

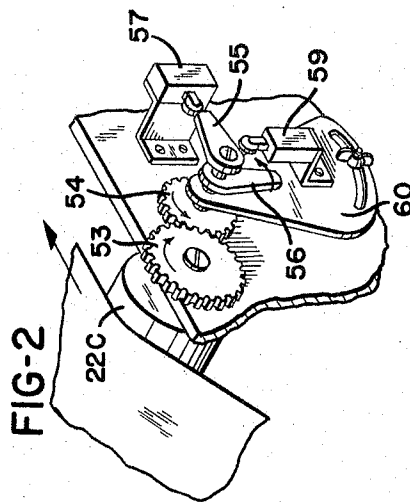
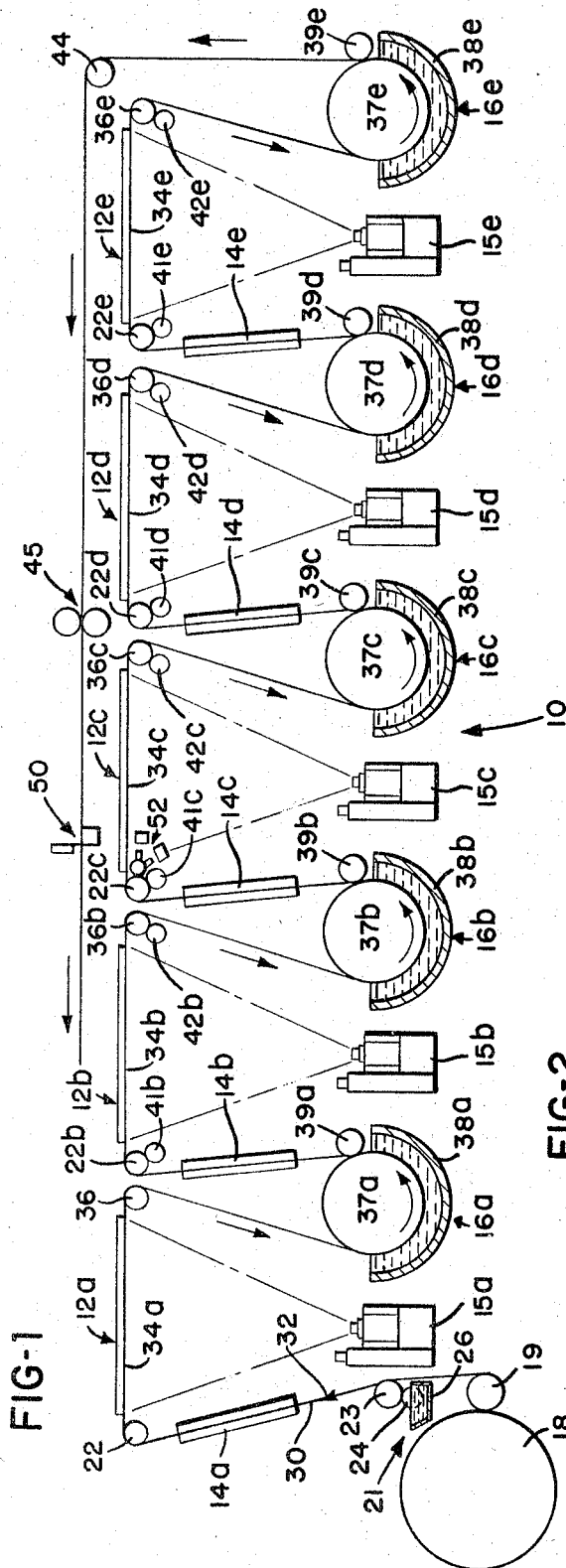
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ELECTROPHOTOGRAPHIC APPARATUS

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ELECTROPHOTOGRAPHIC APPARATUS

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This invention relates to an electrophotographic apparatus and more particularly to an improved and compact electrophotographic apparatus for forming a series of images on an electrophotographic member to provide a composite multi-colored image.

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 adjustments 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 a compact multi-color printing apparatus 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 smaller, more compact and 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 a compact electrophotographic apparatus capable of producing a plurality of properly registered images on a web of electrophotographic material passing through the apparatus.

A further object of the present invention is the provision of a compact multi-color electrophotographic apparatus wherein the various components thereof are arranged for effective operation while at the same time occupying a minimum of space, and more particularly wherein the components are positioned relative to each other for maximum utilization of space.

A further object of the present invention is the provision of a compact multi-color electrophotographic apparatus utilizing a liquid developer.

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A further object of the present invention is the provision of a multi-color electrophotographic apparatus including a plurality of stations, each station including a unit projecting an image bearing light beam which is generally pyramidal in shape towards an electrophotographic web, and wherein the path of the web between projecting units is such as to form a diverging loop, and wherein a developing unit and/or charging unit is located along the path of travel of the diverging loop.

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

In the drawing—

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

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.

Referring to the drawing, which illustrates a preferred embodiment of the present invention, the electrophotographic apparatus 10 shown in FIG. 1 includes a plurality of stations 12a, b, c, d and e. Each station includes a charger 14a through e, a projection unit 15a through e, and a developing unit 16a through e. 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 14a 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 34a which defines the projected image plane where it is exposed to form an electrostatic latent image having a charge configuration representative of the first color to be deposited. Included in each station is a projection table 34b to e defining the projected image plane in each station. During the exposure operation in the first station 12, 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 34a, the web is advanced over freely rotatable roll 36 with the exposed surface in contact with the roll and into the developing station 16a which includes a driven developing drum 37a which is positioned transversely of the web in a tank 38a containing liquid developer of the type described in application Serial No. 762,756, filed September 23, 1958.

Positioned in pressure contact with the web 30 on the upturning side of the drum 37a is a squeegee roller 39a, and the axis of roll 39a is positioned with reference to the axis of developing drum 37a 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 37a 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 12b, c, d and e include basically the same components described in connection with the first station 12a and designated with the suffix b through e with the exception that wiper mechanisms 41b and 42b are associated with guide rolls 22b and 36b, respectively, and similar wiper mechanisms are provided for the remaining stations. Guide rolls 22b through e and guide rolls 36b 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 41b through e and 42b through e which may be periodically rotated to provide a clean wiping surface as needed. Alternately, rolls 22b through e and 36b 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 12e, 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 Serial No. 241,423, filed November 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 Serial 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 22b through e or 36b through e or with a separate roll arranged to be driven by the web is a gear train 52 (also shown schematically in station 12c of FIG. 1) 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.

One feature of the present invention is the compact arrangement of elements constituting the apparatus of the present invention. Referring to FIG. 1, each projector is arranged with respect to the adjacent projector to project an enlarged light image of an original onto the corresponding image plane which is preferably spaced vertically above the projector. The light pattern from the projector is preferably divergent and pyramidal in

form. The web 30 travels generally in a vertically upwardly direction through the charger of each station, and generally vertically downwardly from the image plane after exposure thereof.

The guide rolls 36 of one station cooperate with the guide rolls 22 of a succeeding station to provide a loop of web which extends vertically downwardly between adjacent projectors.

The developer rolls 37 of each station are preferably arranged vertically below the guide rolls 36 and 22 between each image plane to provide a generally diverging loop which is preferably tapered in form but oppositely oriented with respect to the taper generated at each projector. Each developer roll 37 is of a diameter which is greater than the space between guide roll 36 of one station and guide roll 22 of the succeeding station. The generally pyramidal shape of the emitted light beams and the inverted tapered shape of the loop between projectors offers the advantage of permitting the developer units to be spaced vertically below the image planes and adjacent the projector of the corresponding station, and rearwardly thereof along the path of web travel.

With the physical arrangement shown in FIG. 1, the mechanics of web transport are simplified particularly in a machine utilizing a liquid developer since the surface to be exposed, surface 32, is properly oriented so as to be in facing relation to the projectors in each of the stations. Similarly, only one guide roll 36 contacts the exposed portion of the web prior to development thereof, and the web so moves about the outer periphery of each developer roll 36 that the exposed portion thereof is in facing relation to the liquid developer. By driving rolls 37 at a peripheral speed which corresponds to the linear speed of the web, the back surface of the web is maintained in intimately close contact with the developer roll and this assists substantially in reducing the development of inverted images on the back surface of the web.

In the preferred form shown in FIG. 1, all of the image planes are in a common plane and spaced from the projectors which are also in a common plane. Likewise, the developer rolls are positioned so that their axes are in a common plane and spaced vertically below the image planes.

For further details with respect to the projection units, reference is made to application Serial No. 372,503 filed of even date herewith and assigned to the same assignee as this application.

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 forming a plurality of images on a moving electrophotographic web travelling in a predetermined path comprising:
 - a plurality of stations, each station including charger means, exposure means and developing means,
 - said exposure means of each station including projection means and means defining a projected image plane spaced vertically above said projection means,
 - means to advance the web through said stations,
 - said projection means of each station being disposed with respect to the corresponding image plane to expose that portion of the web therein,
 - said projection means of each station forming a diverging image carrying light beam directed generally vertically upwardly,
 - first means to guide the web for travel into each station in a generally upwardly direction,
 - second means to guide travel of the web from the image plane of a preceding station in a generally downwardly direction,
 - said developing means being located along the path of

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web travel and positioned generally vertically below said first and second guide means, said first and second means and said developing means being so disposed as to provide a downwardly extending diverging loop in that portion of the web between successive image planes, and said charger means of each station being positioned to deposit charge on the web prior to exposure thereof.

2. An electrophotographic apparatus for forming a plurality of images on a moving electrophotographic web travelling in a predetermined path comprising:

a plurality of stations, each station including charger means, exposure means and developing means, said exposure means of each station including projection means and means defining a projected image plane spaced vertically above said projection means, means to advance the web through said stations, said projection means of each station being disposed with respect to the corresponding image plane to expose that portion of the web therein, said projection means of each forming a generally pyramidal shaped image carrying light beam, first means to guide the web for travel into each station in a generally upwardly direction, second means spaced from said first to guide travel of the web from the image plane of a preceding station in a generally downwardly direction, said developing means being located along the path of web travel and positioned generally vertically below said first and second guide means and adjacent the corresponding projector, said developing means of each station including roll means and means to hold a liquid developer, said first and second guide means being so disposed relative to the developer roller positioned vertically therebelow to provide a generally diverging vertical loop of web between successive image planes, said image planes all being generally in a common plane, the axis of said rolls being in a common plane which is vertically below said common plane, and said charger means of each station being positioned along the path of web travel ahead of said first guide means and the developing roll of a preceding station to charge the web prior to exposure thereof.

3. An apparatus as set forth in claim 2 wherein said guide means contacting the web after development of an image includes means to prevent offsetting or mechanical transfer of the liquid developer.

4. An apparatus as set forth in claim 2 wherein said means to hold a liquid developer is of a horizontal width greater than the space between the leading and trailing edges of adjacent image planes.

5. An electrophotographic apparatus for forming at least two images on a moving electrophotographic web travelling in a predetermined in-line path comprising:

at least two stations, each station including charger means, exposure means and developing means, each exposure means of each station including projector means and means defining a projected image plane, said image plane of one station being in spaced relation to the other, said projector means being arranged adjacent to each other to project enlarged light images to substantially parallel image planes with said projected images being in adjacent spaced relation, means supporting said charger means to deposit an electrostatic charge on the web prior to its entry to each said image plane, developing means effective to apply developer material to the web after exposure thereof, means to convey an electrophotographic web in a path extending through one of said image planes then into the space lying between the light paths formed by said adjacent projector means and then out of said space and through the other said image planes,

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and each said developing means being positioned in said space for applying developer to that portion of the web therein.

6. An electrophotographic apparatus for forming at least two images on a moving electrophotographic web travelling in a predetermined path comprising:

at least two stations, each station including charger means, exposure means and developing means, each exposure means of each station including projector means and means defining a projected image plane, said image plane of one station being substantially parallel to and in adjacent spaced relation to the other, said projector means being substantially similar and similarly arranged adjacent to each other, means to convey an electrophotographic web in an in-line path extending through one of said image planes then into the space lying between the light paths formed by said adjacent projector means and then out of said space and through the other of said image planes, means supporting said charger means to deposit an electrostatic charge on the web prior to its entry to each said image plane, and developing means effective to apply liquid developer material to that portion of the web which at any given time lies in said space between said light paths, said developing means including roller means adapted to immerse said web in said developer material with latent images thereon facing outwardly of said roller means and in contact with the liquid developer material.

7. Apparatus as set forth in claim 6 wherein said developing means includes means to hold a liquid developer whose width dimension measured along the path of web travel is greater than the longitudinal dimension between adjacent image planes.

8. An electrophotographic apparatus for forming a plurality of images on a moving electrophotographic web travelling in a predetermined path comprising:

a plurality of stations, each station including charger means, exposure means and developing means, said exposure means of each station including projection means defining a projected image plane, said projected image plane being located generally vertically above said projection means, means to advance the web through said stations, said projection means of each station being disposed with respect to the corresponding image plane to expose that portion of the web therein, said projection means of each station forming an upwardly directed diverging image carrying light beam, first means between adjacent stations to guide the web for upward travel into each station, second means to guide travel of the web from the image plane of a preceding station in a direction generally downwardly, said first and second means being so disposed as to provide a downwardly diverging loop in that portion of the web between adjacent projection means with the non-image side of the web facing inwardly thereof, said developing means of each station including roller means for immersing the loop portion of the web in a liquid developer and being located to develop the image on that portion of the web in said loop, and said charger means of each station being positioned to deposit charge on the web prior to exposure thereof.

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