

Feb. 11, 1969

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3,427,658

ELECTROPHOTOGRAPHIC APPARATUS AND METHOD

Filed May 6, 1966

Sheet 1 of 2

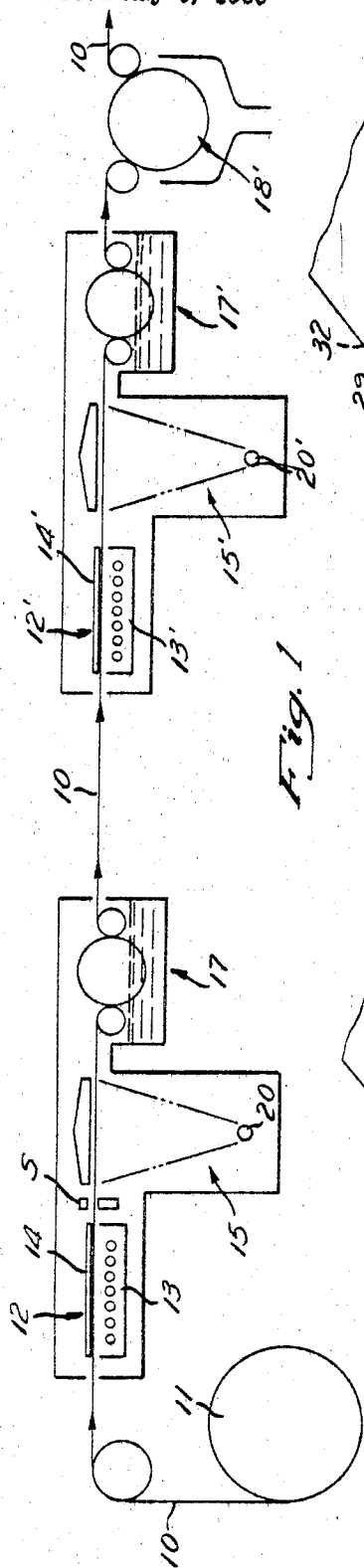


Fig. 1

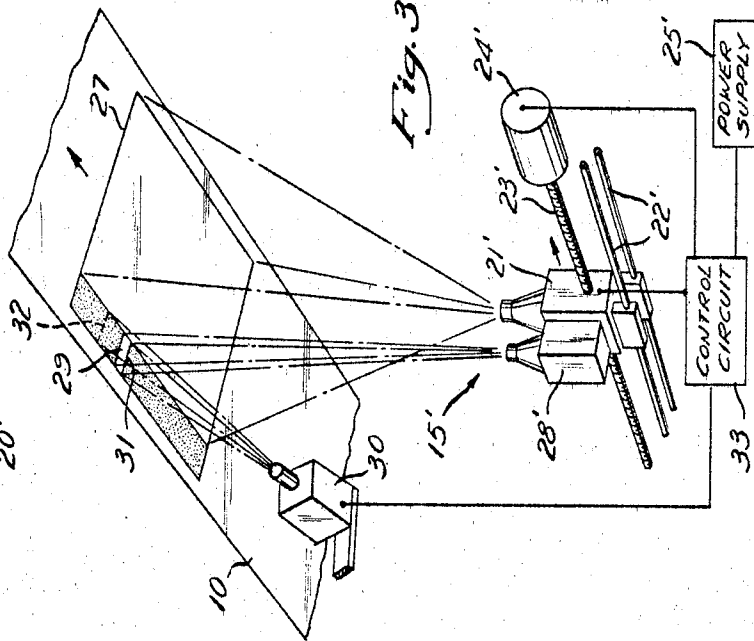


Fig. 3

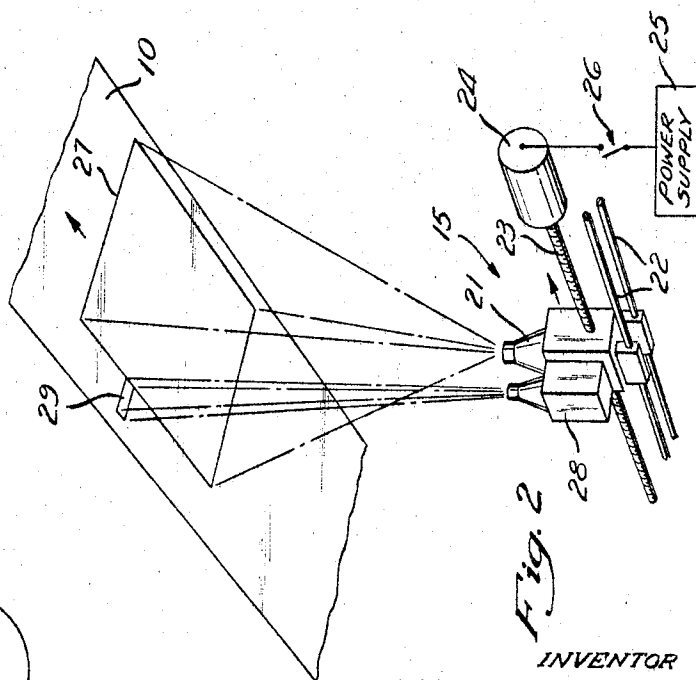


Fig. 2

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Sheet 2 of 2

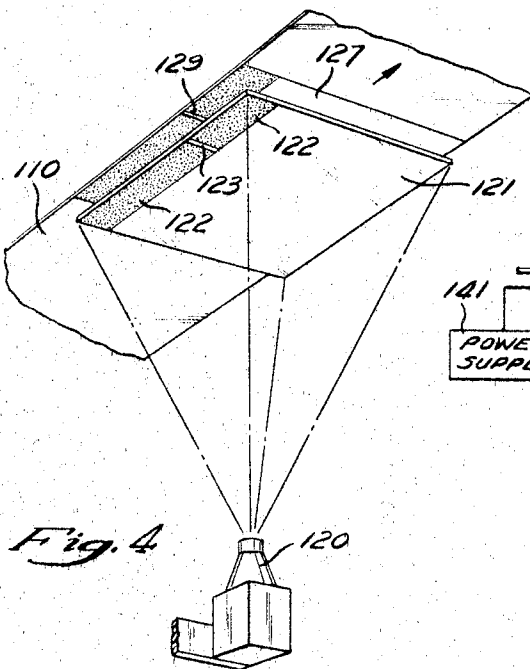


Fig. 4

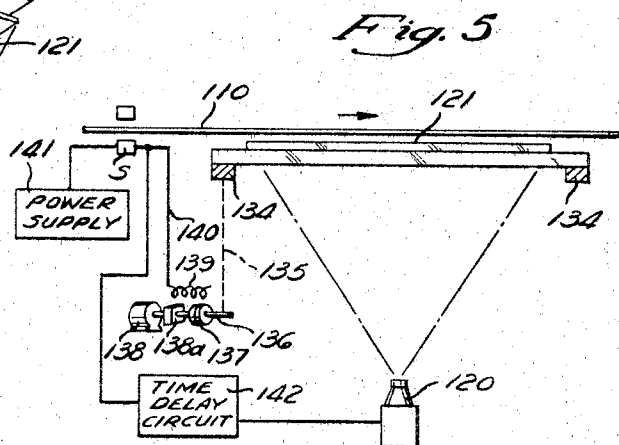


Fig. 5

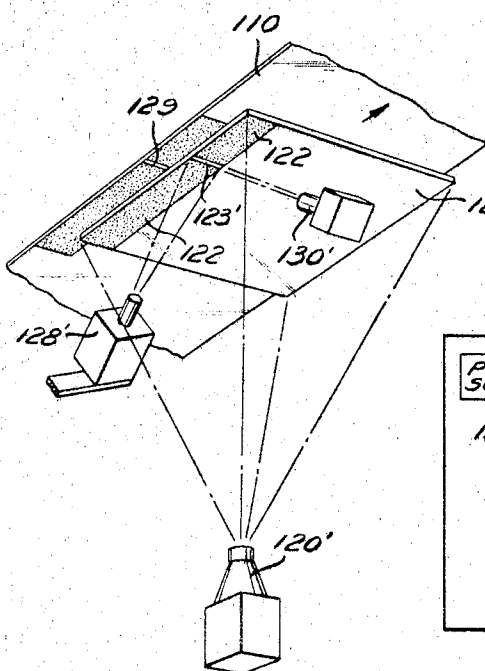


Fig. 6

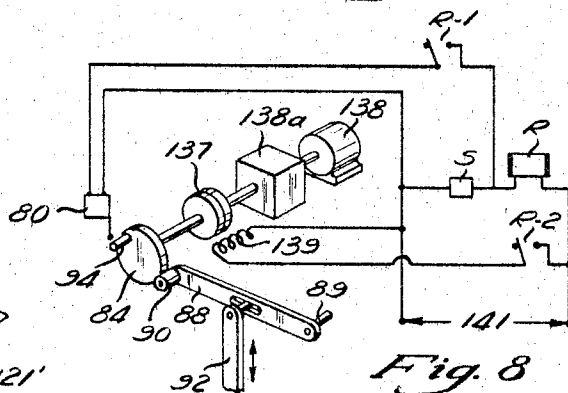


Fig. 7

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ELECTROPHOTOGRAPHIC APPARATUS AND METHOD

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10 Claims

Int. Cl. G03g 5/02, 13/00

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 nonlight 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 noncharged 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, a 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.

One aspect of the present invention is directed to reducing such smearing or blurring of the recorded images by reducing the speed of relative movement between the moving web and each projected image while the image is being projected onto the web.

The present electrophotographic equipment records a plurality of different photographic images, such as different color images, superimposed on one another in registration on the web. To this end the equipment will have, in addition to the aforementioned charging station, exposing station and developing station for printing the first image, a series of charging, exposing and developing stations for each additional image to be printed on the web. It is, of course, vitally important that there be provision for establishing proper registration of the successively recorded, superimposed images so that they will provide the desired total or composite printed image.

Another important aspect of the present invention is directed to an improved electrophotographic apparatus and method having novel provision for establishing proper registration of the superimposed recorded images, in addition to reducing the smearing or blurring of these recorded images as referred to above.

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 a plurality of photographic images, superimposed on one another in proper registration.

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

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In accordance with the present invention, reduced blurring or smearing of each photographic image recorded on the web is obtained by reducing the speed of relative movement between the moving web and the image being projected thereon. This is done, in the described embodiments, by moving the projected image along the path of the web in the same direction as the web movement. Since a plurality of images are to be recorded, superimposed on one another on the web, a registration mark is recorded adjacent the first recorded image on the web, and this registration mark is employed in a novel manner at subsequent exposing stations to control the recording of the images there so as to insure that the superimposed recorded images will be in proper registration with one another.

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

FIGURE 1 is a schematic view of electrophotographic equipment which may embody the present invention and having provisions for recording two different photographic images, superimposed on one another, on a moving web;

FIGURE 2 is a schematic perspective view of the image-recording apparatus at the first exposing station in this equipment, in accordance with a first embodiment of the present invention;

FIGURE 3 is a view similar to FIG. 2 and showing the image-recording apparatus at the second exposing station in this equipment, in accordance with this first embodiment of the present invention;

FIGURE 4 is a fragmentary perspective view showing schematically a part of the image-recording apparatus at the first exposing station in this equipment, in accordance with a second embodiment of this invention;

FIGURE 5 is a schematic view, partly in vertical section, showing additional components of the FIG. 4 apparatus;

FIGURE 6 is a fragmentary perspective view showing schematically part of the image-recording apparatus at the second exposing station, in accordance with this second embodiment of the present invention;

FIGURE 7 is a schematic view, partly in vertical section, showing additional components of the FIG. 6 apparatus; and

FIGURE 8 is a schematic view showing a control mechanism for effecting movement of the projected image along the path of the web through an exposing station in the present invention.

Referring to FIG. 1, in the equipment illustrated there, a web of sheet-like photoconductive material 10 moves vertically from a supply roll 11, and then horizontally through a first corona charging station 12 for charging one side of the photoconductive web, the underside in the illustrated embodiment, with an overall electrostatic charge in known fashion as the web passes through the charging station. The charging station will not be described in detail but suffice it to say that it may include a corona charging unit 13 on the underside of the web and a metallic plate 14 on the upper side of the web.

From the charging station 12, the web moves to a first exposing station 15 where the web is exposed to light transmitted through a photographic transparency (not shown) having light transmitting areas and nonlight transmitting, or "shadow," areas. The light transmitted by the transparency will strike selected portions of the web as determined by the light-transmitting areas of the transparency to discharge the electrostatic charge on these portions only. Consequently, the web leaving the exposing station 15 has selected portions which are charged and selected portions which are not charged. The charged

portions correspond preferably to the image portions of the material but, depending on the process, may correspond to either the image or nonimage portions of the material to be printed. The web moves from the exposure unit 15 to a first developing station 17 where toner particles are applied while suspended in liquid form. The toner particles may be applied to the charged or uncharged portion of the web, depending upon the particular type of developing system being employed.

At the first exposing station 15, the web, which is wider than the image which is projected thereon, is exposed through the transparency by flashing a high intensity lamp 20, which is flashed while the web is moving. The timing of the flashing of the lamp 20 may be controlled in any suitable fashion. For example, the web may have spaced register marks thereon which are sensed by a suitable sensing device S which initiates the flashing of the lamp at the proper time. For example, the web may have a series of holes along its edge which are disposed so that each time the web has moved sufficiently to enable a new image to be recorded on the web, a hole is disposed opposite a light to pass light to a photocell to initiate the flashing of the lamp. Alternatively, the sensing device S at the first exposing station may be omitted and the flashing of the projector lamp at the first exposing station may be correlated with the operation of the feed rolls (not shown) which advance the web continuously at uniform speed through the equipment. In either case the flashing is controlled so that the successive recorded first images are printed in close succession along the length of the web without unnecessary web wastage.

The web passes from the first developing station 17 to a second corona charging station 12', identical to the first, and from there to a second exposing station 15', and thence through a second developer tank 17'. At the second exposing station 15' a second photographic image is projected onto the web, superimposed over the first image thereon and in registration with the first image, as explained hereinafter. Corresponding elements of the second series of stations have the same reference numerals as those of the first stations with a "prime" suffix added and, since they are similar, the description of these elements will not be repeated.

If only two different images are to be recorded on the web, the web passes from the second developing station through squeegee rolls to a drying drum 18'. However, if more than two images are to be recorded this drying station will be omitted and the web will pass through one or more additional series of charging, exposing and developing stations (not shown), which are identical to those of the second stations, the number of such additional series of stations depending upon the number of different images which are to be superimposed on one another on the web. The drying station will be provided after the final developing station.

Referring to FIG. 2, in accordance with a first embodiment of the present invention there is provided at the first exposing station 15 a main projector 21 and an auxiliary projector 28 mounted for movement in unison parallel to the straight line path of movement of the web through this station. To this end the main projector 21 is slidably mounted on fixed guide rods 22 extending parallel to the path of the web. The projector 21 is screw-threadedly coupled to a rotary lead screw 23 driven by a servomotor 24. The motor is energized from a power supply 25 through a suitable switching arrangement 26, which will be closed to initiate the movement of the projector 21 in the same direction as the web just before the projector 21 is to be flashed. The energization of the motor may take place in response to the operation of the control arrangement for triggering the flash of projector 21, such as the aforementioned sensing device S or any suitable means associated with the web feed rolls.

The main projector 21 contains the aforementioned lamp 20, a photographic transparency, and a lens system,

all arranged in a manner well known to those skilled in the art.

When the motor 24 is at full speed it moves the projector 21 linearly in the same direction as the web 10, but at a speed which is either slightly higher or slightly lower than that of the web by an amount substantially less than the speed of the web itself. The flash of the main projector 21 is triggered at a time when the projector is moving as just described, so that the relative movement between the web and the projected image 27 is relatively low. This minimizes the smearing or blurring of the projected image on the web, at the same time avoiding the need for an extremely short flash duration to keep such smearing or blurring within acceptable limits. Such a short flash duration is undesirable because it would require high light intensity, high voltage and expensive light equipment in the projector.

As an illustrative example, if the web 10 is moving at a uniform speed of 24 inches per second, the projector 21 may be moved at a speed of 30 inches per second during the recording of the image on the web. The relative velocity between the web and the projector is thus only 6 inches per second, and if the duration of the flash is 100 microseconds the blur of the projected image on the web will be only 0.0006 inch.

As shown in FIG. 2, the auxiliary projector 28 is attached to the main projector 21 at the first exposing station, so that the two projectors move in unison. The auxiliary projector is constructed and arranged to project onto the web 10, at one side edge of the image 27 projected by the main projector 21, a slit-like registration mark 29 which is extremely narrow in the direction of movement of the web. The auxiliary projector 28 is flashed at the same time as the main projector 21, and the registration mark 29 has a predetermined position with respect to the first photographic image 27 recorded on the web. This registration mark 29 is used to control the operation of the image projector at each succeeding exposing station in the apparatus, so that each successive image will be superimposed in proper registration with the first image 27 recorded on the web. After the toner particles are applied, this registration mark 29 is a narrow bright slit and the remainder of this marginal area is a dark or shadow area.

After each flash of the main projector 21 is completed, the projectors 21 and 28 are returned in the opposite direction to the original starting positions before the next flash is initiated. This may be done by reversing the motor 24 or by providing a lead screw 23 which reverses the direction of movement of the projectors at the end of their forward stroke. In the specific example given above, with the web traveling at 24 inches per second, if the length of the projected image on the web is 24 inches this gives almost one full second to return the projectors to their original position prior to the projection of the image onto the next 24 inch length of the web.

If desired, the registration mark may be put on the web next to the first recorded image 27 by any suitable means other than an auxiliary projector.

As shown in FIG. 3, at the second exposing station 15' (as well as at any additional exposing stations in the apparatus), there is provided a stationary photoelectric cell 30 for detecting the narrow registration mark 29 beside each first image 27 recorded on the web. This photoelectric cell is directional, sensing only the marginal area of the web where the registration mark 29 will appear, but it senses a substantially longer length of the web than the extremely narrow dimension of the registration mark 29 lengthwise of the web. As shown in FIG. 1, the photocell senses this marginal area from line 31 to line 32, whereas the registration mark 29 has a dimension lengthwise of the web which is only a small fraction of the distance between these lines.

At the second exposing station the main projector 21' is mounted for slidable movement along guide rods 22'

parallel to the direction of web movement by means of a lead screw 23' driven by a servomotor 24'. The main projector 21', when flashed, projects a second photographic image onto the web, superimposed on the first image 27.

An auxiliary projector 28' is attached to the main projector 21' for movement in unison with it. The auxiliary projector 28' continuously projects a narrow beam of light onto the marginal area of the web where the registration mark 29 will appear. The energization of the motor 24' and the flashing of the main projector 21' are under the control of a suitable control circuit 33, which is operated by the photocell 30 as follows:

With the web 10 moving from left to right in FIG. 3, when the registration mark 29 on the web first comes into registration with the beam of light projected by the auxiliary projector 28', the resulting illumination of the registration mark is sensed by the photocell 30. The photocell now operates the control circuit 33 to energize motor 24' so as to move the two projectors 21' and 28' in the same direction as the web, but at a speed which is slightly higher than that of the web by an amount substantially less than the speed of the web itself.

The narrow beam of light projected by the auxiliary projector 28' overtakes the registration mark 29 on the moving web, and when they are in registration again the photocell 30 is again actuated. At this instant the main projector 21' is moving at a speed somewhat higher than that of the web, the speed differential between them preferably being the same as it was when the first photographic image 27 was being projected onto the web at the first exposing station 15. The second actuation of the photocell 30 causes it to operate the control circuit 33 to initiate the flash of the main projector 21' to project onto the moving web a second photographic image which is superimposed over, and in registration with, the first image thereon.

As a specific example, with the web traveling at 24 inches per second, assume that there is a time delay of 0.01 second between the first energization of the photocell 30 (in response to the first registration of the narrow beam from the auxiliary projector 28' with the registration mark 29 on the web) and the starting of the servomotor 24'. If the servomotor comes up to full speed substantially instantaneously, the registration mark 29 on the web will have moved about .24 inch past the auxiliary projector beam, and it will take the auxiliary projector beam about 0.04 second to overtake the registration mark 29. During this 0.04 second, the web will have moved only about one inch. Therefore, the total time elapsed between the first and second registrations of the auxiliary projector beam with the registration mark 29 on the moving web will be only about .05 second. After the flashing of the main projector, which may take about 100 microseconds, this leaves almost one full second to return the projectors to their starting position to begin the next sequence of detection, registration and flashing, assuming that the length of the projected image on the tape is 24 inches.

With this arrangement, at the second exposing station 15' (and at each additional exposing station, if any, in the FIG. 1 equipment) the projected image is recorded on the moving web in precisely registering, superimposed relationship with respect to the first recorded image 27 while the image being projected is moving at a relatively low speed with respect to the moving web, so that blurring or smearing is minimized.

In this first-described embodiment of the present invention the entire projector assembly is moved during the recording of each image. In situations where it is desired to minimize the inertia and the speed and the extent of movement of the moving parts, an arrangement may be used in which only the object lens in the projector is moved during the projection of an image onto the web. Such an arrangement will satisfy the basic purpose of moving the projected image along the path of the web at a speed only

slightly different from that of the web itself, and it will have the advantage that the speed at which the lens is moved and the distance through which the lens is moved will be only a fraction of the speed and distance of movement of the projected image, this fraction being $1/M$, where M is the magnification ratio of the projector. Also, relatively small acceleration forces will be involved in achieving registration with the first recorded image on the moving web, so that the entire process of initial detection, registration and flashing of the projector at each exposing station after the first may be accomplished in a shorter time and over a very short distance of the moving web. Alternatively, in order to further reduce the blurring or smearing of the projected image, the speed differential between the projected image and the moving web may be reduced and still the entire sequence of detection, registration and flashing will take place in an acceptably brief interval of time and over a short distance of the moving web.

FIGURES 4-7 illustrate a further embodiment of this invention in which the movement of the projected image along the path of the web is accomplished by moving the photographic transparency parallel to, and closely spaced from, the web.

As shown in FIG. 4, at the first exposing station the projector 120 is fixedly positioned and the photographic transparency 121 is immediately adjacent to, but spaced from the moving web 110. The transparency has a shadow or dark region 122 along one longitudinal edge which is intersected by a "bright" or transparent region 123. This transparent region 123 is extremely narrow longitudinally of the web, so that when the projector 120 is flashed it will record a narrow registration mark 129 at this side of the first photographic image 127 recorded on the web. The shadow region 122 and transparent region 123 may be on the transparency holder, rather than on the transparency, if desired.

As shown in FIG. 5, the photographic transparency 121 is positioned on a suitable support frame 134 which is movable longitudinally of the path of the web 110 at the first exposing station. To this end, the support frame is coupled through a suitable mechanical linkage, designated schematically by the dashed line 135, to the output shaft 136 of a quick-acting magnetic clutch 137. The input shaft of this clutch is driven continuously by a motor 138 through a gear reduction 138a. The clutch is engaged when its field coil 139 is energized. The coil of the clutch is connected through a suitable electrical connection, designated schematically by the line 140 in FIG. 5, to the power supply 141 through a suitable switching device S. This switching device S may be a sensing device at the first exposing station or it may be associated with the web feed rolls, such that coil 139 will be energized each time a predetermined length of the web has been advanced. When coil 139 is thus energized it brings the clutch 137 into engagement to begin moving the support frame 134 and the first photographic transparency 121 to the right in FIG. 5, in the same direction as the moving web 110.

The operation of the switching device S also connects the projector 120 to the power supply 141 through a suitable time delay circuit 142, the arrangement being such that the projector 120 is not flashed until after the transparency 121 is moving at the desired speed, either slightly lower or slightly higher than the web speed, and in the same direction, so that the speed differential between the moving web and the projected image will be substantially lower than the speed of the web itself.

When the projector 120 is flashed, it records on the moving web the first photographic image 127 and the narrow registration mark 129 at one side of the recorded image, as already stated.

After the brief interval of time during which the first image is recorded, the support frame 134 is returned to the left in FIG. 5 to its starting position before the web 110 has advanced far enough to initiate the next operation of the switching device S.

At the second exposing station, a second photographic transparency 121' (FIGS. 6 and 7) is similarly movably supported in close proximity to the web. The spacing between the transparency and the web is greatly exaggerated in FIG. 6 for convenience of illustration. The movable support frame 134' (FIG. 7) for this second transparency also supports a light source 128' and a photoelectric cell 130'. The light source 128' directs a beam of light through a narrow transparent region 123' of the second photographic transparency 121' onto the side edge region of the moving web where the registration mark 129 will appear. The photocell 130' is positioned to sense this same region of the moving web through the transparent region 123' of the photographic transparency 121'. The photocell is activated by the registration of the narrow beam of light from light source 128' with the narrow registration mark 129 on the web. When such registration occurs, the photocell 130' completes an energization circuit for the projector 120' from the power supply 141'.

The support frame 134' for the photographic transparency 121 at the second exposing station is connected through a suitable mechanical linkage 135' to the output shaft 136' of a magnetic clutch 137', whose input shaft is driven continuously through a gear reduction 138a' from a motor 138'. The coil 139' of this clutch is connected through a sensing device S' to the power supply 141'.

In operation, as each successive length of the web bearing a recorded first image moves into the second exposing station it operates the sensing device S', which causes the clutch 137' to become engaged so as to start the support frame 134' moving to the right in FIG. 7 at a speed slightly slower than the web speed. The light source 128', the photocell 130' and the photographic transparency 121' move in unison with the support frame 134'. While the support frame is in motion, the registration mark 129 on the web overtakes the narrow beam of light projected by the light source 128', and when they are in registration this operates the photocell 130', causing the projector 120' to be flashed to project the second photographic image onto the web, superimposed over the respective recorded first image thereon.

Following the projection of the second image onto the web, the support frame 134' is returned to its starting position before the web has advanced far enough to operate the sensing device S' again.

Each additional exposing station, if any, in the equipment has an arrangement similar to that of FIGS. 6 and 7 for insuring that the respective photographic image will be projected onto the web, superimposed over the previously-recorded images and in proper registration with them.

Various mechanisms and controls may be utilized to produce movement of the image to reduce the relative speed between the image and the web at the time the flash occurs, and such mechanisms and controls can be provided by those skilled in the art. FIG. 8 illustrates one general type of mechanism which might be used to produce movement of the image, for example, in apparatus of the type shown in FIGS. 5 and 7.

Referring to FIG. 8, the closing of switching device S energizes a relay R from the power supply 141 to close its normally open contacts R-1 and R-2. The closing of the normally-open relay contacts R-1 provides a self-holding circuit for the relay R through a normally-closed switch 80. The closing of the relay contacts R-2 energize the coil 139 of magnetic clutch 137. With clutch 137 engaged, the motor 138 drives a cam 84 to produce a reciprocating movement of a pivoted lever arm 88. The lever arm 88 is pivoted at one end, at 89, and has a cam follower 90 on its other end which cooperates with the cam 84. Reciprocation of the lever arm 88 by the cam 84 reciprocates a link 92 which may be connected to move the transparency holder, the objective lens, or the entire projector to effect movement of the projected image. The cam 84 also has a switch operating dog 94 which operates

switch 80 after one revolution of the cam to open the self-holding circuit for the relay R to deenergize the magnetic clutch.

Consequently, each signal from the sensing device S causes the cam to rotate one revolution to move the transparency holder, objective lens, or projector forwardly to reduce the relative movement between the web and image, and then to return the element operated thereby to its start position. The throw of the cam and the speed of the operation are timed so that the flash will occur during the forward movement of the element control by link 92.

Direct timing with the movement of the web can be accomplished by driving the input to the magnetic clutch directly from the mechanism for driving the web.

The basic control mechanism as shown in FIG. 8 can be used to operate the motor 24 for driving the lead screw 23 in apparatus of the type shown in FIGS. 2 and 3, where the entire projector is moved. The motor 24 can be continuously rotated and connected to the lead screw 23 by a magnetic clutch corresponding to the clutch 137 in FIG. 8 and controlled by the relay R, as described. The lead screw 23 may be a double lead screw which automatically returns the projector as the motor operates in one direction and the return of the projector may operate a switch for breaking the self-holding circuit for relay R.

It is to be understood that the photographic image projecting arrangement of FIGS. 4-7, in which the photographic transparency is supported in close proximity to the photoconductive surface of the web for movement in the same direction as the web while the image is being recorded on the web, may be modified to have a registration arrangement of the general type shown in FIGS. 2 and 3, instead of the registration arrangement described for FIG. 7. In that case, the photographic transparency at the second exposing station (and at each subsequent exposing station, as well) will be moved at a speed slightly higher than that of the web while its image is being recorded on the web in a manner similar to the movement of the entire projector as described with reference to FIG. 3.

Also, the image projecting arrangements described with reference to FIGS. 2 and 3 may be under the control of a registration arrangement of the general type shown in FIGS. 4-7, instead of the registration arrangement described for FIG. 3. In that case, at the second exposing station (and at each subsequent exposing station) the projected image will be moved along the path of the web at a speed slightly lower than the web speed. The movement of the projector or its object lens will be started by a detection arrangement similar to that of FIG. 7 and registration with the image already recorded on the web will be achieved when the registration mark on the moving web overtakes the narrow beam of light which is moving in unison with the photographic image being projected.

It will be evident to those skilled in the art to which this invention pertains that arrangements differing from those specifically disclosed may be adopted without departing from the spirit and scope of this invention. For example, the image projector at each station may be shutter-operated instead of flash-operated, if desired. Also, the projected image movement during each recording step, and the initial detection and registration steps at each exposing station subsequent to the first, may be effected by moving prisms or mirrors in the projectors, instead of by moving the entire projector, or its object lens, or the photographic transparency, as described.

Accordingly, while the present invention has been described in detail with reference to the embodiments illustrated in the accompanying drawings, it is hereby my 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.

I claim:

1. An electrophotographic apparatus for recording on a photoconductive surface of a web of sheet-like material a plurality of photographic images superimposed on one another on said surface comprising:

means for advancing the web along a predetermined path through a first charging station, a first exposing station and a first developing station positioned in succession along said path and thereafter through an additional series of charging, exposing and developing stations positioned in succession along said path for each additional photographic image to be recorded;

means at said first exposing station for projecting onto said surface of the moving web a first photographic image;

means for providing a registration mark on the web adjacent said recorded first image;

means operative during the projection of the image onto the moving web for limiting the speed of relative movement between the moving web and the projected first image thereon to a value which is substantially less than the speed of the web between said first charging, exposing and developing stations;

means at each additional exposing station for projecting the respective additional photographic image onto said surface of the moving web thereat;

sensing means at each additional exposing station for detecting said registration mark on the moving web and operative thereby to trigger the respective image projecting means thereat to project the respective photographic image onto the web;

and means operative during the projection of said last-mentioned image onto the moving web for limiting the speed of relative movement between the moving web and said last-mentioned projected image thereon to a value which is substantially less than the speed of the web between the respective charging, exposing and developing stations.

2. An electrophotographic apparatus according to claim 1, wherein each said means for limiting the speed of relative movement between the moving web and the respective projected image moves said projected image along the path of the web at the respective exposing station in the same direction as the web movement thereat.

3. An electrophotographic apparatus according to claim 2, wherein said means for projecting each photographic image onto the web includes a photographic transparency and a support for said transparency positioning the latter in closely-spaced proximity to said photoconductive surface of the web, and said means for moving the respective projected image moves said support in the same direction as the web movement while the image is being projected onto the web.

4. An electrophotographic apparatus according to claim 2, wherein said means for projecting each photographic image onto the web includes a projector at a substantial distance from the web, and said means for moving the projected image moves at least a portion of said projector in the same direction as the web movement while said image is being projected onto the web.

5. An electrophotographic apparatus according to claim 4, wherein said last-mentioned means moves the entire projector while the latter is projecting said image onto the web.

6. An electrophotographic apparatus according to claim 4, wherein said projector has a movable object lens, and said last-mentioned means moves said object lens while the projector is projecting said image onto the web.

7. An electrophotographic apparatus according to claim 2, wherein:

said sensing means at each additional exposing station includes means for projecting a narrow beam of light onto the region of the web where said registration mark will appear, and means for detecting

the registration of said narrow beam with the registration mark as the web moves past;

and said means for limiting the speed of relative movement between the moving web and the projected image at each additional exposing station is operative, in response to said registration, to move said narrow beam of light along the path of the web in the same direction as the web movement and at a speed higher than that of the web so that said narrow beam overtakes said registration mark and registers with the latter a second time;

and said sensing means at each additional station is operative, in response to said second registration of said narrow beam of light with said registration mark, to trigger the respective image projecting means thereat to project the respective additional image onto the moving web, superimposed on said first image thereon, while moving the respective projected image at a speed higher than that of the web.

8. An electrophotographic apparatus according to claim 2, and further comprising:

means for sensing the movement of the recorded first image into each additional exposing station and operative thereby to begin moving the respective image projecting means in the same direction as the web movement and at a speed lower than that of the web;

and wherein said sensing means at each additional exposing station is mounted for movement in unison with said image projecting means thereat, said last-mentioned sensing means including means for projecting a narrow beam of light onto the region of the web where said registration mark will appear and means for detecting the registration of said beam with the registration mark when the registration mark on the moving web overtakes said beam;

and wherein said sensing means at each additional exposing station is operative, in response to the registration of said narrow beam with said registration mark, to trigger the respective image projecting means thereat to project onto the moving web the respective additional image, moving in the same direction as the web and at a lower speed.

9. A process of electrophotographically recording on a photoconductive surface of a web of sheet-like material a plurality of photographic images superimposed on one another on said surface comprising the steps of:

advancing the web through a first charging station, a first exposing station and a first developing station in succession and thereafter through an additional series of charging, exposing and developing stations in succession for each additional photographic image to be recorded;

at said first exposing station, projecting onto said surface of the moving web a first photographic image and providing a registration mark adjacent said recorded first image;

during said projection of the first image onto the moving web, effecting relative movement between the moving web and the projected first image thereon at a speed differential which is substantially less than the speed of the web between said first charging, exposing and developing stations;

at each additional exposing station, detecting said registration mark on the moving web and, in response to said detection, projecting the respective additional photographic image onto said surface of the moving web thereat;

and, during the projection of said last-mentioned image onto the moving web, effecting relative movement between the moving web and said last-mentioned projected image thereon at a speed differential which is substantially less than the speed of the web between the respective charging, exposing and developing stations.

10. A process according to claim 9, wherein each step

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of effecting relative movement between the moving web and the respective projected image comprises moving said projected image along the path of the web at the respective exposing station in the same direction as the web movement thereat.

References Cited

UNITED STATES PATENTS

2,713,814 7/1955 Sonne ----- 95—12.5

12

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

5 JOHN M. HORAN, *Primary Examiner.*

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355—10, 13, 16, 17