image, and an actuatable sheet feeder movable through a predetermined sheet feeding cycle and operative when actuated for feeding a receiver sheet into an image transferring relationship with respect to an electrostatic image on the member for permitting the transfer of at least a portion of the medium in an image configuration to such receiver sheet;
 b. means coupled to said sheet feeder and the member for moving the electrophotosensitive member along a first endless path relative to said plurality

of actuatable work stations;
 c. means defining a second predetermined path;
 d. means coupled to the member moving means and movable along said second path for sequentially (1) providing a first signal when a charged portion of the member moves to a position wherein it is capable of being exposed to a light image at said exposure station, and (2) actuating said sheet feeder, in timed relation to movement of the member past predetermined positions along said first path; and
 e. exposure station actuating means comprising:
 i. means defining a third predetermined path;
 ii. means coupled to said sheet feeder and movable along said third path for providing a second signal in response to said sheet feeder moving through a predetermined position in said sheet feeding cycle; and
 iii. means responsive to said first and second signals for actuating said exposure station causing said exposure station to expose a light image on the member, whereby image exposure on the member is synchronized with the operation of said sheet feeder.

6. The invention as claimed in claim 5 wherein sequential means includes:
 means for producing a third signal indicative that a charged portion of the member has entered said exposure station; and
 exposure arming means effective in a first condition in response to said third signal to provide said first signal and in a second condition to prevent said exposure arming means from producing said first signal.

7. The improvement claimed in claim 6 wherein: said third signal providing means is an AND gate.

8. The improvement as claimed in claim 6 further including:
 a flash trigger circuit responsive to said third signal from said AND gate to expose an image of an original on the web and to produce a further signal to said arming means causing it to be in said second condition.

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