

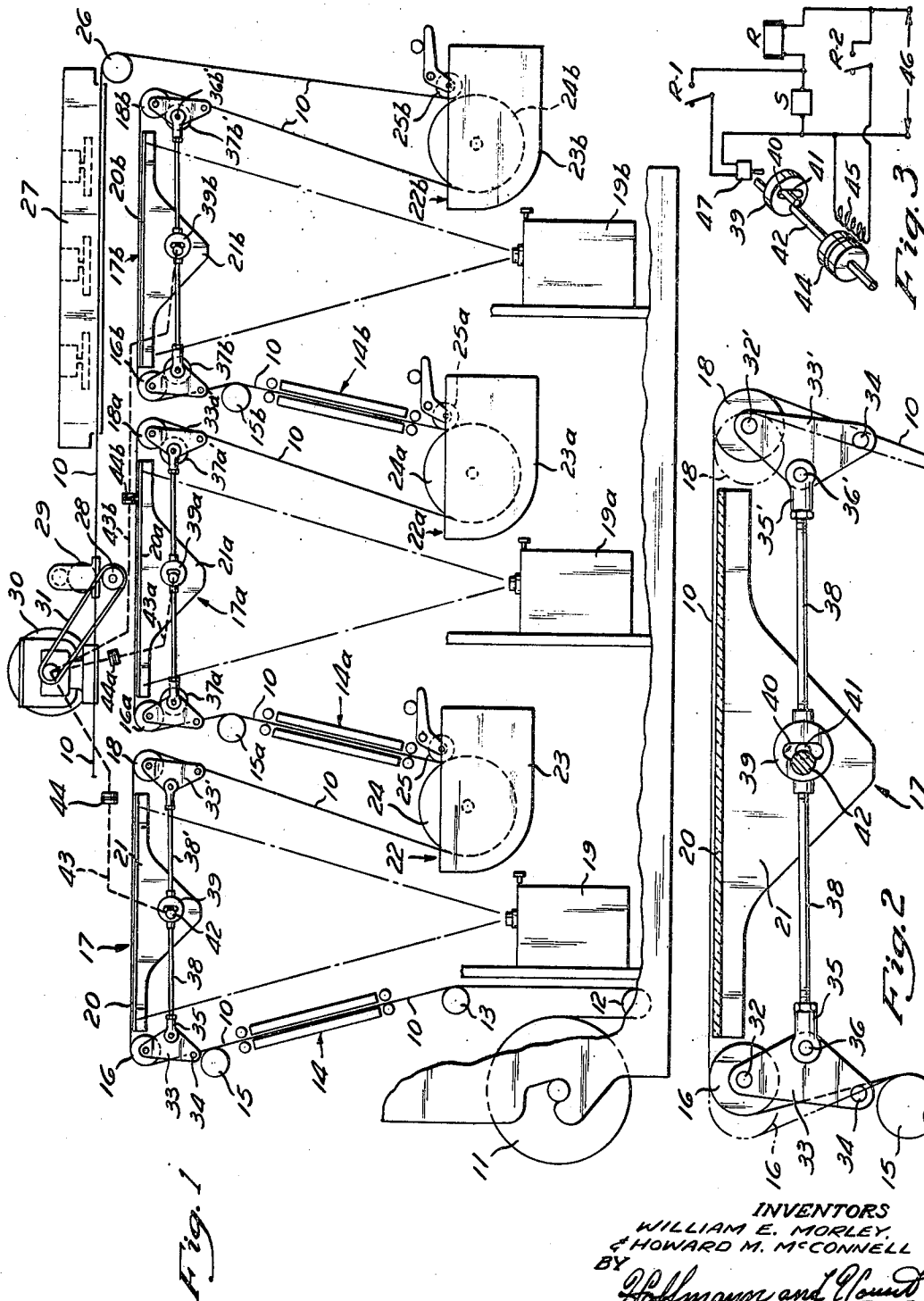
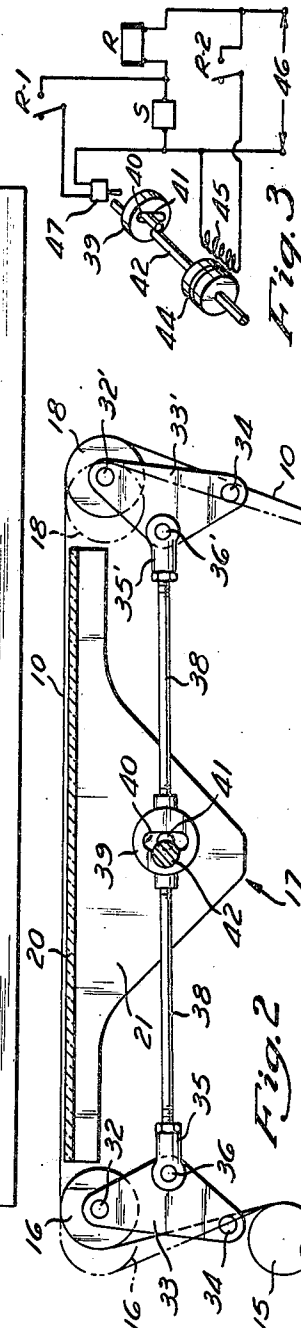
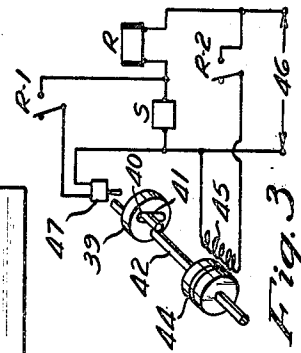
Feb. 17, 1970

W. E. MORLEY ET AL

3,495,903

ELECTROPHOTOGRAPHIC APPARATUS AND METHOD

Filed May 6, 1966



INVENTORS
WILLIAM E. MORLEY,
& HOWARD M. MCCONNELL
BY *[Signature]*

Hoffmann and Found

ATTORNEYS

1

3,495,903

ELECTROPHOTOGRAPHIC APPARATUS AND METHOD

William E. Morley, Bay Village, and Howard M. McConnell, Chagrin Falls, Ohio, assignors to Harris-Intertype Corporation, Cleveland, Ohio, a corporation of Delaware

Filed May 6, 1966, Ser. No. 548,194

Int. Cl. G03g 13/00, 15/00; G03b 27/00

U.S. Cl. 355-17

3 Claims

ABSTRACT OF THE DISCLOSURE

A web with a photoconductive surface is advanced at constant speed through a series of electrophotographic recording units, each having a charging station, an exposing station and a developing station in succession. In each exposing station, an image is recorded repetitively on the web by flash illumination of a photographic transparency in close proximity to the charged photoconductive surface of the web. During each image projection the web speed in the exposing station is slowed down without affecting its constant speed travel in the charging and developing stations.

This invention relates to an apparatus and method for electrophotographically recording on a moving web having a photoconductive surface.

In the type of equipment to which the present invention relates, a web of sheet-like material having a photoconductive surface is moved through a charging station where it is electrostatically charged and then past an exposing station where selected portions of the web are exposed by light which travels through a photographic transparency having light-transmitting areas and non-light transmitting, or "shadow," areas which respectively transmit and block light. The portions of the web which are exposed to the light from the transparency become conductive and discharge the electrostatic charge on that portion of the web. The web is then moved to a developing station where either the charged areas or the non-charged areas receive electrostatic toner particles of a given electrical potential which are subsequently fixed to the web and these areas will become the image areas of the final print.

In such equipment the photographic image may be recorded on the continuously moving web by energizing a light source in the projector for a brief length of time as the web moves past. Preferably, the projector is flashed briefly at spaced intervals so that the image is recorded at successive adjacent locations along the length of the moving web so as to minimize waste of the web material.

One difficulty with such apparatus is the smearing or blurring of the recorded image on the web caused by the relative movement between the web and the projected image during the recording of the latter on the web. Where the photographic transparency is positioned in close proximity to the web during the projection of its image onto the web, a high relative speed between the moving web and the projected image also produces distortion of the middle tones and loss of highlights of the recorded image.

The present invention is directed to a novel and improved electrophotographic apparatus and method which

2

minimizes such deleterious effects by reducing the effective speed of the web through the exposing station while the photographic image is being projected onto the web.

Accordingly, an important object of the present invention is to provide a novel and improved method and apparatus for electrophotographically recording on a moving web having a photoconductive surface.

Another object of the present invention is to provide such a method and apparatus having novel provision for reducing the blurring or smearing of the image recorded on the web.

Another object of the present invention is to provide such a method and apparatus which reduces the distortion of the middle tones and the dropping out of highlights of the recorded image when the recording of the image involves positioning a photographic transparency in close-spaced proximity to the web.

Further objects and advantages of the present invention will be apparent from the following detailed description made with reference to the accompanying drawing forming a part of the present invention for all subject matter therein and in which:

FIGURE 1 is a schematic elevational view showing electrophotographic equipment embodying the present invention;

FIGURE 2 is an enlarged elevational view of the mechanism for slowing down the web at each exposing station in the FIG. 1 equipment, the parts being shown in their position prior to the web-slowdown movement of this mechanism;

FIGURE 3 is a schematic diagram showing the control circuit for the web-slowdown mechanism at each exposing station in FIG. 1.

Referring to FIG. 1, a web of photoconductive material 10 moves from a supply roll 11 upward past guide rolls 12 and 13 through a first corona charging station 14, at which one side of the web is charged electrostatically in a known fashion.

From the first charging station 14 the web passes over a guide roller 15 which insures that the web follows a predetermined path through the charging station 14. The web passes up over a guide and support roller 16, which is supported at the entrance side of the first exposing station 17 for displacement horizontally as explained hereinafter. The web 10 passes from roller 16 horizontally through the first exposing station 17 to a guide and support roller 18, which is supported at the exit side of station 17 for displacement horizontally in unison with roller 16.

At the first exposing station 17 the charged underside of the web 10 is exposed to light from a fixedly positioned projector 19 which is transmitted through a photographic transparency 20. This transparency has light-transmitting areas and non-light-transmitting, or "shadow", areas. The light transmitted through the light-transmitting areas of the transparency will impinge on corresponding areas of the web to discharge the electrostatic charge on the portions, only, of the web. Consequently, the web leaving the first exposing station 17 has portions which are charged and portions which are not charged, as determined by the shadow and light-transmitting areas of the transparency 20. Preferably, the charged portions correspond to the image portions but, depending on the process, they

may correspond to either the image or non-image portions, as desired.

In accordance with the preferred embodiment of this invention, the transparency 20 is supported in close proximity to the charged underside of the web 10 by a holder 21 which is stationary with respect to the longitudinal path of the web 10. This holder 21 also preferably is mounted for movement laterally of the web to follow any lateral wandering or displacement of the web as it passes through this station, as disclosed in the copending U.S. patent application of Francis Hunstiger and Webster C. Roberts, Ser. No. 449,984, filed Apr. 22, 1965, now abandoned, assigned to the same assignee as the present invention.

However, if desired, the transparency may be within the fixedly positioned projector 19.

The projector 19 has a high intensity lamp which is flashed for a brief interval to project the photographic image onto the web. The timing of the flash of the projector is controlled in a known manner in response to the movement of the web itself so that the photographic image is projected on successive areas of the web which are disposed in close succession along the length of the web. At the first exposing station a registration mark is put on the web, either photographically or mechanically, adjacent the first recorded image to control the timing of the flash at subsequent exposing stations, so that the later-recorded images will be superimposed over the first recorded image in proper registration.

As it comes out of the first exposing station, the web passes down over the guide roller 18 into a first developing station 22 having a developer tank 23 in which toner particles, suspended in liquid, are applied. These toner particles may be applied to either the charged or uncharged areas of the web, depending upon the particular developing process involved. The web passes around a rotatable guide drum 24 in the developer tank.

The web then passes up out of the developer tank 23 between the drum 24 and a squeegee roll 25, which removes excess developer fluid, to a second series of charging, exposing and developing stations, which are essentially identical to the already-described first charging station 14, first exposing station 17 and first developing station 22. Corresponding elements of these second stations and the guide rollers for the web are given the same reference numerals as those of the first stations and guide rollers, but with an *a* suffix added. A detailed description of these corresponding elements will be omitted as unnecessary. At the second exposing station 17*a*, a second photographic image is projected onto the web, superimposed over the first image thereon.

After passing in succession through the second charging station 14*a*, the second exposing station 17*a* and the second developing station 22*a*, the web then passes to an identical third series of charging, exposing and developing stations for printing a third photographic image on the web, superimposed over the first two images thereon. The elements of these third stations and the respective guide rollers are given the same reference numerals as those of the first stations and guide rollers, but with a *b* suffix added.

Proper registration of the second and third recorded images with the first recorded image on the web may be accomplished by detecting the registration mark which was put on the web adjacent the first image, and timing the flash of the second or third projector in response to such detection of the registration mark.

From the third developing station 22*b* the web passes up over a guide roller 26 to a dryer station 27 where the toner particles are fixed to the web. From the dryer station the web passes between drive rolls 28, 29, which advance the web through the equipment continuously at a constant speed. The lower drive roll 28 is driven from a motor 30 through a belt or chain drive 31. From the drive rolls 28, 29 the web may pass through a sheeter

station (not shown) in which it is cut into successive sheets, one sheet for each set of three superimposed images on the web.

In accordance with the present invention, during the brief interval when a photographic image is being projected onto the web at a respective exposing station, the speed differential between the moving web and the projected image is reduced by reducing the effective speed of the web within the exposing station. This reduces the blurring or smearing of the recorded image on the web, as well as reducing the distortion of middle tones and the dropping out of highlights of the recorded image.

Referring to FIG. 1, at the first exposing station 17 this reduction of the effective speed of the web is effected by simultaneously displacing both guide rollers 16 and 18 quickly to the left while the projector 19 is being flashed. The speed at which the rollers 16, 18 are displaced to the left is less than the constant speed at which the web continues to be driven to the right by the feed rolls 28, 29, so that the net speed of the web past the transparency support 21 in the first exposing station at this time is only a fraction of the speed at which the web is being driven through the entire equipment by the feed rolls 28, 29. For example, if the rated web speed through the equipment is about 13 inches per second, the guide rollers 16, 18 may be displaced at a speed of about 10 inches per second in the opposite direction while the image is being projected onto the web, so that the speed differential between the moving web and the stationary projected image will be only 3 inches per second.

At the completion of each projection of an image onto the web, as described, the guide rollers 16, 18 are displaced quickly to the right to their original starting position, ready to be displaced again to the left the next time the image is to be projected onto the next length of the web.

The same operation takes place at each of the subsequent exposing stations 17*a* and 17*b*.

Referring to FIG. 2, the web guide roller 16 at the left (entrance) side of the first exposing station is rotatably mounted at 32 on the upper end of a support member 33. The lower end of this support member is pivotally mounted on a fixed horizontal pivot 34. A bifurcated coupling sleeve 35 is pivotally connected to the support member 32 at a pivot pin 36 located midway between the upper and lower ends of support member 32. The coupling sleeve 35 is attached to the outer end of a rigid horizontal rod 38, whose opposite, inner end is attached to the right side of a cam 39.

The web guide roller 18 at the right (exit) side of the first exposing station is similarly supported by a similar assembly, the elements of which are given the same reference numerals as those just described, but with a "prime" subscript added. The inner end of the rod 38' in this assembly is attached to the right side of cam 39.

Cam 39 is formed with an elongated vertical slot 40 which slidably receives a horizontal pin 41. This pin is rigidly attached off-center to a rotatable horizontal shaft 42. Elements 39-42 constitute a so-called "Scotch yoke" mechanism for imparting a sinusoidal movement to cam 39, so that the acceleration and deceleration of the web are almost constant. Shaft 42 is coupled to the drive motor 30 through a suitable mechanism which is designated schematically by the dashed line 43 in FIG. 1. This mechanism 43 includes a quick-acting, single revolution clutch 44, which will be engaged when the shaft 42 is to be driven from motor 30. Clutch 44 may be a magnetic clutch whose field coil is energized to engage the clutch just before the projector 19 is flashed, so that the web support rollers 16, 18 will have started moving to the left when the projection of the image begins.

Referring to FIG. 3, the control circuit for this clutch may include a sensing device S which senses the web

5

movement and is closed for a brief period each time the web has moved through a distance corresponding substantially to the length of a single image area. The closing of sensing device S completes an initial energization circuit for relay R across a power supply 46. Relay R closes its contacts R-2 to energize the field coil 45 of clutch 44 across this same power supply. Also, relay R closes its holding contacts R-1 to maintain relay R energized through R-1 and a normally-closed switch 47. Switch 47 is controlled by cam 39 such that after this cam has completed one revolution it will open switch 47 to de-energize relay R, thus disengaging clutch 44 until the next time that the sensing device S is closed.

FIGS. 1 and 2 show the "normal" or starting position of the parts, before the web slowdown through the exposing station is to take place.

When the flash of the projector is to take place, shaft 42 is rotated from the position shown in FIG. 2, and through the pin-and-slot connection 41, 40 it displaces cam 39 to the left so as to move both web guide rollers 16 and 18 to the left, to the positions shown in phantom in FIG. 2. Such movement of the cam is imparted through the respective rods 38 and 38' to move the respective roller supports 33 and 33' pivotally counterclockwise about the respective pivots 34 and 34'. The projector flash takes place during the essentially straight-line part of the sinusoidal movement of cam 39, so that the linear speed of the web-supporting rollers to the left will be substantially constant for the entire duration of the flash. At the end of the first half-turn of shaft 42, web guide rollers 16 and 18 and the web will be in the phantom line positions in FIG. 2.

The horizontal spacing between the pivot pins 34 and 34' for the roller supports 33 and 33' is equal to the spacing between the roller pivots 32 and 32'. Also, the distance between the pivots 34 and 32 at the roller support 33 is equal to the distance between the pivots 34' and 32' at the roller support 33'. Therefore, the web guide rollers 16 and 18 are supported at the upper corners of what is, in effect, a parallelogram linkage. As shown in FIG. 1, the web 10 passes substantially through the axis of the lower pivot 34 of this linkage at the entrance side of the exposing station, and the web also passes substantially through the axis of the lower pivot 34' at the exit side of this exposing station. Consequently, the distance through which the web moves between these lower pivots 34 and 34' of the linkage remains the same, regardless of the displacement of the web guide rollers 16 and 18, and the speed of the web between the charging station 14 and the developing station 22 also remains unchanged. That is to say, the displacement of the web supporting rollers 16 and 18, as described, only changes the effective speed of the web within the exposing station 17, but not its speed from one station to the next, which is its overall speed through the equipment, as determined by the feed rolls 28, 29.

After the completion of the image projection onto the web, the shaft 42 continues rotating to return the parts to the full-line starting position shown in FIG. 2. This re-accelerates the web within the first exposing station 17 to the overall speed of the web through the equipment.

An essentially similar arrangement is provided at each of the subsequent exposing stations 17a and 17b for shifting the respective web-supporting rollers to the left so as to slow down the effective speed of the web within that station while the respective projector is being flashed. The roller arrangement at the second exposing station 17a differs from that at the first exposing station in that the respective pivots 36 and 36a' also carry Molleton cleaner rolls 37a and 37a', respectively, which wipingly engage the web-supporting rollers 16a and 16a' to keep them clean. Similar cleaner rolls 37b and 37b' are provided at the third exposing station 17b.

Also, at the second and third stations the respective clutches 44a and 44b operate individually essentially as

6

described with reference to FIG. 3, except that the sensing devices for causing clutch engagement here preferably sense the registration mark adjacent the recorded first image on the web. The projector flash at the second and third exposing stations takes place after the respective clutch is engaged to cause the respective web-support rollers to start moving to the left in FIG. 1, so that projection takes place while the web-support rollers are moving at substantially constant velocity, as described. Preferably, the projector flash at each of the second and third exposing stations takes place out of phase (i.e., not simultaneously) with each other and with the projector flash at the first exposing station.

From the foregoing, it will be apparent that the particular arrangement illustrated in the drawing provides an effective way to reduce the speed differential between the continuously moving web and the projected image while the latter is being recorded on the web. However, it will be evident to those skilled in the art to which this invention pertains that arrangements differing from the embodiment specifically disclosed may be adopted without departing from the spirit and scope of this invention.

Accordingly, while the present invention has been described in detail with reference to the embodiment illustrated in the accompanying drawing, it is hereby our intention to cover all constructions, modifications and arrangements which fall within the ability of those skilled in the art and within the scope and spirit of the present invention.

Having described our invention, we claim:

1. An electrophotographic apparatus for recording the image of a transparency on a photoconductive surface of a web of sheetlike material comprising a charging station, an exposing station, a developing station, driving means for advancing the web through said charging station, exposing station and developing station, said driving means advancing the web through said charging station to said exposing station and from said exposing station through said developing station at a substantially constant given speed, means at said exposing station for periodically and briefly projecting said image onto the moving web comprising a flash lamp and means for supporting said transparency containing said image in a stationary position relative to said flash lamp so as to project said image onto said web on the flashing of said lamp, and web slowdown means at said exposing station operative prior to and during each flashing of said lamp for moving the portion of the web to be exposed at the station opposite to the direction of the web movement imparted by said driving means to decrease the speed at which the web is moving relative to said flash lamp while maintaining a constant speed of the web to and from said exposing station and for moving the web in the direction of web movement after each flashing of said lamp to increase the speed of the web relative to said lamp in said exposing station above the constant speed of the web moving to and from the station to maintain the average speed through said station equal to said constant speed.

2. An electrophotographic apparatus according to claim 1 wherein said means for supporting said transparency in said stationary position relative to said flash lamp in said exposing station supports the transparency in close-spaced proximity to said photoconductive surface of said web and said apparatus includes means driven in timed relationship to said web slowdown means to actuate said flash lamp.

3. An electrophotographic apparatus according to claim 1 wherein said web slowdown means in said exposing station comprises a pair of web guiding members located respectively at the web entrance and exit sides of the exposing station, a pair of support members which

7

respectively support said web guiding members, a pair of respective pivotal supports for said support members, operating means for simultaneously moving both said support members pivotally in one direction to displace said web guiding members opposite to the direction of said web movement during the projection of said image onto the web and for simultaneously moving both said support members pivotally in a direction opposite to said one direction to return said web guiding members in the same direction as the web movement following the projection of said image onto the web, and means driven by said operating means for actuating said flash lamp.

5

10

8

References Cited

UNITED STATES PATENTS

2,333,768	11/1943	Davies	95—12.5	X
2,796,009	6/1957	Doyle	95—12.5	
2,909,971	10/1959	Barber	95—1.7	
3,066,589	12/1962	Beatty	95—12.5	

JOHN M. HORAN, Primary Examiner

U.S. Cl. X.R.

355—18