June 17, 1969 F. HUNSTIGER 3,450,473

ELECTROPHOTOGRAPHIC APPARATUS

Original Filed June 4, 1964 Sheet 1 of 3

FIG-1

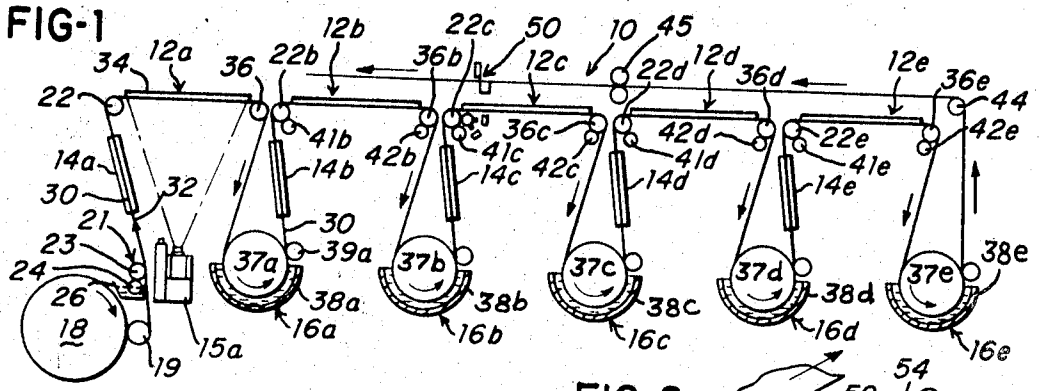


FIG-2

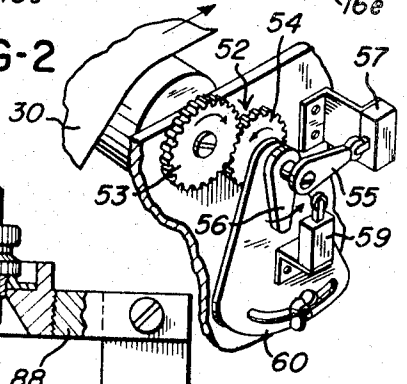


FIG-3

INVENTOR
FRANCIS HUNSTIGER
BY
Marshall, Bibel, French & Bugg
ATTORNEYS

June 17, 1969 F. HUNSTIGER 3,450,473

ELECTROPHOTOGRAPHIC APPARATUS

Original Filed June 4, 1964 Sheet 2 of 3

FIG-4

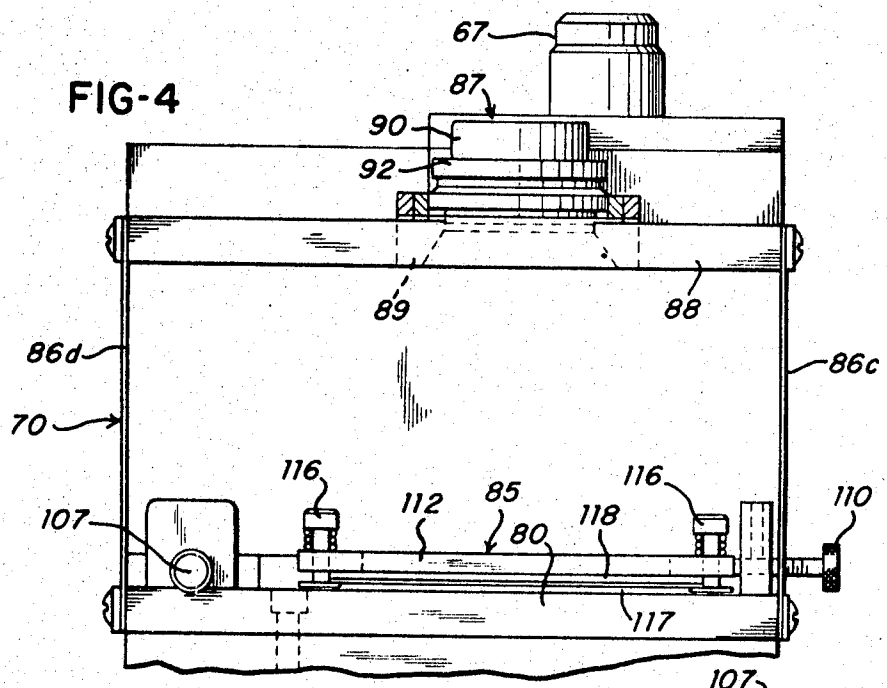


FIG-5

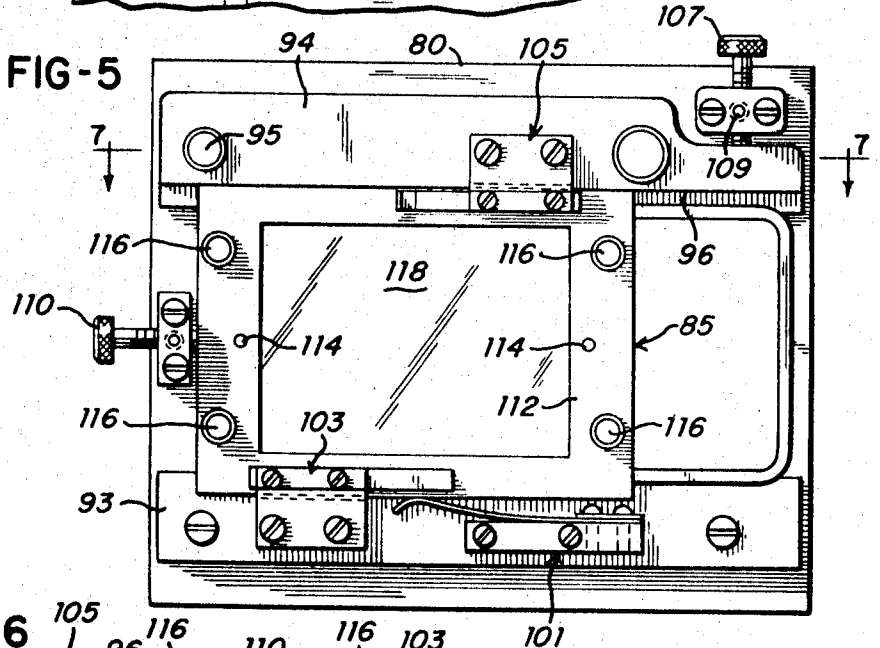
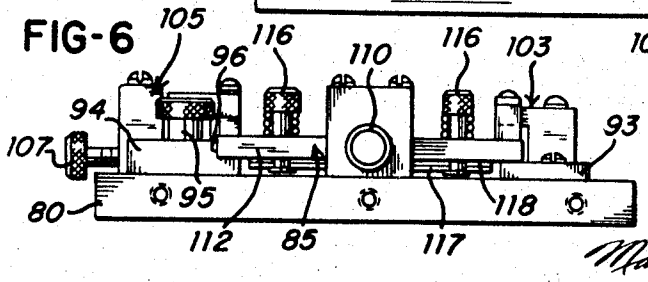


FIG-6



INVENTOR
FRANCIS HUNSTIGER

BY

Marechal, Bicbel, French & Bugg
ATTORNEYS

June 17, 1969 F. HUNSTIGER 3,450,473

ELECTROPHOTOGRAPHIC APPARATUS

Original Filed June 4, 1964 Sheet 3 of 3

FIG-7

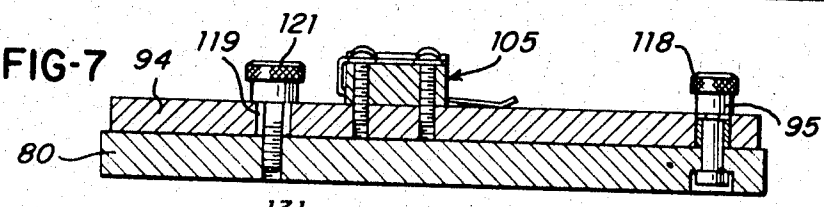
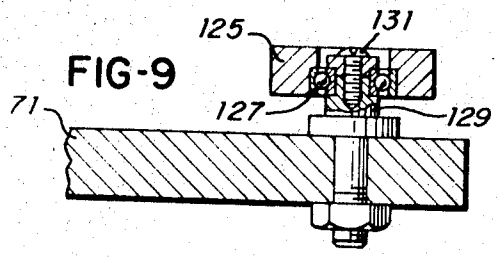


FIG-9



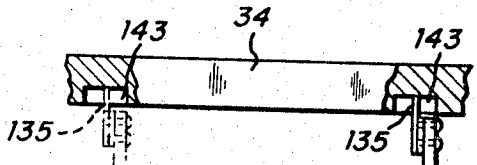
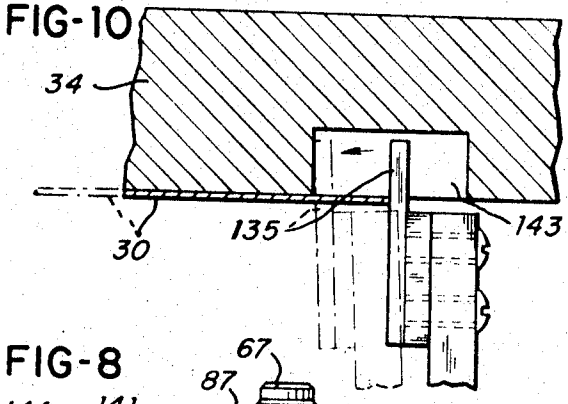


FIG-10



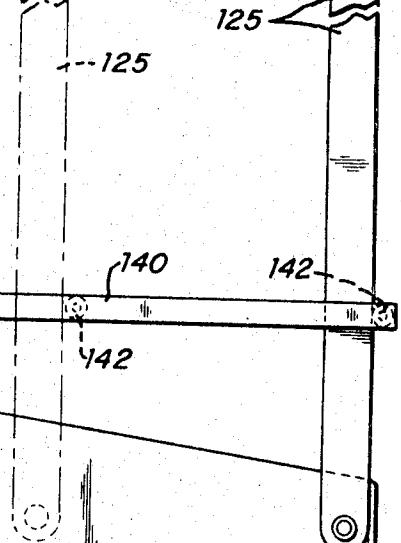


FIG-8

INVENTOR
FRANCIS HUNSTIGER

BY

Marechal, Bibel, French & Bugg
ATTORNEYS

United States Patent Office 3,450,473
Patented June 17, 1969

3,450,473

ELECTROPHOTOGRAPHIC APPARATUS

Francis Hunstiger, Parma Heights, Ohio, assignor to Harris-Intertype Corporation, Cleveland, Ohio, a corporation of Delaware

Original application June 4, 1964, Ser. No. 372,503, now Patent No. 3,307,458, dated Mar. 7, 1968. Divided and this application July 18, 1966, Ser. No. 566,053
Int. Cl. G03g 15/10, 15/00
U.S. Cl. 355—4 7 Claims

ABSTRACT OF THE DISCLOSURE

An electrophotographic printing and developing system for the liquid development of multi-color images on a web of paper utilizing a series of printing and developing stations. The non-image side of the web is maintained in a dry condition throughout the printing and liquid developing steps. An index mark is placed on the edge of the web as the first developing station. This index mark triggers a photo pick-up device at each station for assuring the precise registration of the images from station to station.

This application is a division of application Ser. No. 372,503, filed June 4, 1964, now patent No. 3,307,458 and assigned to the same assignee.

This invention relates to electrophotographic apparatus and more particularly to an improved electrophotographic system for forming a series of images and especially multi-colored images on an electrophotographic member.

In conventional printing systems, for example, multi-color lithographic or letterpress printing machines, the process usually involves the making of printing plates by any of several well known techniques, and the plates are thereafter assembled on the press. Each of the stations representative of the several colors constituting the multi-color image requires a plate representative of the image to be printed in a particular color, and after all of the plates have been prepared, they are assembled on the machine and the plates are secured in registered position to provide a composite multi-colored printed image with the several images being in registry. The registration procedure for this type equipment generally includes printing test copies, making any necessary adjustment of the plates, and repeating these operations as many times as may be required to bring the plates into proper registry. Additionally, the cylinders about which the plates are secured are of a fixed diameter and thus in the case of web fed equipment, present practical limitations on the size of images that may be printed without undesirable waste of the web between images.

These procedures represent conventional practices in the printing industry and one of the disadvantages is that the set-up time is extensive, for example, from one-half hour to six hours or more depending on the number of colors and the complexity of the equipment involved.

The present invention relates to multi-color printing equipment which eliminates pressure contact between the members which form the printed image. The apparatus in accordance with the present invention makes use of transparencies in the form of color separation units each of which is representative of one of the colors constituting the composite color subject. The set-up time for the apparatus of the present invention is substantially less than that of lithographic and letterpress equipment previously described. Additionally, there is the advantage that maximum web utilization is possible since the length of the image is not dependent upon the fixed diameter of a printing roll, but the image length may be varied within substantial limits and successive images may be spaced any desired distance apart along the web. Further, the equipment itself is substantially lighter in weight than letterpress and off-set equipment, and requires less clean-up time.

Accordingly, it is an object of the present invention to provide electrophotographic apparatus capable of producing images properly registered with respect to a web of electrophotographic material passing through the apparatus, which apparatus requires no pressure contact between the image forming elements.

It is a further object of the present invention to provide electrophotographic apparatus capable of producing images representative of different colors, or portions of a composite subject, which images are properly registered with each other.

Another object of the present invention is the provision of an improved web fed electrophotographic apparatus useable in multi-color reproduction systems wherein the web and projection system are so arranged and disposed that there is intially proper registration of an image on the web, and all subsequent images are registered with reference to the first image.

Another object of the present invention is the provision of an improved projector and registering system for lateral alignment of an optical image on a moving electrophotographic member.

Other objects and advantages of the present invention will be apparent from the following description, the accompanying drawings and the appended claims.

In the drawings:

FIG. 1 is a schematic view of the multi-colored electrophotographic printing equipment in accordance with the present invention;

FIG. 2 is a schematic view of the relative position of the switches which are adjustable to coordinate severance of the web in conjunction with the image formation thereon;

FIG. 3 is an enlarged detail view of the projector shown schematically at the first station in FIG. 1;

FIG. 4 is an enlarged fragmentary view of a portion of the projector as seen from the right of FIG. 3;

FIG. 5 is a plan view of the film holder and mounting assembly therefor;

FIG. 6 is a view from the left of FIG. 5 of the film holder and mounting assembly;

FIG. 7 is a view partly in section and partly in elevation along the lines 7—7 of FIG. 5;

FIG. 8 is a view of the projector and web position sensing assembly of the present invention as viewed from the right of the first station shown in FIG. 1;

FIG. 9 is an enlarged view partly in section and partly in elevation of the mounting between the pivot lever arm and pivot support of the web position sensing device in accordance with the present invention; and

FIG. 10 is an enlarged fragmentary view illustrating the relative position of the sensing arm with respect to the position of the web.

Referring to the drawings, which illustrate a preferred embodiment of the present invention, the electrophotographic apparatus **10** includes a plurality of stations **12***a*, *b*, *c*, *d* and *e*, and each station includes a charger **14***a* through *e*, a projection unit **15***a* through *e*, and a developing unit **16***a* through *e*. For simplicity of illustration, the projection unit has only been shown in the first station **12***a*. The various components of each station are assembled and secured to frame elements not shown which support these individual components in their proper relationship. A roll of electrophotographic paper **18** is supported by the frames for rotation as indicated, and the web is fed along a path of advancement which includes guide

roll **19**, over a guide roll and dampening assembly **21** through the first charger **14***a* and over a freely rotatable guide roll **22**. The guide roll and dampening assembly **21** includes a freely rotatable guide roll **23** which rotates in contact with a dampening roll **24** which is partly submerged in a trough of water **26** so that a relatively thin film of water off-sets on the guide roll **23** and is transferred to one side of the electrophotographic web **30**. The other side **32** of the electrophotographic web is positioned to be charged, exposed and developed seriatim as will be described more fully hereinbelow.

After passing over guide roll **22**, the web passes across the lower face of the projection table **34** which defines the image plane where it is exposed to form an electrostatic latent image having a charge configuration representative of the first color to be deposited. During this exposure operation an index mark is also placed along one edge of the web in predetermined relation to the latent image to control automatic exposure of the subsequently projected images in longitudinal registration with the first image. The exposure of the web in the first and subsequent station is carried out by a high intensity, short duration flash while the web is moving. The exposure of the web in the subsequent stations is also by a high intensity flash triggered by the index mark formed in the first station.

From the projection table **34**, the web is advanced over freely rotatable roll **36** with the exposed surface in contact with the roll and into the developing station **16***a* which includes a driven developing drum **37***a* which is positioned transversely of the web in a tank **38***a* containing liquid developer of the type described in application Ser. No. 762,756, filed Sept. 23, 1958, now Patent No. 3,311,490.

Positioned in pressure contact with the web **30** on the upturning side of the drum **37***a* is a squeegee roller **39***a*, and the axis of roll **39***a* is positioned with reference to the axis of developing drum **37***a* so as to form a pressure nip therebetween to effect removal of the carrier liquid of the liquid developer. The web is preferably maintained in intimate contact with the outer periphery of the developing drum **37***a* to prevent wetting the reverse side of the web with developer carrier and to prevent deposit of toner on the reverse side of the web.

The remaining stations **12***b*, *c*, *d* and *e* include basically the same components described in connection with the first station **12***a* with the execption that wiper mechanisms **41***b* and **42***b* are associated with guide rolls **22***b* and **36***b*, respectively and similar wiper mechanisms are provided for the remaining stations. Guide rolls **22***b* through *e* and guide rolls **36***b* through *e* include an outer covering whose surface characteristics minimize transfer of the deposited developer to the roller for example such as polytetrafluoroethylene from which any off-set material may be easily removed by the respective wiper assemblies **41***b* through *e* and **42***b* through *e* which may be periodically rotated to provide a clean wiping surface as needed. Alternately, rolls **22***b* through *e* and **36***b* through *e* may be wetted with water to prevent offsetting of the developer since the toner is dispersed in a hydrocarbon vehicle which does not mix readily with water.

From the last station **12***e*, the web moves over a freely rotatable guide roll **44** and through a dryer (not shown) and through driving pinch rolls **45**, and to a sheeter assembly shown schematically at **50**. For the details of the sheeter mechanism, reference is made to application Ser. No. 241,423, filed Nov. 30, 1962, now Patent No. 3,223,008, and assigned to the same assignee as this application.

The web is maintained under relatively constant tension during travel through the various stations by suitable web tensioning devices, for example, of the type described in Ser. No. 241,423 previously referred to. Associated with one of the stations is a triggering device which is actuated by movement of the web to cause triggering of the flash circuit of the projector in the first station and which also includes a second switch for controlling the sheeter assembly **50**.

Referring to FIG. 2, associated with one of the rolls **22***b* through *e* or **36***b* through *e* or with a separate roll arranged to be driven by the web is a gear train **52** including gears **53** and **54** which may be changed to form different ratios which determine the length of web per image. By changing the ratio between gears **53** and **54** various lengths of web may be established with reference to the image size so as to provide a relatively small web length between successive images in series. Associated with gear **54** are two cams **55** and **56** which are adjustably mounted to gear **54**, cam **55** operating to actuate a switch **57** for providing a trigger pulse for the flash tube in the projector of the first station, and switch **59** which is tripped by cam **56** to actuate the sheeter assembly **50**. Switch **59** is affixed on a support member **60** which is mounted for rotational adjustment about the axis of gear **54** thereby permitting adjustment for severance of the web between two images along the length of web during operation of the machine. By adjusting cams **55** and **56**, and adjusting switch **59** through movement of supporting member **60** and by changing gears **53** and **54** to different ratios the web travel and the severance of the web may be so coordinated that a series of images of a given length may be cut in sequence from the web and thereafter a series of images of different length may be made and the web cut to proper lengths.

Affixed to the frame, not shown, is a stationary slide assembly **66**, movement of slide assembly being controlled by a micrometer screw knob **67**. Turning of the micrometer screw knob **67** effects movement of a slide element **69** and thus the entire projector assembly generally designated **70** is moved towards or away from the corresponding projection table. The projector assembly **70** is fixed to the slide member **69** by a supporting base **71** which also forms a fixed support member for a pivotal arm used to sense the position of the web as will be described more fully hereinbelow.

The projector assembly **70** includes a cover **73** which houses a flash tube, a trigger transformer, a mirror and condensing lenses, not shown. Cable connection **74** receives a cable supplying the trigger pulse to fire the flash tube, and cable connectors **76** and **77** supply the power to the flash tube itself. Member **80** is fixed to the supporting base **71** and provides a support for the film holder assembly, generally designated **85**. As shown, flexure plates **86***a* and **86***b*, and a second pair of flexure plates **86***c* and **86***d* positioned in spaced relationship thereto are fixed at one end to member **80** so that the pairs of plates **86***a* and *d*, and **86***b* and *c* permit slight lateral movement of a lens and holder assembly **87** mounted on the other end thereof. To the upper portion of the flexure plates is fixed a support member **88** which is provided with an internally threaded aperture to receive an externally threaded lens housing **89** to which is affixed a lens **90**. The lens **90** includes an adjustable aperture and an objective lens, not shown, and the aperture of the lens **90** may be adjusted in the conventional manner by turning rotatable ring **92** relative to the lens **90**.

Referring to FIGS. 5 through 7, mounted on member **80** are a pair of spaced guides **93** and **94**, guide **93** being fixed relative to member **80** while guide **94** is mounted for movement around pivot **95**. Guide **94** includes a shoulder **96** running the length thereof to provide a track and reference edge for the film holder **85**. Mounted on guide **93** is a leaf spring assembly **101** which urges the film holder **85** toward guide **94** and against the shoulder **96** while a second spring assembly **103** forces one side of the film holder **85** into contact with the upper surface of guide **93**. Mounted on guide **94** is a third spring assembly **105** which forces the other side of the film holder down against the guide **94** so that the film holder is in spaced parallel relationship to the plane of the transparency and member **80**.

Mounted on member **80** is an angular registration adjusting screw **107** which is movable into engagement with guide **94** to pivot the guide **94** and the film holder around pivot point **95**. The strength of spring assembly **101** is sufficiently height to maintain the film holder against the shoulder **96** in the event of counterclockwise movement of the guide **94** and film holder **85** about pivot point **95**. Angular registration adjusting screw **107** includes a pressure screw **109** to provide automatic locking of the thumb screw once a proper position has been selected.

Also mounted on member **80** is a transverse positioning screw assembly **110** identical in structure to angular registration adjusting screw assembly **107** which operates to position the transparency holder **85** in a transverse direction.

The transparency holder **85** including a generally rectangular support member **112** which carries pins **114** which serve as locating pins for the transparency. Referring to FIGS. 4 and 6, the rectangular transparency supporting member **112** includes four spring-loaded clips **116** which can be manually depressed and rotated to unclamp the transparency which is preferably held between two flat glass plates **117** and **118**. In this way, the transparency is properly registered in the film holder assembly and maintained in substantially parallel relationship with respect to member **80**.

Referring to FIGS. 5 and 7, the guide assembly **94** is mounted for pivotal movement around pivot **95** which includes a clamping nut **118** which locks the guide in its final position. To permit rotational movement of the guide **94**, an oblong slot **119** is provided in the guide permitting arcuate guided movement, and received in the aperture is a second locking thumb screw **121**. The second locking screw **121** in conjunction with clamping nut **118** eliminates lifting of either end of guide **94**.

Referring to FIGS. 8 through 10, the web position sensing assembly of the present invention is shown and includes a pivotal lever arm **125** which is mounted for movement on support **71** by a bearing assembly, the details of which are shown in FIG. 9. Lever arm **125** is press-fitted over a bearing **127** which in turn is slip-fitted over stud **129** and held relative to the stud by the screw and washer assembly **131**. This construction permits easy transposition of the lever **125** to a second or more positions for webs of different widths, as shown in dotted lines of FIG. 8.

As shown in FIG. 10, the lever arm includes fingers **135** mounted on the free end thereof which contacts the edge of the web during its travel and which is biased into contact with the edge of the web whenever a web is present in the station. The web position sensing assembly also includes a laterally movable linkage arm **140** having attached to one end thereof a constant force spring **141** with the other end of the constance force spring being affixed to support element **71**. This spring urges the linkage **140** toward the left as viewed in FIG. 8 and urges the lever am **125** through the bearing **142** positioned on the end of the linkage arm **140** toward the left as viewed in FIG. 8 to contact the edge of the web. The linkage arm **140** is connected to the support member **88** by screws **144** to move the lens an amount proportional to the movement of the web as sensed through the lever and linkage assembly. Fingers **135** affixed to the lever arm **125** travel in slots **143** (one being shown) on the projection side of the table. The apparatus of the present invention also includes conventional equipment for providing a pressure differential to maintain the web in contact with the projection table **34** as previously described. Accordingly, the edge of the web which is being sensed by the fingers **135** is maintained flat and prevented from curling. In the absence of a web, the travel of the fingers is limited by the ends of the slots **143** as shown in FIG. 10. If desired, a plate may be affixed to the projection table in registry with the portions of the table between the slots to engage the edge of the web and maintain it in close proximity to the table to prevent edge curling away from the table and the sensing fingers **135**.

The pivot point of lever **125** preferably lies in the same plane as the transparency while bearing **142** lies essentially in the same plane as the plane of the center of the lens **90** which in turn is in parallel spaced relation to the transparency and the projection table. The ratio of that portion of the lever arm between the plane of the image projection table and the plane of the center of lens **90** to the portion of the lever arm between the plane of the transparency and the plane of the center of lens **90** is substantially identical to the magnification ratio. Therefore, any pivotal movement of arm **125** as a result of slight lateral shifting of the web will bring about a proportional movement of the lens **90** in a plane which remains substantially parallel to the plane of the transparency. Flexure plates **86***a*, *b*, *c*, and *d*, tend to maintain member **88** in a normal position, and movement of member **88** from that position is in effect opposed by the plates. The movement of the member **88** about the fixed ends of flexure plates **86***a*, *b*, *c* and *d* as a result of movement of arm **125** is relatively small therefore vertical movement of member **88** toward or away from the transparency is relatively small and is negligible. Such movement has little, if any, effect upon magnification or focus of the projected image. Once the projected image is properly aligned angularly, transversely and with the proper magnification and focus, the web position sensing assembly previously described operates in effect to shift the image with the shifting movement of the web so as to maintain the web and image in lateral registry. Each projection assembly in each station is substantially the same as the assembly previously described. In this way, the transparency in each station, once oriented properly with respect to that station is maintained in that registered position notwithstanding small lateral movements of the web at the projection table in each station.

Further, the web contacting fingers **135** and the projected image in each station are located in the same longitudinal relationship to each other so that a given point on the edge of the web is at the sensing finger in each unit at the movement the flash exposure occurs.

In operation, transparencies are prepared with each representative of one color of the multi-color image. The individual transparencies are thereafter provided with registration holes for alignment of the transparencies in the film holder **112**. The transparency is assembled between two glass plates with the emulsion side facing the projection table, and the assembled glass plates and transparencies are positioned within the film holder and locked therein by the spring biased latching elements **116**. The films are each provided with a hole and a slot. The hole closely fits one pin **114**, while the slot fits opposed parts of the other pin **114**. The slot extends parallel to a line between the pins. In this way, any buckling of the film due to expansion as a result of increases in the ambient temperature is substantially eliminated.

Transparency holder **112** with the transparency properly mounted and oriented thereon is inserted to ride on guide **93** with the opposite edge thereof being received by the shoulder **96** of guide **94**. A modeling light is activated as described in application Ser. No. 240,253, filed Nov. 27, 1962, now Patent No. 3,299,787 and assigned to the same assignee, and an image is projected to the projection table. The projected image is focused by turning lens housing **89** until a sharp well-defined image is obtained. By manipulating the micrometer thumb screw and the angular registry adjustment knob **107** and the transverse adjustment knob **110**, the magnified and focused image is brought into proper registry in the image plane.

The details of the registration sequence are as follows: Focus has been accomplished by manipulation of the lens housing **89**, angular alignment is accomplished by manipulation of the knurled thumb screw **107** to effect angular registration of the projected image. Next, some

transverse adjustment may be made by the transverse position assembly **110** which effects transverse shifting of the projected image. At this point an evaluation of registration is made and in most instances magnification of the image may be slightly different from the desired. Compensation may be made by adjusting the micrometer knob **67**.

Once the focus and magnification have been established, relatively little further adjustment of these two items is required from one transparency to the next transparency in a given station, provided the transparencies are of reasonably the same quality. For example, in running one composite color image from five color transparencies, and thereafter running another composite image from a second set of transparencies it is usually not necessary to make substantial changes in magnification and focus after the initial adjustment for the first set has been made. Assuming the sets of transparencies are of similar quality, little further adjustment of focus and magnification is required by the user.

All rolls are arranged with the respective axis of each roll in parallel relationship with the axis of the remaining rolls, and thus the web during its travel through the machine and through the pinch rolls remains relatively close to a mean position and does not wander substantially. Any slight transverse movement of the web without correction would tend to bring about transverse misregistry of the images in each station. By providing an automatic transverse web position sensing assembly which maintains the projected image transversely registered with respect to the web and the previous image, as described, and by providing an index mark for all subsequent flash exposures, at the time that the flash tube fires to expose the web in stations **12***b* through *e*, the previously developed image and the projected image of that particular station are maintained in proper transverse and longitudinal registry. Stations **12***b* through **12***e* are provided with a longitudinally adjustable photo pick-up device of the type described in application Ser. No. 240,253 previously mentioned, to provide accurate longitudinal registration with respect to the index mark. The adjustment of the photo pick-up device is the last adjustment required for registration. At this point, the machine has been properly adjusted with respect to focus, magnification, transverse, angular and longitudinal registry.

One feature of the present invention is movement of lens **90** relative to the transparency such that the lens moves without appreciably changing the magnification and focus. Since a relatively small lateral movement of the lens is required in proportion to the lateral movement of the web, the change of distance between the lens and the transparency is relatively small. The same effect may be achieved by moving any element projection system which effects lateral movement of the projected image.

While the forms of apparatus herein described constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to these precise forms of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. An electrophotographic apparatus for directly producing multi-color prints on a moving web of electrophotographic material having an image side and non-image side comprising a plurality of stations, each station including a charger for charging said web, an exposure unit receiving said web from said charger and forming a latent image on said web, and a developer unit receiving said web from said exposure unit for developing said image, exposure table means in each station in spaced relation to the corresponding exposure unit, each said developer unit including a tank for holding liquid developer including toner and a carrier liquid, roll means associated with each tank for bringing the web in contact with the developer in the tank, means associated with each said exposure table means for maintaining the non-image side of the web in contact therewith during exposure by said exposure unit, and means to maintain the non-image side of the web free of liquid developer during said contact with said developer so that the non-image side of the web is free of liquid developer during contact with the exposure table means of the next said station.

2. An electrophotographic apparatus as set forth in claim **1** wherein the non-image side of the web is in contact with the roll means of each said developing unit.

3. An electrophotographic apparatus as set forth in claim **1** in which the non-image side of the web is in intimate contact with a portion of the outer periphery of the roll means to prevent deposition of toner and carrier liquid on the non-image side of the web.

4. An electrophotographic apparatus as set forth in claim **1** including means to wet the non-image side of the web with a conductive liquid prior to advancement of the web into the first station.

5. An electrophotographic apparatus as set forth in claim **2** further including means to drive said roll means.

6. An electrophotographic apparatus as set forth in claim **3** wherein each roll means is positioned with respect to the corresponding tank to bring the image side of the web beneath the level of liquid developer in each said tank.

7. An electrophotographic apparatus as set forth in claim **3** wherein each station includes means to remove carrier liquid adhering to the image side of the web after development of the image thereon.

References Cited

UNITED STATES PATENTS

2,986,466	5/1961	Kaprelian	95—1.7
3,060,829	10/1962	Leighton	95—89
3,286,616	11/1966	Limberger	95—89
3,307,466	3/1967	Fukuda	95—89

NORTON ANSHER, *Primary Examiner.*

LEO H. McCORMICK, JR., *Assistant Examiner.*

U.S. Cl. X.R.

95—89; 355—10, 13