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Weber et al.

[11] **3,785,730**

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[54] **METHOD AND SYSTEM FOR VARYING THE POSITIONS OF IMAGE-FORMING SURFACES ON AN ELONGATE FLEXIBLE ELECTROPHOTOGRAPHIC SUPPORT BELT FOR DIFFERENT RUNS THEREOF**

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[21] Appl. No.: **238,130**

[52] **U.S. Cl.** **355/16,** 355/14, 355/40

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

[58] **Field of Search** 355/16, 41, 14, 3, 355/64, 13, 29, 40; 96/1.3; 242/55, 208

[56] **References Cited**

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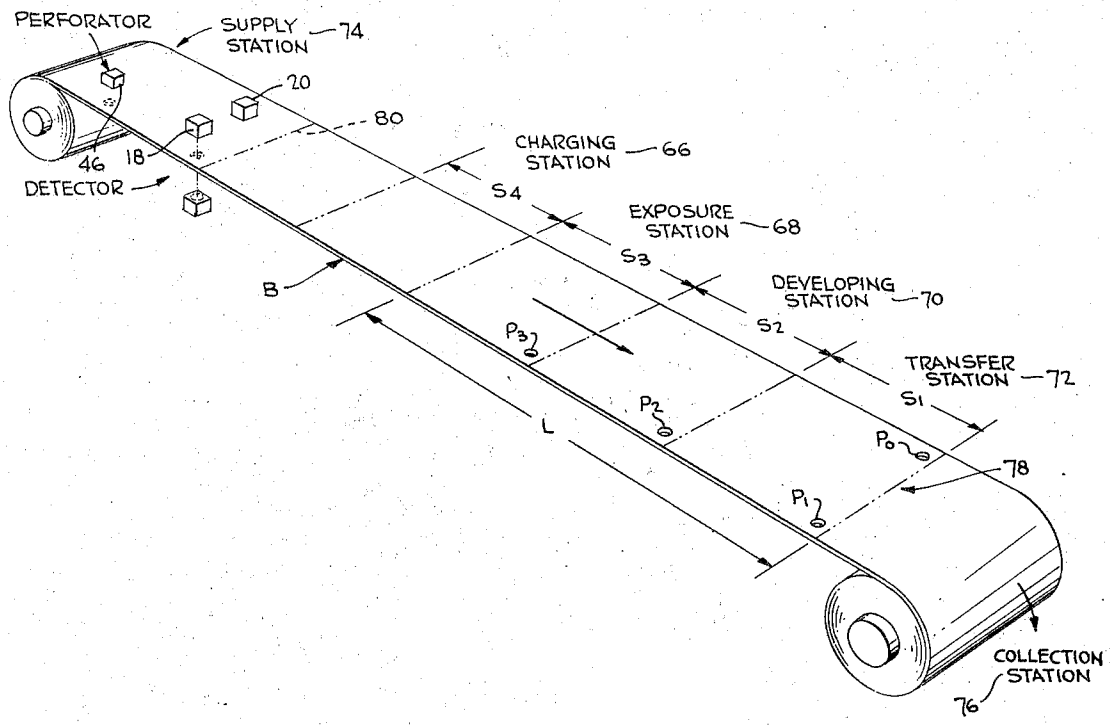
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[57] **ABSTRACT**

Method and system for varying the positions of image-forming surfaces on an elongate flexible electrophotographic support belt for different runs thereof wherein the belt is marked during a run of substantially the entire length thereof from a supply station to a collection station past a charging station, an exposure station, a developing station and a transfer station, and during a following run the position of the belt relative to a reproduction commencement point is varied in accordance with the mark such that image-forming surfaces for the following run are positioned in areas between image-forming surfaces for the preceding run.

4 Claims, 2 Drawing Figures



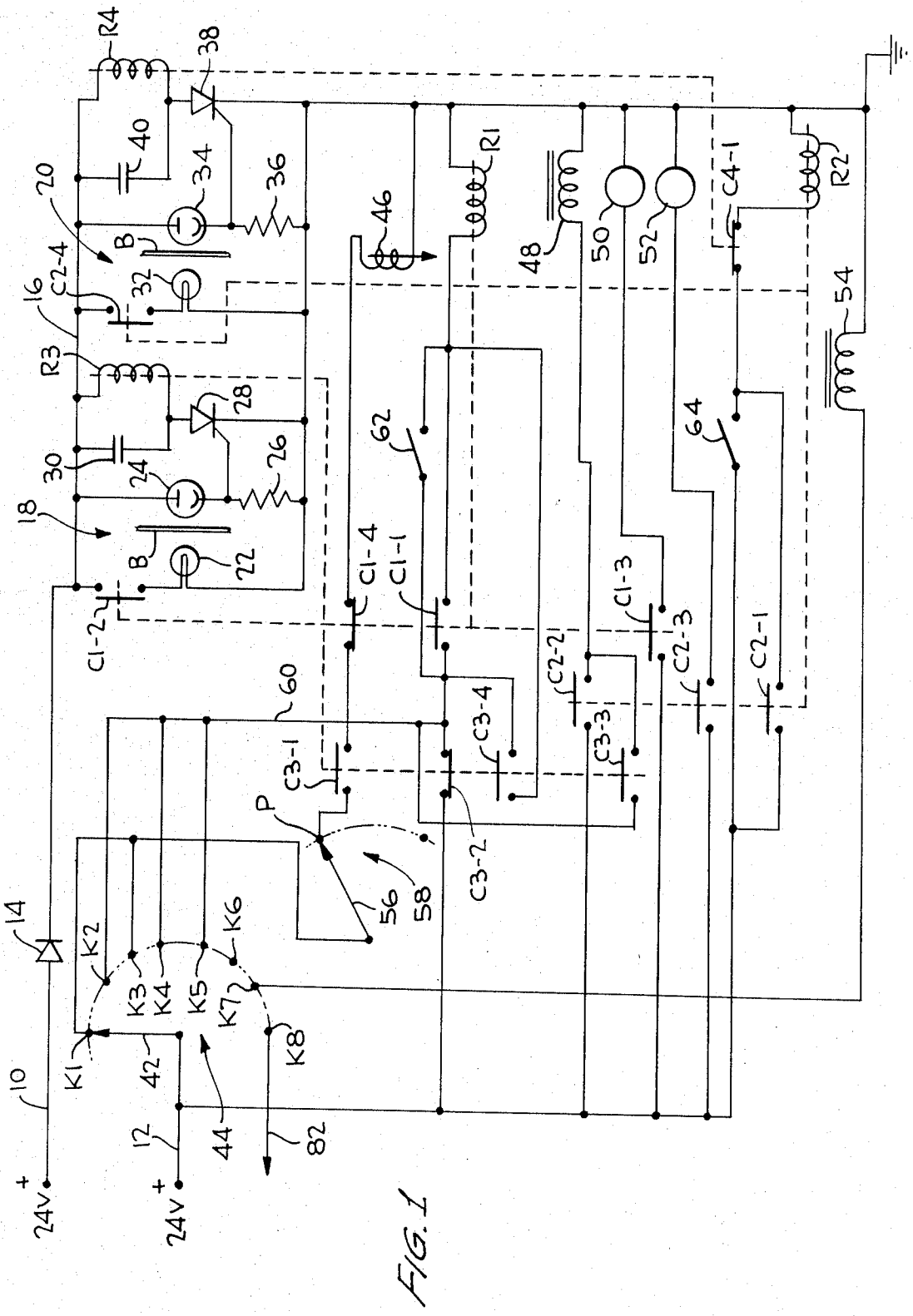

R4
38
40
34
36
20
B
C2-4
16
32
R3
28
30
24
26
18
22
C1-2
C1-4
C1-1
46
R1
48
50
52
C4-1
R2
54
62
64
60
C3-1
C3-4
C3-3
C2-2
C1-3
C2-3
C2-1
P
56
58
C3-2
14
K2
K6
K3
K4
K5
K7
K8
K1
42
44
82
10
12
24V
24V

FIG. 1

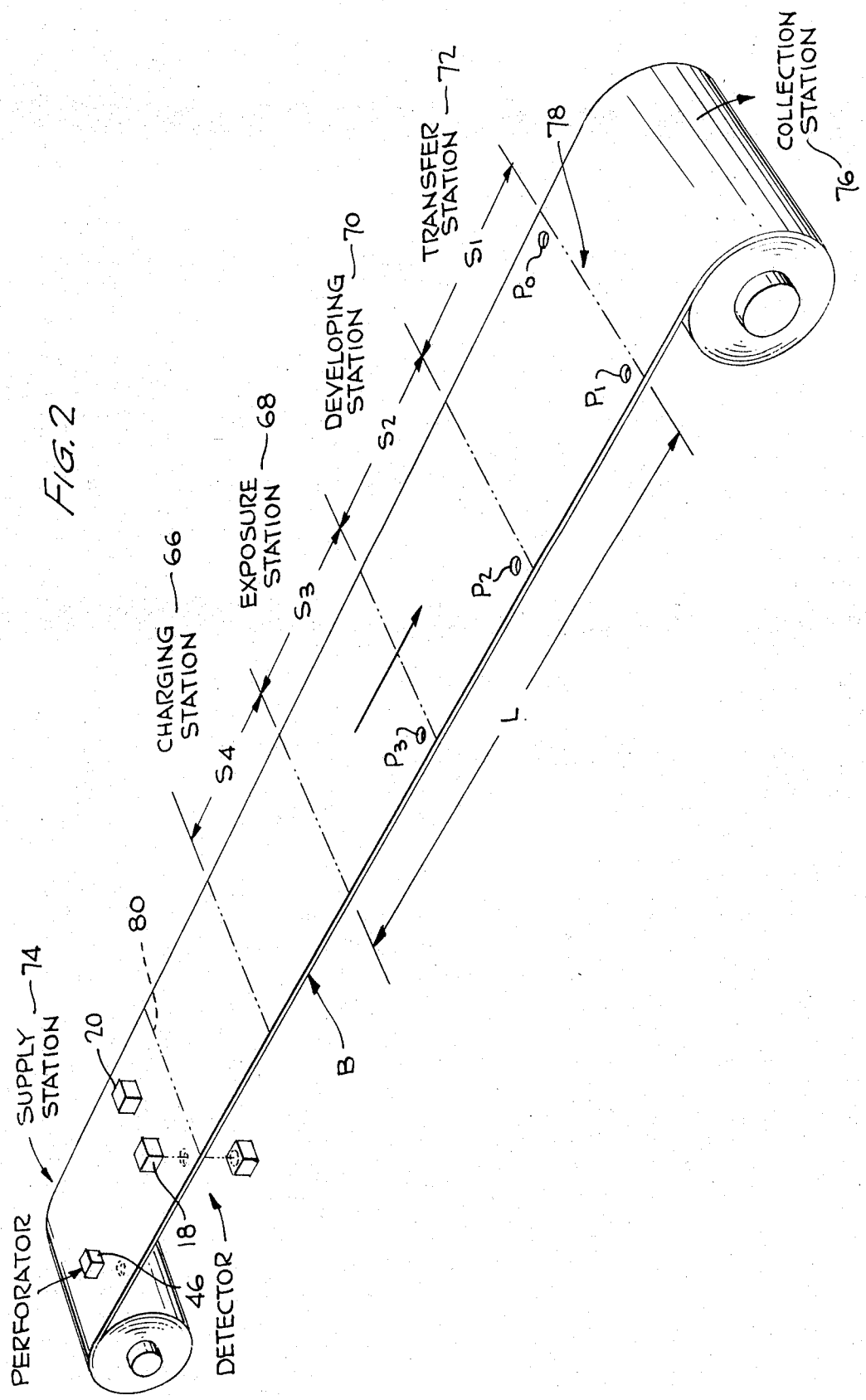

PERFORATOR
SUPPLY STATION 74
DETECTOR
CHARGING STATION 66
EXPOSURE STATION 68
DEVELOPING STATION 70
TRANSFER STATION 72
COLLECTION STATION 76
20
18
46
80
78
B
L
S1
S2
S3
S4
P0
P1
P2
P3

FIG. 2

METHOD AND SYSTEM FOR VARYING THE POSITIONS OF IMAGE-FORMING SURFACES ON AN ELONGATE FLEXIBLE ELECTROPHOTOGRAPHIC SUPPORT BELT FOR DIFFERENT RUNS THEREOF

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention pertains to electrophotographic reproduction and, more particularly, to a method and system for varying the positions of image-forming surfaces for different runs of an elongate flexible electrophotographic support belt which is moved to be charged at a charging station and exposed to light from an original to be reproduced to form a latent image in an exposure station, the latent image being developed with a charged powder at a developing station and the powder image being removed from the belt at a transfer station.

2. Discussion of the Prior Art

Electrophotographic reproduction machines in the past have utilized selenium coated drums to support a latent or intermediate image; however, such drums are expensive to produce, install and maintain and require cleaning or removal of excess or non-transferred charged toner particles between successive reproduction cycles.

In order to overcome the disadvantages concomitant with the use of selenium drums, elongate flexible supports have been proposed, such supports being constructed of a belt of paper or plastic such as polyethylene terephthalate, cellulose acetate, polyolefin or the like, with such materials being made conductive chemically or by coating with a metal and being uniformly coated with a photoconductive material. In practice, there exist organic photoconductive materials such as, for example, among others, poly-N-vinyl carbazole, having the characteristic of transferring substantially all of the toner or powder image while permitting reuse.

In conventional electrophotographic reproduction machines utilizing flexible, electrophotographic support belts, the belt passes successively through an electrostatic charging station, an exposure station for forming a latent image of the original to be reproduced, a developing station for applying a powder developer or toner to the latent image and a transfer station where the developed image removed from the belt such as by transference to a transfer or copy sheet for later fixing. The photoconductive material utilized in forming the belts in such apparatus may be reused a substantial number of times; however, the continual reuse of the photoconductive material as the belt is cycled does cause wear of the photoconductive surface. Thus, rather than utilizing endless flexible support belts, necessarily limited in length, it is preferable to utilize a roll of an elongate flexible electrophotographic support belt traveling from a supply or unwinding station passing through the electrostatic charging, exposure, developing and transfer stations to a collection winding station. After substantially the entire length of the flexible electrophotographic support belt has been utilized and wound at the winding station, the direction of the belt is reversed such that the belt is rewound at the supply station on its starting roller for continued use in following runs as long as the copies obtained therefrom are acceptable. Thus, one of the disadvantages of utilizing an elongate flexible electrophotographic support belt is that during each use of the belt, the belt stops at the same relative position at the exposure developing and transfer stations with successive images formed on discreet areas separated from each other such that the same image forming surfaces of the belt are continuously reused.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a method and system for overcoming the above mentioned disadvantages of elongate flexible electrophotographic support belts by varying the positions of the image-forming surfaces on the belts during different runs thereof.

The present invention is generally characterized in a method of electrophotographic reproduction wherein an elongate flexible electrophotographic support belt is moved from a supply station to a collection station past a charging station, an exposure station, a developing station and a transfer station, the belt having a plurality of spaced image-forming surfaces defined during each run of the belt, the image-forming surfaces each having a latent image formed thereon at the exposure station and developed with a powder at the developing station, the powder image being removed at the transfer station, having the improvement of varying the positions of the image-forming surfaces during successive runs such that image-forming surfaces during a following run are formed on areas of the belt positioned between the image-forming surfaces of a preceding run.

The present invention is further characterized in a system for implementing the above described method including means for marking the belt during a first run and a detector for detecting the mark to start a following run with the belt varied in position relative to the preceding run.

Another object of the present invention is to provide a method and system to control the movement of an elongate flexible electrophotographic support belt to assure uniform wear thereon and to increase the consistency and quality of reproduced images formed therewith.

A further object of the present invention is to provide a system for marking an elongate flexible electrophotographic support belt such that the areas of the belt between image-forming surfaces, as required by the physical spacing of exposure, charging and transfer stations, may be utilized as image-forming surfaces during following runs of the belt.

The present invention has another object in that an elongate flexible electrophotographic support belt is marked during the first run at a position spaced from a reproduction commencement point for the electrophotographic reproduction machine such that the mark may be detected during a following run and the following run commenced from the marked position on the belt.

Some of the advantages of the present invention over the prior art are that the useful lifetime of elongate flexible electrophotographic support belts is substantially increased and the quality and consistency of copies is substantially increased.

Other objects and advantages of the present invention will become apparent from the following description of the preferred embodiment taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of a system in accordance with the present invention.

FIG. 2 is a diagrammatic perspective view of an elongate flexible electrophotographic support belt after marking by the system of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A system in accordance with the present invention is illustrated in FIG. 1 and includes circuitry composed of both electromechanical and solid state components receiving electrical power on leads 10 and 12 of 24 volts relative to ground. It will be appreciated, of course, that the circuitry of the marking system of FIG. 1 may be implemented with any suitable components including electronic or solid state components in the entirety, if so desired.

The power on lead 10 is in the form of a positive half-wave rectified signal and is supplied through a diode 14 to a bus 16. A pair of similar sensing networks 18 and 20 are connected between bus 16 and ground with network 18 including a light source such as a lamp 22 in series with a pair of normally open contacts C1–2 across bus 16 and ground and the series combination of a photocell 24 and a resistor 26 in parallel therewith. A controlled rectifier 28, such as an SCR or thyristor, has a gate connected to the junction between photocell 24 and resistor 26, a cathode connected to ground and an anode connected to bus 16 through the parallel combination of a holding capacitor 30 and a relay winding R3. Similarly, connected between bus 16 and ground in sensing network 20 are normally open contacts C2–4 in series with a light source such as a lamp 32 and a series combination of a photocell 34, and a resistor 36 in parallel therewith. The gate of a controlled rectifier 38 is connected to the junction between photocell 34 and resistor 36 and the cathode of controlled rectifier 38 is grounded with the anode being connected to bus 16 through the parallel combination of a holding capacitor 40 and a relay R4.

The power to lead 12 is full-wave rectified and is supplied through a switching arm 42 of a stepping switch 44 to a plurality of contacts K1–K8 of the stepping switch to selectively energize a perforating solenoid 46, a relay winding R1, an electromagnet 48 controlling movement of arm 42, a forward clutch solenoid 50, a reverse clutch solenoid 52, a relay winding R2 and an electromagnet 54 controlling movement of a switching arm 56 of a stepping switch 58 to operate the perforator.

Switch 44 has contacts K1 and K3 connected together and to arm 56 of switch 58. Contacts K2, K4 and K5 of switch 44 are connected together and through a lead 60 to energize relay winding R1 through the parallel combination of normally open holding contacts C1–1, a forward start switch 62 and normally open contacts C3–4 connected in series with relay winding R1. Lead 60 is also connected to energize electromagnet 48 through normally open contacts C3–3, and lead 12 is connected to lead 60 through normally closed contacts C3–2, while normally open contacts C2–2 connect electromagnet 48 to lead 12. Clutches 50 and 52 are connected between lead 12 and ground by normally open contacts C1–3 and C2–3, respectively; and, relay winding R2 is connected between lead 12 and ground by the parallel combination of a reverse start switch 64 and normally open holding contacts C2–1 in series with normally closed contacts C4–1. Electromagnet 54 is connected directly to ground from contact K7 of switch 44. Perforator 46 is connected between a contact P of switch 58 and ground through normally open contacts C3–1 in series with normally closed contacts C1–4.

The present invention will be better understood with reference to FIG. 2 wherein an elongate flexible electrophotographic support belt B is illustrated relative to the components of a conventional electrophotographic reproduction machine as well as the detector and perforator of the system of FIG. 1. That is, such machine includes, in order of movement of the belt, a charging station 66 for electrostatically charging the belt B, an exposure station 68 for exposing the charged belt to light from an original to be reproduced to form a latent image, a developing station 70 for developing the latent image by applying a suitably charged powder or toner thereto, and a transfer station 72 for removing the developed or powder image from the belt such as by transferring the image directly to a copy sheet or to a a transfer sheet for fixing thereafter. Thus, it can be seen that as the belt B is unwound from a roll at a supply station 74, a portion of the surface, hereinafter referred to as the image-forming surface S, will be stopped at the exposure station 68 after charging. The image-forming surface S will be similarly stopped at the developing station and the transfer station to permit the above operations; however, it is noted that electrostatic charging of the belt is normally a continuous process and requires no stopping of the belt. As illustrated in FIG. 2, when an image-forming surface S1 is positioned at transfer station 72 to transfer the image therefrom, areas S2 and S3, which are disposed at the exposure and developing stations, respectively, are not utilized as image-forming surfaces; and, accordingly, the next area to be utilized as an image-forming surface is denoted S4. The total length L, therefore, of belt B required to make a single reproduction is equal to the sum of S1, S2 and S3. Accordingly, during a run of the belt B, which is defined as the movement of substantially the entire length of belt B from supply station 74 to collection station 76, only areas S1, S4, S7, S10, etc., are utilized as image-forming surfaces with the areas therebetween being nonused.

The length L, of course, will vary and may not be an integral multiple of the length of the required image-forming surface S but is determined by three times the length required for image-forming surfaces S plus the distance between the exposure and developing stations and the distance between the developing and transfer stations. Accordingly, it will be appreciated that the length L is illustrated as being three times the length of an image-forming surface S only in order to facilitate understanding of the present invention.

In operation of the system of the present invention, the leading portion indicated at 78 in FIG. 2 of the belt B is provided with perforations P_0 and P_1 in any suitable manner, including, if desired, manual operation of a perforator. The perforation P_1 is aligned with sensing or detecting network 18, and the perforation P_0 is aligned with sensing or detecting network 20 such that photocells 24 and 34 of the system of FIG. 1 receive light in accordance with perforations P_1 and P_0, respectively, with the leading portion of the belt marked with

the perforations P_0 and P_1 at different areas or tracks thereof so as not to intefere with each other as a run of the belt is initiated.

With the commencement of the initial run of the belt, arm **42** of switch **44** is on contact K1 and arm **56** of switch **58** is on contact P. Forward start switch **62** is depressed to energize relay winding R1 and pull in holding contacts C1–1 to maintain energization thereof. Contacts C1–3 are, thus, closed to energize forward clutch solenoid **50** and drive the belt forward until perforation P_1 is detected by sensing network **18** since contacts C1–2 are closed to energize lamp **22.** Once the perforation P_1 is aligned with the sensing network, the light received therethrough will decrease the resistance of photocell **24** to provide a sufficient voltage drop across resistor **26** to trigger controlled rectifier **28** and energize relay winding R3. Energization of relay winding R3 opens contacts C3–2 to de-energize relay winding R1, and, similarly, de-energize forward clutch solenoid **50** by the opening of contacts C1–3 to stop movement of the belt as well as interrupting the power to lamp **22.** With the belt stopped in a specific relationship with reproduction commencement point **80,** perforator **46** is energized since arm **42** of switch **44** is on contact K1 and arm **56** of switch **58** is on contact P with contacts C3–1 closed. Operation of the perforator **46,** which is spaced from the detector **18** by a distance equal to the length of the image-forming surface S, provides a perforation P_2 at the leading edge of area **S2.** Relay winding R3 in only momentarily energized due to the interruption of power to lamp **22;** and, accordingly, controlled rectifier **28** is returned to its nonconductive state.

The belt is now ready to commence the initial run thereof, such run being initiated by operation of the electrophotographic reproduction machine to make the first desired copy. That is, movement of belt B after the initial preparation and positioning thereof, as above described, is controlled by operation of the machine in its normal reproduction cycle. As is conventional, the belt is utilized to reproduce originals until substantially the entire length of the belt has been wound at the collection station **76.** During this run, areas **S1, S4, S7, S10,** etc., are utilized as image-forming surfaces in the manner above described.

Once the initial run of the belt has been completed, the belt is rewound by depressing reverse start switch **64** which energizes relay winding R2 to close holding contacts C2–1 and contacts C2–3 and energize reverse clutch solenoid **52** to rewind the belt. The energization of relay winding R2 also closes contacts C2–4 to supply power to lamp **32,** and electromagnet **48** is energized through contacts C2–2 to step arm **42** to contact K2. When perforation P_0 is aligned with detector **20,** controlled rectifier **38** is triggered in the same manner as described above with respect to controlled rectifier **28** to momentarily energize relay winding R4 which opens contacts C4–1 to de-energize relay winding R2. Thus, reverse clutch solenoid **52** is de-energized to stop reverse movement of the belt and power to lamp **32** is interrupted.

In order to initiate a following run of the belt B, forward start switch **62** is depressed to energize relay winding R1 and forward clutch solenoid **50** as above described. The belt will now move forward; and, when light from lamp **22** is detected by photocell **24** through perforation P1 to momentarily energize relay winding R3, relay winding R1 will remain energized due to the position of arm **42** on contact K2 such that the belt continues to move forward. The momentary energization of relay winding R3, however, is utilized to close contacts C3–3 to energize electromagnet **48** and step arm **42** of switch **44** to contact K3.

The system is, thus, now in essentially the same condition as when the first run was made in that contacts K1 and K3 of switch are connected together. Accordingly, when perforation P_2 is detected by sensing network **18,** forward clutch solenoid **50** will be de-energized to stop movement of the belt, and perforator **46** will be energized to provide perforation P_3 at the leading edge of area **S3.** The belt is now in condition to complete another run during normal electrophotographic reproduction as above described. During this run, areas **S2, S5, S8, S11,** etc., are utilized as image-forming surfaces, such surfaces, it being appreciated, have been nonused during the first run due to their positioning between the utilized image-forming surfaces.

In the same manner as above described, at the end of the run reverse start switch **64** is depressed to energize relay winding R2 which energizes reverse clutch solenoid **52** to rewind the belt at the supply station and closes contacts C2–2 to energize electromagnet **48** to step arm **42** of switch **44** to contact K4. The reverse movement of the belt is stopped upon sensing of perforation P_0 by sensing network **20.**

To start the next run, forward start switch **62** is depressed to energize relay R1 and forward clutch solenoid **50** to initiate forward movement of the belt B. When perforation P_1 is sensed, relay winding R3 is momentarily energized; however, since arm **42** is on contact K4, relay R1 is not de-energized and forward movement of the belt continues. The momentary energization of R3 closes contacts C3–3 to pulse electromagnet **48** and step arm **42** to contact K5; and, accordingly, when relay winding R3 is momentarily energized after sensing of perforation P_2, relay winding R1 remains energized such that the belt continues to move forward. The arm **42,** however, of switch **44** is moved to unconnected contact K6 by the momentary energization of relay winding R3.

Thus, when perforation P_3 is sensed by detector **18,** the momentary energization of relay winding R3 will de-energize relay R1 and stop forward movement of the belt B as well as pulsing electromagnet **48** to move arm **42** to contact K7. Perforator **46** is not energized at this time; and, accordingly, no perforation is made in the belt. Electromagnet **54** is energized through contact K7 of switch **44** to move arm **56** of switch **58** to an open contact to assure no further operation of the perforator.

The belt is now in condition for another run through the electrophotographic reproduction process with areas **S3, S6, S9, S12,** etc., being utilized as image-forming surfaces. At the end of the run, reverse start switch **64** is depressed to energize relay winding R2 and rewind the belt as above described, stopping when perforation P_0 is sensed. The energization of relay winding R2 also pulses electromagnet **48** to move arm **42** to contact K8 which triggers through a lead **82,** a zero-setting network.

The elongate flexible electrophotographic support belt may now be utilized in continuous operation through the above described cycle with the only differ-

ence being that perforator 46 will remain de-energized until a new belt is placed in the machine or for any other reason arm 56 of switch 58 is moved back to contact P. Thus, it will be seen that the belt B will have its movement varied on consecutive runs to vary the positions of the image-forming surfaces utilized during each successive run. It is noted, however, that, if desired, suitable counting means can be provided such that the belt would make any predetermined number of consecutive runs utilizing image-forming surfaces S1, S4, S7, S10, etc., followed by predetermined numbers of runs utilizing image-forming surfaces S2, S5, S8, S11, etc., and image-forming surfaces S3, S6, S9, S10, etc., respectively.

From the above description of the operation of the system of FIG. 1, it can be seen that the combination of switches 44 and 58 along with the control relays R1 through R4 provide a static sequential memory or program relating to the manner in which the elongate flexible electrophotographic support belt is to be marked and moved through the machine. Of course, while the circuitry is illustrated as electromechanical, the system could be constructed entirely of electronic or solid state components if so desired; however, the unique circuitry illustrated in FIG. 1 provides the advantage that if there is an interruption in the supply of power to the system, the circuit will resume operation from its state immediately prior to the interruption of power.

As mentioned above, the present invention has been described as utilized in an electrophotographic reproduction machine requiring the unwinding of a length of the elongate flexible electrophotographic support belt corresponding to three successive areas or stations for operating upon an image formed on the belt for exemplary purposes only. Accordingly, it will be appreciated that the method and system of the present invention may be utilized with electrophotographic reproduction machines utilizing four or more areas or stations to operate on the belt, for example, to remove excess developing powder or toner therefrom.

The method in accordance with the present invention includes the step of varying the positions of image-forming surfaces during successive runs of an elongate flexible electrophotographic support belt such that the image-forming surfaces during a following run are formed on areas of the belt positioned between image-forming surfaces of a preceding run. More specifically, the method according to the present invention includes varying the position of the belt relative to a point of commencement for each run by marking the belt during a preceding run thereof, detecting the mark during a following run, and commencing movement of the belt from a position corresponding to the detected mark.

Inasmuch as the present invention is subject to many variations, modifications and changes in detail, it is intended that all matter described above or shown in the accompanying drawings be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A system for varying the positions of image-forming surfaces on an elongate, flexible, electrophotographic support belt for different runs of the belt, each run of the belt constituted by movement of substantially the entire belt along a path from a supply station to a collection station past a charging station, an exposure station, a developing station and a transfer station, the system comprising

forward drive means for moving the belt along the path from the supply station to the collection station;

reverse drive means for moving the belt along the path from the collection station to the supply station after completion of a run;

marking means for placing marks on the belt;

detection means for detecting marks on the belt and providing output signals responsive thereto; and

control means connected with said forward drive means, said reverse drive means, said marking means and said detection means;

said detection means providing a first output signal to said control means in response to marks carried on a leading portion of the belt during a first run of the belt, and said control means being responsive to said first output signal to operate said forward drive means to stop movement of the belt at a reproduction commencement point and to operate said marking means to place a mark on the belt at a position spaced from the leading portion of the belt; and

said detection means providing a second output signal to said control means in response to said placed mark during a following run of a belt, and said control means being responsive to said second output signal to operate said forward drive means to stop the belt at the reproduction commencement point whereby image-forming surfaces for the following run are formed on areas of the belt between image-forming surfaces for the preceding run.

2. The system as recited in claim 1 wherein said control means operates said marking means in response to said second output signal to place a second mark on the belt at a position spaced from the first placed mark, and said detection means provides a third output signal to said control means in response to said second placed mark during a further run of the belt, said control means being responsive to said third output signal to operate said forward drive means to stop the belt at the reproduction commencement point whereby image-forming surfaces for the further run are formed on areas of the belt between image-forming surfaces for both the preceding runs.

3. A system for controlling an elongate flexible electrophotographic support belt comprising position-varying means for positioning successive runs of the belt through an electrophotographic reproduction machine to start from staggered commencement points including detection means for providing an output signal upon sensing a mark on the belt, marking means spaced from said detecting means for placing marks on the belt, and control means connected with said detecting means and said marking means and responsive to said output signals to selectively operate said marking means to mark said belt during a first run such that a following run may be started from the spaced mark.

4. The system as recited in claim 3 wherein said control means includes memory means storing data corresponding to the operation of said marking means to provide marks on successive runs of the belt in staggered positions such that said control means is selectively responsive to output signals from said detecting means to operate said marking means to mark the belt only at one position during each run.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,785,730 Dated January 15, 1974

Inventor(s) Guy Paul WEBER ET AL

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

IN THE HEADING:

The name of the Assignee "La Cellophene" is correctly spelled --La Cellophane--

Insert Claim for Priority as follows:

--Claims priority, application France, April 29, 1971, No. 71/15313.--

Signed and sealed this 9th day of April 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

UNITED STATES PATENT OFFICE

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