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[45] **Feb. 27, 1973**

[54] VARIABLE SHEET LENGTH PAPER FEED AND CUTTING SYSTEM

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[73] Assignee: **Van Dyk Research Corporation,** Whippany, N.J.

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[52] **U.S. Cl.** **355/13,** 83/365, 355/14, 355/17

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

[58] **Field of Search** 355/13, 14, 17; 83/365, 205

[56] **References Cited**

UNITED STATES PATENTS

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Assistant Examiner—Richard L. Moses
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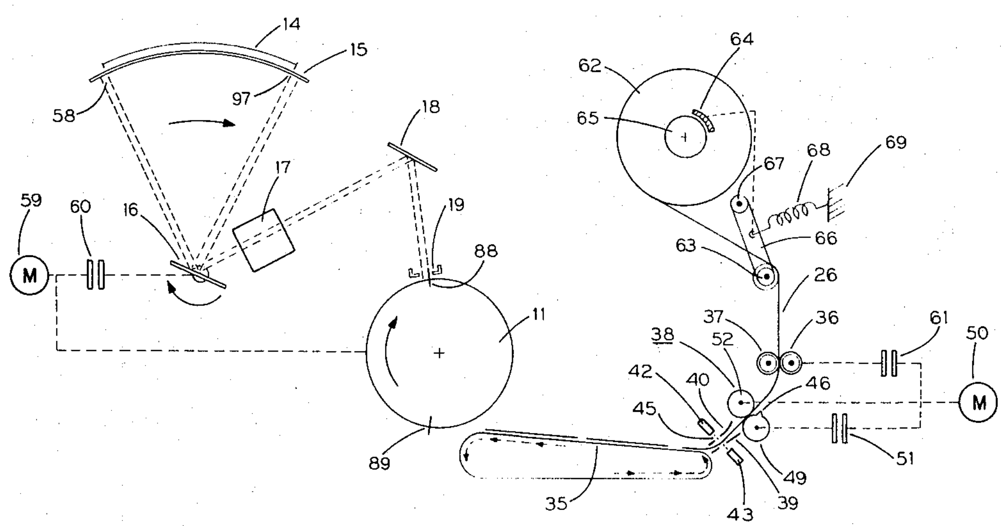
[57] **ABSTRACT**

An arrangement for use in a xerographic copier to cut copy sheets to desired variable lengths from a continuous paper roll. Both the length of scan and the operation of the paper cutter are controlled in response to the movement of the paper. Control circuitry is provided to insure maximum efficiency of utilization of available machine time.

14 Claims, 5 Drawing Figures



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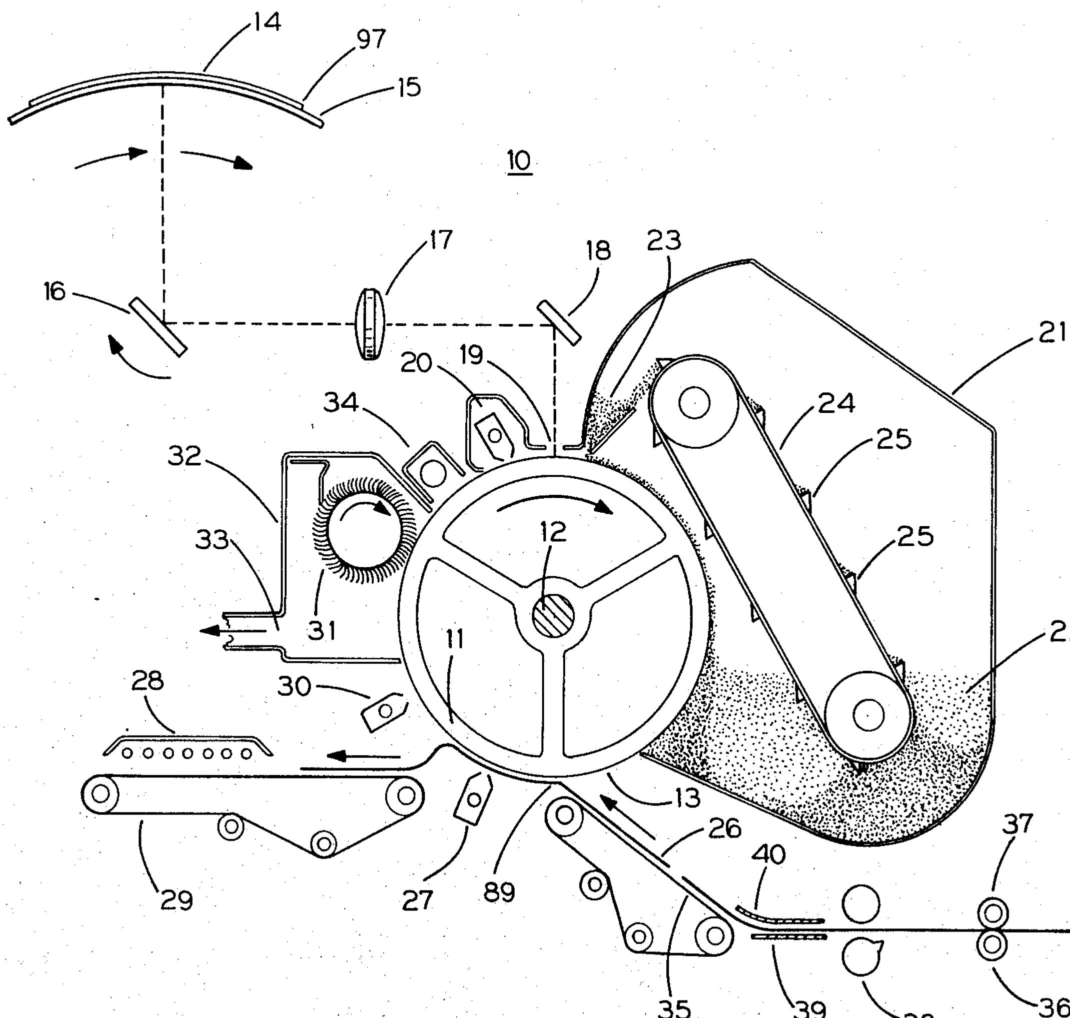
SHEET 1 OF 5

FIG. 1



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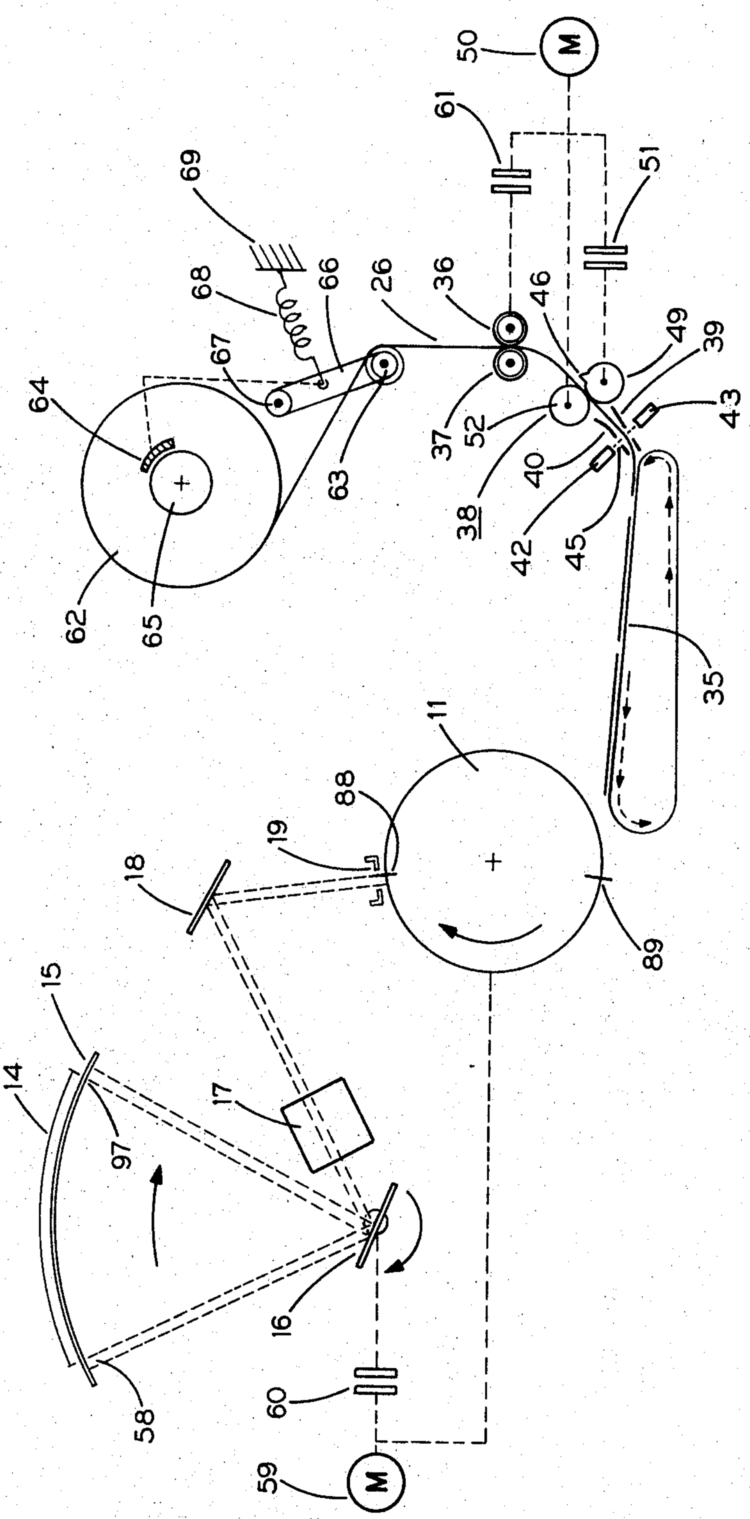
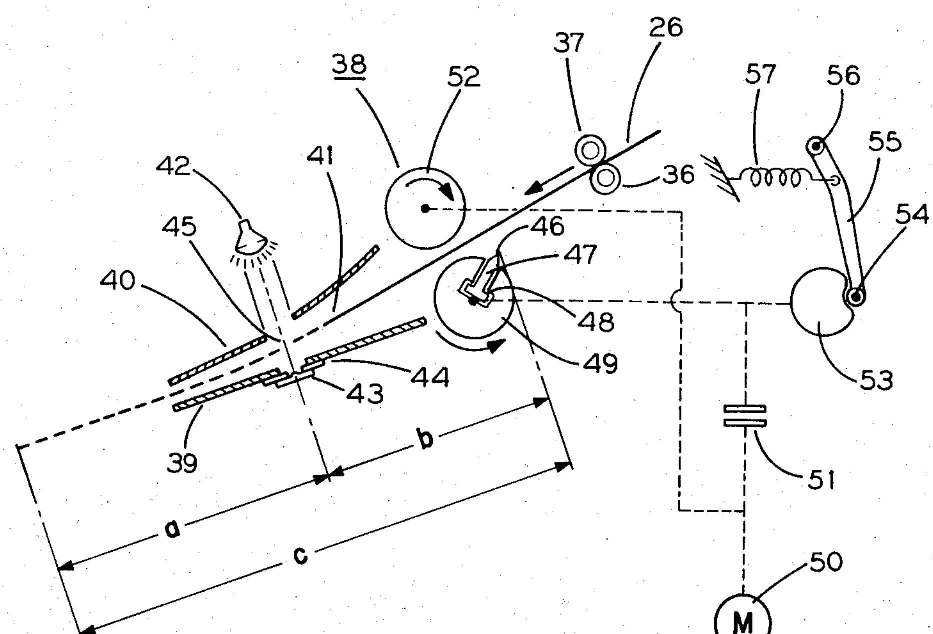


FIG. 2

FIG. 3


38
52
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26
57
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42
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44
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b
51
a
c
50
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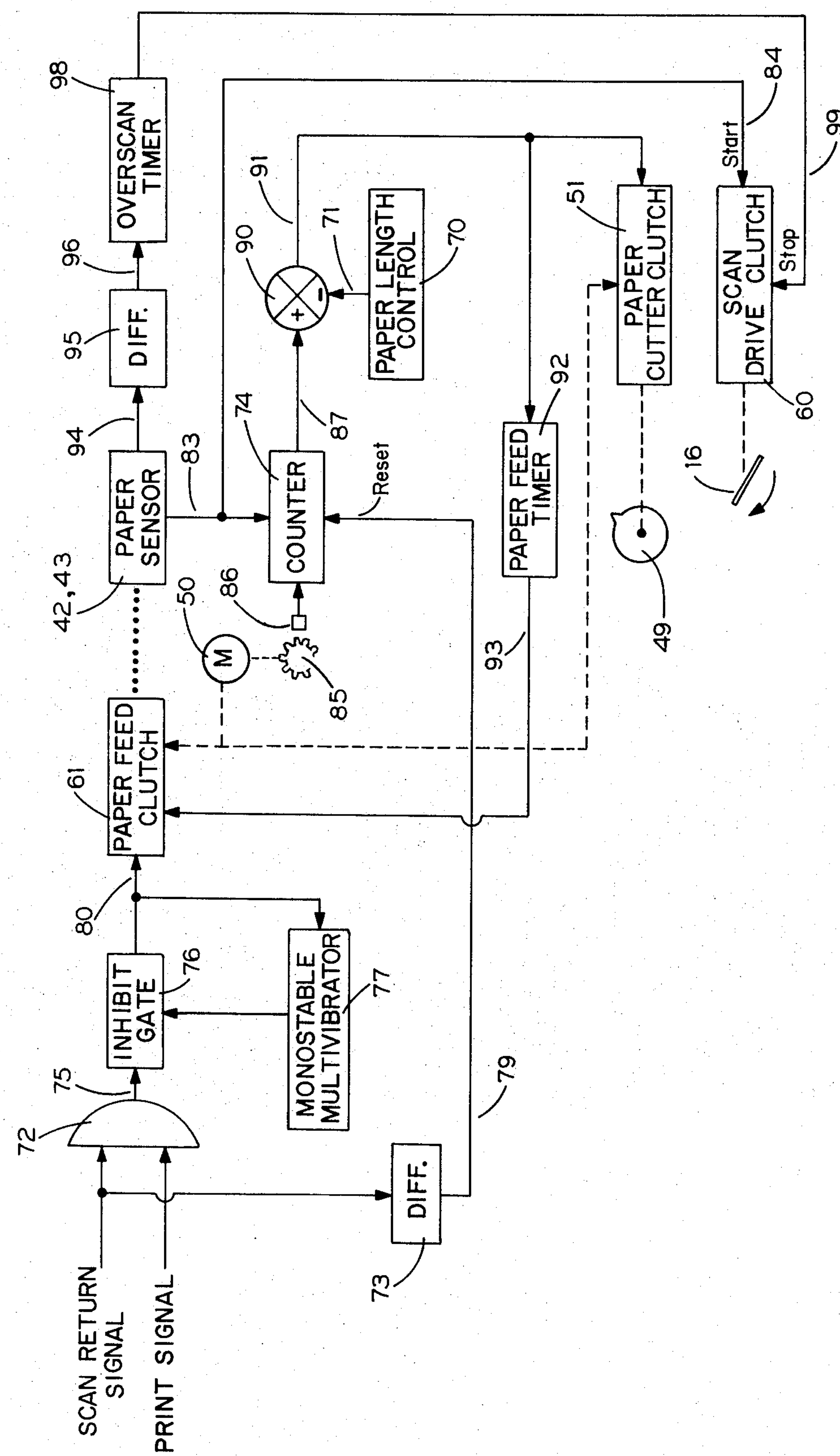
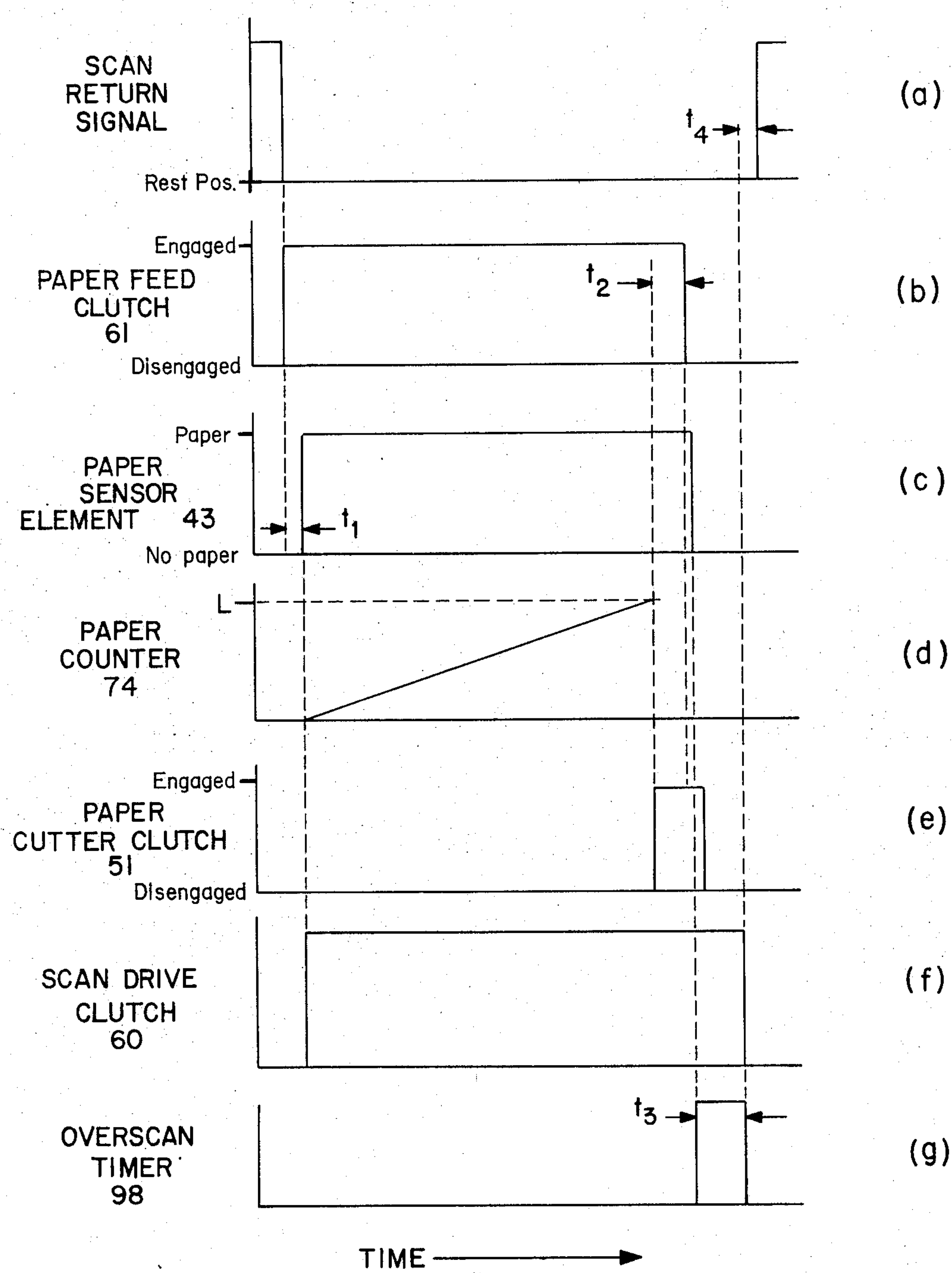

OVERSCAN TIMER
DIFF.
PAPER SENSOR
COUNTER
PAPER LENGTH CONTROL
PAPER FEED TIMER
PAPER CUTTER CLUTCH
SCAN DRIVE CLUTCH
Start
Stop
Reset
PAPER FEED CLUTCH
INHIBIT GATE
MONOSTABLE MULTIVIBRATOR
DIFF.
SCAN RETURN SIGNAL
PRINT SIGNAL
M
98
96
95
94
42, 43
83
74
87
90
91
71
70
84
99
51
60
92
93
16
49
50
86
85
61
80
76
77
75
72
79
73

FIG. 4

FIG. 5


SCAN RETURN SIGNAL
Rest Pos.
t_4
(a)
Engaged
PAPER FEED CLUTCH 61
Disengaged
t_2
(b)
Paper
PAPER SENSOR ELEMENT 43
No paper
t_1
(c)
L
PAPER COUNTER 74
(d)
Engaged
PAPER CUTTER CLUTCH 51
Disengaged
(e)
SCAN DRIVE CLUTCH 60
(f)
OVERSCAN TIMER 98
t_3
(g)
TIME

VARIABLE SHEET LENGTH PAPER FEED AND CUTTING SYSTEM

This invention relates to xerographic copying, and provides an apparatus and process for producing copies of variable length from a continuous web.

In the practice of xerography, a xerographic surface comprising a layer of photoconductive insulating material affixed to a conductive backing is used to create and support electrostatic images. In the usual method of carrying out the process, the xerographic plate is electrostatically charged uniformly over its surface and then exposed to a light pattern of the image being reproduced to thereby dissipate the charge in the areas where light strikes the photoconductive layer. The undischarged areas of the layer thus form an electrostatic charge pattern in conformity with the configuration of the original light pattern.

The latent electrostatic image is then developed with a finely divided electrostatically attractable (electroscopic) material such as a resinous powder. The powder is held in image areas by the electrostatic charge on the photoconductive layer. Where the charge is greatest, the greatest amount of material is deposited; and where the charge is least, little or no material is deposited. Thus, a visible powder image is produced in conformity with the light image of the copy being reproduced. The powder image is subsequently transferred to a sheet of paper or other surface and suitably affixed (usually by application of heat) to thereby form a permanent print of the desired image.

In order to transfer the powder (commonly referred to as "toner") image to a paper support surface, it is necessary to transport the paper to a position adjacent the photoconductive surface. In many xerographic copiers, only two copy sizes are provided (usually 8½ × 11 and 8½ × 14 inches).

Where, however, it is desired to provide a xerographic copier capable of producing copies of any of a number of desired lengths, it is impractical to provide a corresponding number of stacks of paper precut to the desired lengths. Such an arrangement would require considerable space within the copier, and the necessity of storing, reordering and inserting into the machine paper having the various lengths required. In addition, a costly, complex and relatively unreliable mechanism would be required for selecting and feeding the paper.

Another approach to the provision of variable length capability in a xerographic copier is to store the paper in the form of a continuous roll within the copier, and to automatically cut the paper to the selected length in response to the setting of the copy length control on the machine. However, prior art systems of this type have exhibited relatively inefficient utilization of machine time, thus limiting the rate at which copies can be produced, and have provided limited accuracy of synchronization of the various operating mechanisms involved.

Accordingly, an object of the present invention is to provide an apparatus and process for efficiently and rapidly producing copies of variable length from a continuous web.

As herein described, there is provided, in a xerographic copying apparatus, a process for producing copies of variable length from a continuous web. The process involves the steps of positioning the leading edge of the web adjacent a web sensor, feeding the web toward the web sensor, illuminating an object bearing an image to be copied, and causing a moving optical element to scan the object to project the image thereon onto a charged photoconductive surface to form on the photoconductive surface a corresponding latent electrostatic image. The scanning step is initiated when the leading edge of the web is detected by the web sensor. Electroscopic toner material is deposited on the portion of the photoconductive surface bearing the latent electrostatic image. The toner material adheres to the surface to form a visible toner pattern corresponding to the electrostatic image. The distance traversed by the leading edge of the web beyond the web sensor is measured, the measured distance being compared with a signal indicative of a desired web length. The leading portion of the web is severed from the remainder thereof in response to the comparison between the measured distance and the desired web length, so that the length of the leading portion is equal to the desired length. The scanning step is terminated when the trailing edge of the leading portion of the web traverses the web sensor. The web feeding step is terminated at a predetermined time after the web severing step is initiated.

Also described herein is a xerographic copying apparatus for producing copies of varying length. The apparatus comprises a charged photoconductive surface, means for illuminating an object bearing an image to be copied, and scanning means responsive to a scan start signal for scanning the object with a moving optical element to project the image thereon onto the photoconductive surface. The scanning means is responsive to a scan stop signal to return the moving optical element to a predetermined rest position. Developer means is provided for depositing electroscopic toner material on the portion of the photoconductive surface bearing the latent electrostatic image, to form a visible toner pattern corresponding to said electrostatic image. Means is provided for feeding the web to a position adjacent the toner pattern, and for transferring the toner pattern to the adjacent portion of the web and affixing the toner pattern thereto. A web sensor is provided, and means is provided for initially positioning the leading edge of the web adjacent the web sensor. Means responsive to a print signal operates when the moving optical element is in its rest position, to initiate the operation of the web feeding means to feed the web towards the web sensor and the toner image. The scan start signal is generated by the web sensor when the leading edge of the web is detected thereby. Distance measuring means provides a web length signal which is a measure of the distance traveled by the leading edge of the web beyond the web sensor. A web length control signal indicative of a desired web length is provided by suitable means. Means is provided for comparing the web length signal with the web length control signal to provide a web cut signal when the distance traveled by the leading edge of the web beyond the web sensor is equal to the distance represented by the web length control signal. Means is provided for severing the leading portion of the web from the remaining portion thereof at a predetermined time after the occurrence of the web cut signal. The scan stop signal is generated by means operative a first predetermined time after the trailing edge of the severed portion of the web traverses the web sensor. Means is provided to terminate the operation of the web feeding means a second predetermined time after the occurrence of the web cut signal, the second predetermined time being selected to position the leading edge of the remaining portion of the web adjacent the web sensor.

In the drawing:

FIG. 1 shows a xerographic copying apparatus generally typical of the prior art (except for the rotary paper cutter **38** shown therein), employing a continuous paper web which is cut to the desired length in accordance with the setting of a copy length control on the copier control console.

FIG. 2 shows, in schematic form, the various mechanical components associated with a paper feed and cutting system according to an embodiment of the present invention.

FIG. 3 shows a paper cutter, and its associated components, which may be employed in the paper feed and cutting system shown in FIG. 2.

FIG. 4 is a functional block diagram of a paper feed and cutting system incorporating the components shown in FIGS. 2 and 3, according to an embodiment of the present invention.

FIG. 5 is a timing diagram indicating the interrelationship of various components of the paper feed and cutting system shown in FIGS. 2 to 4. The various diagrams shown in FIG. 5 are drawn to a common time base, and are vertically aligned.

The xerographic copying apparatus **10** shown in FIG. 1, which apparatus is generally typical of the prior art, (with the exception of the rotary paper cutter **38** shown therein) comprises a number of operating stations situated about the periphery of a rotatable drum **11**. The drum **11** is rotatably mounted on an axle **12**, and is continually rotated by a suitable drive motor (not shown) while copies are to be made. The outer surface **13** of the drum **11** is coated with a relatively hard photoconductive material, such as vitreous selenium.

A document **14** bearing an image to be copied is placed (face down) on a curved transparent support plate **15**. The image to be copied is then illuminated by a suitable light source (not shown) through the transparent support plate **15**, and scanned by a rotatable mirror **16**, which reflects light from the document **14** through a lens **17** and a fixed mirror **18** onto the photoconductive surface **13** of the rotating drum **11**, through the exposure slot **19**.

The rotation of the scanning mirror **16** is accurately synchronized with the rotation of the drum **11**, so that the linear velocity at which the surface of the document **14** is scanned and the image thereof is projected through the aperture **19** is equal to the linear velocity of the photoconductive layer **13** disposed on the outer periphery of the drum **11**.

Prior to exposure to the image information bearing light beam through the aperture **19**, the photoconductive surface **13** of the drum **11** is passed under a corona emitter or corotron **20**, which charges the photoconductive surface **13** to establish a uniform electrostatic charge density thereon.

Upon passing beneath the masking aperture **19**, the charged photoconductive surface **13** is selectively discharged in accordance with the pattern of the image on the document **14** to be copied, resulting in the formation of a latent electrostatic image on at least a portion of the photoconductive surface **13** (the size of the portion of the photoconductive surface which contains the latent electrostatic image is dependent upon the size of the document **14** to be copied).

As the drum **11** continues to rotate, the latent electrostatic image on the photoconductive surface **13** enters the developer tank **21**. Situated in the lower portion or sump region of the developer tank **21** is a granular developer mixture **22**, which consists of resin coated steel beads and electroscopic toner powder.

The developer mixture is continually carried from the sump region of the developer tank to a hopper **23** at or near the top of the developer tank by means of a conveyor belt **24** having a plurality of carrier buckets **25** affixed thereto.

As the drum **11** continues to rotate, the developer mixture in the hopper **23** continually flows out the orifice at the bottom of the hopper, and cascades over the photoconductive surface **13** of the drum. As the developer mixture cascades over the photoconductive surface, toner particles are attracted away from the moving carrier beads and adhere to the charged portions of the photoconductive surface, thus converting the latent electrostatic image thereon to a corresponding visible pattern of pigmented or dyed toner particles. The developer mixture (less any toner particles which have adhered to the latent electrostatic image on the photoconductive surface **13** of the drum **11**) falls back into the sump of the developer tank **21** after the developer has cascaded over the photoconductive surface **13**.

Upon further rotation of the drum **11**, the pattern of toner particles (the toner particles being electroscopically adherent to the charged areas of the latent electrostatic image on the photoconductive surface **13**) is brought into juxtaposition with a moving paper **26**, which is caused to progress at a velocity equal to the peripheral velocity of the drum **11**, so that there is substantially no relative motion between the paper **26** and the adjacent portion of the periphery of the drum **11**.

The paper **26** is moved toward the transfer region of the drum **11** by a transport comprising a porous moving belt **35**, the paper **26** being retained in contact with the belt **35** by air pressure produced by the action of a vacuum source (not shown) which communicates with the interior of the region encompassed by the belt **35**. The paper is driven toward the transport belt **35** by a capstan **36** and idler roller **37**, the paper **26** being cut to the desired copy length by the rotary cutter **38**, and guided to the belt **35** by the lower guide plate **39** and upper guide plate **40**.

As the toner pattern (corresponding to the latent electrostatic image which in turn corresponds to the image of the document **14**) passes the moving paper **26** in close proximity thereto, an image transfer corona emitter or corotron **27** attracts the toner particles away from the photoconductive surface **13** and onto the adjacent portion of the moving paper **26**. The toner pattern is thus transferred onto the moving paper **26**, and is then passed under a radiant heater or fuser **28** which fuses the toner particle pattern to the paper **26** to form thereon a permanent copy of the image on the document **14**.

The paper **26** is moved along beneath the fuser **28** by a porous moving belt **29**, the paper **26** being retained in contact with the belt **29** by air pressure produced by the action of a vacuum source (not shown) which communicates with the interior of the region encompassed by the belt **29**.

After the toner pattern has been transferred from the photoconductive surface **13** of the drum **11** onto the paper **26**, some residual toner particles remain on the drum surface. In order to remove these residual toner particles, the photoconductive surface **13** is subsequently exposed to a further corona emitting device or corotron **30** which neutralizes any residual charge remaining on the photoconductive surface, thus reducing or cancelling the electrostatic attraction between the residual toner particles and the adjacent photoconductor surface.

A rotating brush **31** situated in a substantially dust-tight compartment **32** mechanically removes any remaining toner particles from the photoconductive surface **13** of the drum **11**, the toner particles so removed being drawn out through the conduit **33** by air pressure as a result of the application of a suitable vacuum source (not shown) to the conduit **33**. Before the toner-laden air is returned to the atmosphere, it is filtered by suitable means (not shown) to remove the toner particles therefrom.

After the residual toner particles have been removed from the photoconductive surface **13** by the action of the brush **31** and the vacuum source associated therewith, the photoconductive surface **13** is irradiated by light from a source **34**, to insure substantially complete discharge of the photoconductive surface.

Thereafter the corona emitter or corotron **20** recharges the photoconductive surface **13** in a uniform manner in preparation for the next cycle of machine operation.

The mechanism for cutting the paper **26** to the desired length, and guiding the paper onto the transport belt **35**, is shown in more detail in FIG. **3**.

As will be hereinafter discussed in more detail, the leading edge **41** of the continuous paper web **26** is initially positioned adjacent to (but not in the path of) a photoelectric web detecting system or sensor which comprises a light source **42** and a photosensitive element **43**. Light from the source **42** normally illuminates the photosensitive element **43**, which may be a phototransistor or other suitable photodetector, through aligned apertures in the upper guide plate **40** and the lower guide plate **39**. The photosensitive element **43** is secured to a mounting plate **44**, which in turn is secured to the lower guide plate **39**, the mounting plate **44** having an aperture therein permitting light from the source **42** to illuminate the photosensitive element **43**.

When the copier is operated, the leading edge **41** of the paper web **26** is fed toward the photoelectric system comprising the source **42** and detector **43**, by engagement of the capstan **36** and idler roller **37** with the web **26**.

A short time after the web **26** begins to move, the leading edge **41** thereof (which may typically be positioned 0.25 inch from the photoelectric system) intercepts the light beam from the source **42**, thus blocking light from the photosensitive element **43**, so that the output signal generated by the element **43** indicates that the leading edge **41** of the web **26** has arrived at the point **45** corresponding to the intersection thereof with the light beam path.

The paper web **26** is caused to move at a constant speed (a speed of **12** inches per second was employed in the copier constructed embodying the present invention), and a counter **74** (to be hereafter described with reference to FIG. **4**) coupled to the shaft of the motor **50** which drives the capstan **36** begins to operate when the leading edge **41** of the web **26** reaches the point **45**. Thus the output of the counter **74** provides a measure of the distance which has been traversed by the leading edge **41** beyond the point **45**.

When the output of the counter indicates that the distance a traversed by the leading edge **41** of the web **26** beyond the point **45** is such that the distance a plus the distance b, from the point **45** to the cutting edge **46** of the paper cutting knife blade **47** mounted in the longitudinal slot **48** of the cutting roller **49**, is equal to the desired copy length *c*, the paper cutter clutch **51** is engaged to cause the capstan drive motor **50** to rotate the cutting roller **49** to sever the web **26** by engagement of the cutting edge **46** of the knife blade **47** with the adjacent periphery of the platen roller **52**, the platen roller **52** being continuously rotated by the motor **50**.

By the distance *b* is meant the linear distance from point **45** to the line of contact between the cutting edge **46** and the roller **52** when the web **26** is severed, plus the circumferential distance (in a direction opposite the direction of rotation of the cutting roller **49**) from said line of contact to the point where the cutting edge **46** is situated when the cutting roller **49** is parked during the period when the clutch **51** is disengaged.

In order to provide stability of the dimension *b*, a detent mechanism comprising a detent cam or wheel **53** and a detent pin **54** secured to a lever **55** mounted for rotation about a pivot **56** is provided, the pin **54** being urged against the detent wheel **53** by a spring **57** secured to a fixed support.

A suitable cam arrangement (not shown) is provided so that when the clutch **51** is engaged, it remains engaged for a single revolution of the cutting roller **49**. When the clutch **51** disengages at the end of the revolution of the cutting roller, the roller **49** is parked in the desired position by interaction of the detent wheel **53** and pin **54**.

Preferably, the paper cutter **38** is of the type described in copending application Ser. No. 224,170 Filed Feb. 7, 1972, and assigned to the assignee of the instant application.

The clutch **51** must be capable of withstanding the sudden shock load, accompanied by high torque, which is applied thereto when the cutting edge **46** of the knife blade **47** engages the web **26** and the platen roller **52**. It has been found that a wrap-spring clutch meets these requirements, and provides excellent performance for this purpose.

In operation of the paper cutter **38**, the platen roller **52** and the cutting roller **49** are driven so that the peripheral speeds of the platen roller and the cutting edge **46** of the knife blade **47** are equal to the speed of movement of the web **26**, thus permitting the web **26** to be accurately and cleanly cut while it is in motion.

The manner in which the paper feed and cutting system operates will now be described in more detail with reference to FIGS. 2 to 5, wherein corresponding parts are identified by the same reference numerals.

Initially, the scanning mirror 16 is at its rest position, with the scanning beam at the initial position indicated by the numeral 58 (see FIG. 2). The scanning mirror 16 is disengaged from the drum drive motor 59 via the scanning clutch 60. A sensing switch (not shown) coupled to the shaft upon which the scanning mirror 16 is mounted, provides a scan return signal when the mirror 16 is in its rest position.

The detailed structure and operation of the scanning system is described in copending U.S. Patent application Ser. No. 247,872, filed Apr. 26, 1972, and assigned to the assignee of the instant application.

The paper web 26 is also initially at rest, with its leading edge 41 (see FIG. 3) positioned adjacent to (but not in the path of) the light beam extending from the light source 42 to the photosensitive element 43.

The paper drive capstan 36 is initially disengaged from the paper drive motor 50 via the clutch 61.

The continuous paper web 26 is wound about the paper support roller 62, and is tensioned by a dancer roller 63 and a brake 64 in contact with the shaft 65 on which the support roller 62 is mounted. The dancer roller 63 is rotatably mounted to support bars 66, which are pivoted at 67 to a fixed support, the bars 66 being secured to springs 68 to urge the dancer roller 63 toward a fixed support 69, thereby tensioning the continuous paper web 26.

The brake 64 is mechanically coupled to the dancer support bars 66, in such a manner that the brake 64 contacts the shaft 65 when the dancer roller 63 is in the fully extended position shown in FIG. 2.

When the copier is to be operated, the document 14 to be copied is placed on the transparent support plate 15, and the paper length control 70 (see FIG. 4), which is located on the machine control console (not shown), is set to the copy length desired (usually equal to the length of the document 14) to provide a paper length control signal on line 71 which is indicative of the desired copy length.

The scan return signal from the switch (not shown) coupled to the shaft upon which the scan mirror 16 is mounted, is applied to a logical and gate 72 (FIG. 4). The scan return signal is also differentiated by the differentiating network 73, the differentiated scan return signal being applied to reset the paper length counter 74 when the scan mirror 16 returns to its rest position after completing a previous scan.

When a copy is to be made, the operator presses the print button on the machine operating console (not shown), to provide a print signal to the and gate 72. When the scan return signal indicates that the scan mirror 16 is in its rest position, the and gate 72 provides an output on line 75. The signal on line 75 is applied to the paper feed clutch 61 to start feeding the paper web 26 toward the photoelectric paper sensor (comprising light source 42 and photosensitive element 43) and the paper transport belt 35. The signal on line 75 is provided to the paper feed clutch 61 by way of an inhibit gate 76 which is normally inoperative, i.e. normally passes the signal on line 75 without hindrance.

The cutting roller 49 requires a certain amount of time to return to its park position after a cut has been made. In order to maintain machine accuracy and synchronization, it is important that a second cut of the paper web 26 not be initiated until the cutting roller 49 has parked. When the distance between the leading edges of successive copies is equal to or greater than the circumferential distance traversed by the knife cutting edge 46 during a single revolution thereof, the cutting roller 49 will park in sufficient time to accurately initiate the subsequent cut. However, if the distance between the leading edges of successive copies is permitted to become less than the aforementioned circumferential distance, the cutting roller 49 cannot accurately cut the paper 26 to the desired length without disturbing the synchronization of the apparatus 10. To avoid this problem, the control system employed herein is designed so that the distance between the leading edges of successive copies is not permitted to fall below the aforementioned circumferential distance. In order to maintain such a minimum distance between the leading edges of successive copies, a monostable multivibrator 77 (see FIG. 4) is provided to delay coupling of the signal on line 75 to the paper feed clutch 61 for a corresponding time after the clutch 61 has been engaged to initiate feeding of paper for the previous copy.

The monostable multivibrator 77 is triggered by the output of the inhibit gate 76 on line 80, the multivibrator 77 providing an output pulse which has a pulse width corresponding to the time required for the cutting roller 49 to make a single complete revolution. The output of the monostable multivibrator 77 causes the inhibit gate 76 to block transmission of the signal on line 75 to the paper feed clutch 61 for the desired time interval.

When the signal on line 75 reaches the paper feed clutch 61 (either immediately, or after a short delay when a previous copy has been produced just before the print signal is generated, the clutch 61 engages, to permit the web drive motor 50 to rotate the capstan 36, to cause the web 26 to be fed between the capstan 36 and idler roller 37 at the desired speed. As seen in FIGS. 5*a* and 5*b*, the paper feed clutch 61 normally engages when the scan return signal indicates that the scan mirror 16 has returned to its rest position.

A short time t_1 after the paper feed clutch 61 begins to feed the web 26 toward the photoelectric web sensing system, the leading edge 41 of the web 26 intercepts the light beam emanating from the source 42, and the output of the photosensitive element 43 (see FIG. 5*c*) indicates that the leading edge 4 of the web 26 has reached the point 45 (see FIG. 3). The time t_1 may typically be on the order of 20 mileseconds for the aforementioned example, wherein the paper speed is 12 inches per second.

When the signal on line 83 indicates that the paper sensor has determined that the leading edge 41 of the web 26 has reached the point 45, the counter 74 is enabled, and a scan start signal is provided to the scan drive clutch 60 (see FIG. 5*f*) on line 84.

A toothed wheel 85 of magnetic material is coupled to the paper drive motor 50, a suitable magnetic pickup 86 being positioned adjacent the toothed wheel 85 to generate pulses as the motor 50 rotates, and therefore as the web 26 moves while the paper feed clutch 61 is engaged. Typically, the toothed wheel 85 may have 60 teeth, and may be directly mounted on the shaft of the motor 50, which may rotate at, e.g., 1,800 rpm. The pickup **86** may be provided with a full wave rectifier to double the effective frequency of the pulses generated thereby in cooperation with the toothed wheel **85**, thus effectively doubling the resolution of the counter **74**.

Since the motor **50** revolves 30 times per second, while the paper web **26** moves 12 inches per second, the motor **50** makes 2.5 revolutions for each inch of paper travel. With 60 teeth on the wheel **85**, 150 pulses are generated within the pickup **86** for each inch of paper travel. The frequency doubler (not shown) within the pickup **86** effectively doubles this value, to provide the equivalent of 300 pulses per inch of paper travel, resulting in an effective resolution on the order of 0.0033 inches for the counter **74**.

Thus, when the counter **74**, which may preferably be of the digital type, is enabled by the paper detection signal on line **83**, the counter provides an output on line **87** which is indicative of the distance a (FIG. 3) which has been traversed by the leading edge **41** of the web **26** beyond the point **45** where the light beam projected toward the photosensitive element **43** by the source **42** intercepts the web **26**, i.e. the point where the web sensor is situated. As previously discussed, this distance a is measured by the counter **74** with a resolution on the order of 0.0033 inch.

When the scan start signal, originating from the photosensitive element **43** on line **83**, is applied to the scan drive clutch **60** on line **84**, the clutch **60** engages to cause the drum drive motor **59** to rotate the shaft upon which the scan mirror **16** is mounted, to cause the mirror **16** to scan the document **14**. The motors **50** and **59** (and the motor which drives the transport belts **29** and **35**) are of the synchronous type, and rotate at speeds accurately related to the frequency of the alternating current source which supplies power to the copier apparatus. Therefore, the movement of the various elements to which the motors **50** and **59** (and the transport belt drive motor) are coupled is synchronous, variations in line frequency causing such elements to vary in speed but to maintain mutual synchronism.

The rate at which the mirror **16** scans the document **14**, the peripheral speed of the drum **11**, the speed of the paper web **26**, the speed of the transport belts **29** and **35**, the peripheral speeds of the capstan **36** and idler **37**, and the peripheral speeds of the knife blade cutting edge **46** and the platen roller **52** are all equal and mutually synchronized at a value corresponding to a paper speed of 12 inches per second. The distance between (i) the point **88** at which leading edge of the scanning beam impinges upon the photoconductive surface of the drum **11** through the scanning aperture **19** and (ii) the transfer point **89** where the leading edge **41** of the web **26** first contacts the periphery of the drum **11**, is equal to the distance which the web **26** travels between the point **45** and the transfer point **89**.

Since, as previously discussed, the velocities of the drum **11** and transport belt **35** are synchronized, as well as the speed of the paper web **26**, the leading edge **41** of the web **26** reaches the transfer point **89** at the same time as the beginning of the toner pattern on the photoconductive surface **13** of the drum **11** corresponding to the image borne by the document **14** being scanned.

As the scanning mirror **16** and drum **11** continue to rotate, paper continues to be fed toward the periphery of the drum **11** by the transport belt **35**, the toner pattern ultimately being transferred to the paper at the transfer point **89**, and fused to the paper by the fuser **28** to form the desired copy.

As the distance traversed by the leading edge **41** of the paper web **26** beyond the web sensing point **45** continues to increase, the value represented by the output of the counter **74** on line **87** likewise increases (see FIG. 5*d*), until the value of the signal on line **87** equals the value of the signal on line **71**, which latter value corresponds to the desired paper length *c* less the distance *b* (see FIG. 3) between the web sensor and the parked position of the cutting edge **46** of the knife blade **47** disposed in the slot **48** of the cutting roller **49**.

When the signals on lines **87** and **71** (which may be in digital form when a digital counter **74** is employed) are equal, as determined by the comparator **90**, the comparator **90** generates a web cut signal on its output line **91**.

The web cut signal on line **91** is coupled to the paper cutter clutch **51** to engage the clutch (see FIG. 5*e*) to cause the paper drive motor **50** to rotate the cutting roller **49** to bring the cutting edge **46** of the blade **47** mounted therein into engagement with the web **26** and the adjacent periphery of the roller platen **52** to sever the web.

The web cut signal on line **91** is also applied to the paper feed timer **92**, which may comprise a suitable delay circuit, so that a predetermined time interval t_2 passes after the web cut signal is generated before the output of the paper feed timer on line **93** causes the paper feed clutch **61** to disengage (see FIG. 5*b*), thus halting motion of the continuous portion of the web **26**.

The duration of the delay introduced by the paper feed timer **92** corresponds to a distance slightly less than the distance *b* (see FIG. 3), so that the leading edge **41** of the remaining continuous portion of the web **26** is positioned adjacent to (but not in the path of) the photoelectric web sensing system comprising the source **42** and photosensitive element **43** at the time the paper feed clutch **61** disengages to halt further motion of the continuous portion of the web **26**.

Thus the leading edge of the continuous portion of the web is placed in proper position for the next cycle of machine operation.

After the leading portion of the web **26** has been severed from the remaining continuous portion thereof, the leading portion continues to move toward the transfer point **89** on the photoconductive drum **11** under the influence of the paper transport belt **35**. The severed leading portion of the web **26** has a length equal to the desired paper length as set by the paper length control **70**.

A short time (typically on the order of 20 mileseconds for the example previously given) after the paper feed clutch **61** is disengaged, the trailing edge of the severed leading portion of the paper web **26** traverses the web sensing point **45**, and the photosensitive element **43** senses that a transition has taken place, in that the light beam transmitted thereto by the source **42** is no longer intercepted by the web **26**. The output of the photosensitive element **43** on line **94** is differentiated by the differentiating network **95** to provide a pulse on line **96** corresponding in time to the aforementioned transition, which pulse occurs when the trailing edge of the severed leading portion of the web **26** passes the web sensing point **45**.

At the time the transition pulse occurs on line **96**, the leading edge of the beam scanning the document **14** is at the end **97** of the document. In order to insure uniform imaging of the document **14**, it is desirable to continue rotation of the scan mirror **16** for a short time thereafter, corresponding to the width of the scanning beam, to permit the trailing edge of the scanning beam to reach the point **97**. With a paper speed of 12 inches per second, and a typical scanning beam width of 1 inch, the scan mirror **16** must continue to rotate for an additional period t_3 (see FIG. **5***g*) of approximately 83 mileseconds after the leading edge of the scanning beam has reached the point **97** at the end of the document **14**, i.e. after the trailing edge of the severed leading portion of the paper web **26** has traversed the point **45**.

This additional scan or "overscan" is provided by the overscan timer **98**, which may comprise a suitable delay circuit to provide a scan stop signal to the scan drive clutch **60** on line **99** approximately 83 mileseconds (for the aforementioned example) after occurrence of the transition pulse on line **96**.

A short time t_4 (typically on the order of mileseconds for the aforementioned example) after the scan stop signal on line **99** causes the scan drive clutch **60** to disengage, the scan mirror **16** is returned to its rest position by suitable biasing means, which may comprise a spring or other suitable mechanism.

Thus it is seen that the initiation and termination of the movement of the scanning mirror **16** is controlled by movement of the paper web, thus providing accurate and reliable synchronization between these two functions.

If desired, this arrangement may be modified to orient the scanning mirror **16** at a rest position wherein the scanning beam is situated slightly ahead of the document **14**, and to start paper feed by engaging the paper feed clutch **61** when the scanning beam (as monitored by a suitable sensor) reaches the beginning of the document **14**. If desired, the remaining system functions may then be carried out as previously discussed, or alternatively the web cut and paper feed termination functions may be initiated at various angular positions of the scanning beam.

We claim:

1. In a xerographic copying apparatus, a process for producing copies of variable length from a continuous web, said process comprising the steps of:

positioning the leading edge of said web adjacent a web sensor;

feeding said web toward said web sensor;

illuminating an object bearing an image to be copied;

scanning said object with a moving optical element to project said image onto a charged photoconductive surface to form thereon a corresponding latent electrostatic image, said scanning step being initiated when the leading edge of said web is detected by said web sensor;

depositing electroscopic toner material on the portion of said photoconductive surface bearing said latent electrostatic image, said material adhering to said surface to form a visible toner pattern corresponding to said image;

measuring the distance traversed by said leading edge beyond said web sensor, and comparing the measured distance with a signal indicative of a desired web length;

severing the leading portion of said web from the remainder thereof in response to the comparison between said measured distance and said desired length, so that the length of said leading portion is equal to said desired length;

terminating said scanning step when the trailing edge of said leading portion traverses said web sensor; and

terminating said web feeding step at a predetermined time after said web severing step is initiated.

2. The process according to claim **1**, wherein said process is employed to produce two successive copies, including the additional step of delaying the web feeding step associated with said second copy for a predetermined time after initiation of the web feeding step associated with said first copy.

3. The process according to claim **1**, further including the step of delaying the termination of said scanning step for a predetermined time after the trailing edge of said web portion has traversed said web sensor.

4. The process according to claim **3**, wherein said photoconductive surface is caused to continuously move at a predetermined speed while said copies are being produced, the linear speed at which said object is scanned and the speed at which said web is fed being substantially equal to said predetermined speed.

5. The process according to claim **4**, including the additional step of positioning said leading web portion adjacent the toner pattern on said photoconductive surface, and transferring and affixing said toner pattern to said leading web portion.

6. The process according to claim **1**, wherein the distance traveled by the leading edge of said web beyond said web sensor is measured by a counter coupled to means for feeding said web, the operation of said counter being initiated when the leading edge of said web is detected by said web sensor.

7. The process according to claim **4**, wherein the time interval between initiation of said web severing step and termination of said web feeding step is selected so that the leading edge of the remaining portion of said web is positioned adjacent said web sensor.

8. Xerographic copying apparatus for producing copies of varying lengths, comprising:

a charged photoconductive surface;

means for illuminating an object bearing an image to be copied;

scanning means responsive to a scan start signal for scanning said object with a moving optical element to project said image onto said photoconductive surface, said scanning means being responsive to a scan stop signal to return said moving optical element to a predetermined rest position;

developer means for depositing electroscopic toner material on the portion of said photoconductive surface bearing said latent electrostatic image to form a visible toner pattern corresponding to said latent image;

means for feeding said web to a position adjacent said toner pattern;

means for transferring said toner pattern to the adjacent portion of said web and affixing said toner pattern thereto;

a web sensor;

means for initially positioning the leading edge of said web adjacent said web sensor;

means responsive to a print signal and operative when said moving optical element is in said rest position for initiating the operation of said web feeding means to feed said web toward said web sensor and said toner image;

said web sensor generating said scan start signal when the leading edge of said web is detected thereby;

distance measuring means for providing a web length signal which is a measure of the distance traversed by the leading edge of said web beyond said web sensor;

means for providing a web length control signal corresponding to a desired web length;

means for comparing said web length signal with said web length control signal to provide a web cut signal when the distance traveled by the leading edge of said web beyond said web sensor is equal to the distance represented by said web length control signal;

means for severing the leading portion of said web from the remaining portion thereof a predetermined time after the occurrence of said web cut signal;

means operative a first predetermined time after the trailing edge of the severed portion of said web traverses said web detecting circuit for generating said scan stop signal; and

means for terminating the operation of said web feeding means a second predetermined time after the occurrence of said web cut signal, said second predetermined time being selected to position the leading edge of the remaining portion of said web adjacent said web sensor.

9. The apparatus according to claim **8**, further including means for delaying the operation of said web feeding means to produce a succeeding copy, the operation of said web feeding means being delayed for a predetermined time after the web feeding means has commenced operation to produce the preceding copy.

10. The apparatus according to claim **8**, wherein said means for measuring the distance traversed by the leading edge of said web beyond said web sensor comprises pulse generating means coupled to said web feeding means, and a counter for counting the pulses generated by said pulse generating means, the operation of said counter being initiated when the leading edge of said web is detected by said web sensor.

11. Apparatus according to claim **8**, wherein said moving optical element scans said object with a beam having a predetermined width, and said first predetermined time is selected so that said scanning means overscans said object by an amount substantially equal to the width of said beam.

12. Apparatus according to claim **8**, wherein said web severing means comprises a cutting roller having a web cutting knife blade therein, the cutting edge of the blade protruding beyond the periphery of the roller, and a platen roller positioned in juxtaposition with said cutting roller, said rollers being disposed on opposite sides of said web, means for rotating said platen roller at a peripheral speed equal to the speed of said web, and means responsive to said web cut signal for rotating said cutting roller at said peripheral speed through a single revolution to sever said web when the cutting edge of said knife engages said web and the periphery of said platen roller.

13. Apparatus according to claim **12**, further including detent means for parking said cutting roller at a predetermined angular position with respect to said web in the absence of said web cut signal.

14. In a xerographic copying apparatus, a process for producing copies of variable length from a continuous paper web, said method comprising the steps of:

positioning the leading edge of said web adjacent a web sensor;

illuminating an object bearing an image to be copied;

scanning said object with a moving optical element to project said image onto a photoconductive surface to form thereon a corresponding latent electrostatic image;

feeding said web toward said web sensor, said web feeding step being initiated when said optical element reaches a predetermined angular position;

depositing electroscopic toner material on the portion of said photoconductive surface bearing said latent electrostatic image, said material adhering to said surface to form a visible toner pattern corresponding to said image;

measuring the distance traversed by said leading edge beyond said web sensor, and comparing the measured distance with a signal indicative of a desired web length;

severing the leading portion of said web from the remainder thereof in response to the comparison between said measured distance and said desired length, so that the length of said leading portion is equal to said desired length;

terminating said scanning step when the trailing edge of said leading portion traverses said web sensor; and

terminating said web feeding step at a predetermined time after said web severing step is initiated.

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