Jan. 4, 1966 O. A. ULLRICH, JR., ETAL 3,227,549

MULTIPLE IMAGE FORMING XEROGRAPHIC REPRODUCTION PROCESS

Original Filed March 1, 1961 5 Sheets-Sheet 1

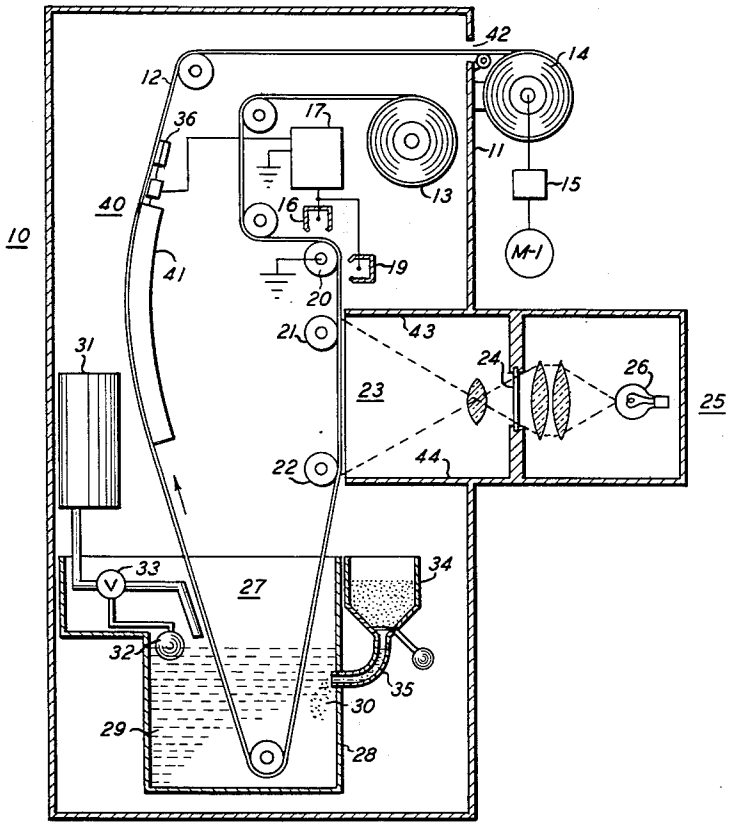


FIG. 1

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MULTIPLE IMAGE FORMING XEROGRAPHIC REPRODUCTION PROCESS

Original Filed March 1, 1961 5 Sheets-Sheet 2

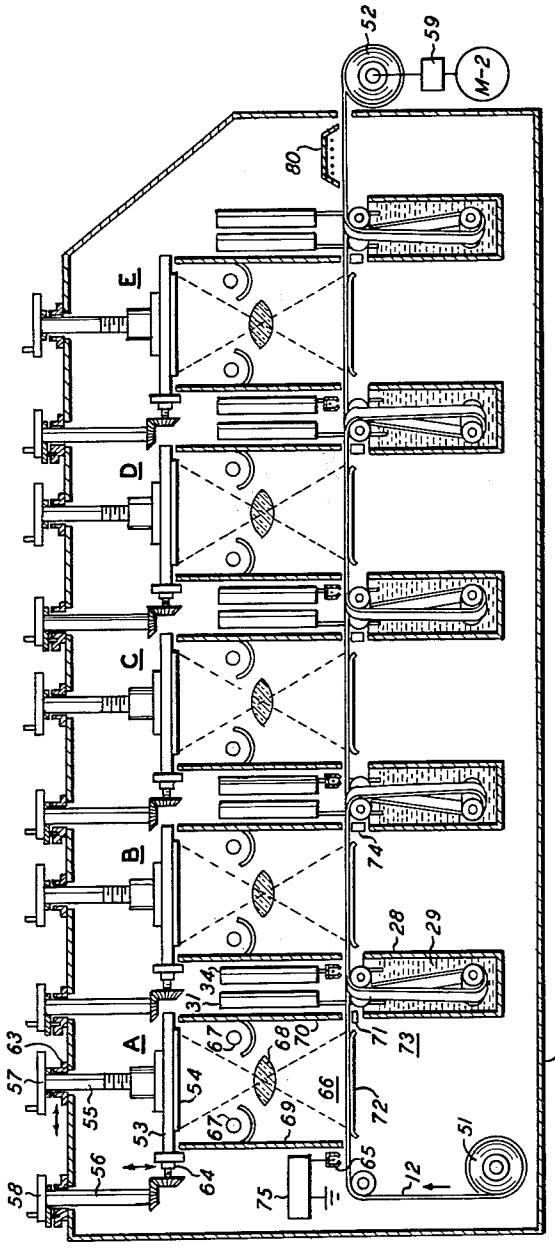


FIG. 2

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MULTIPLE IMAGE FORMING XEROGRAPHIC REPRODUCTION PROCESS

Original Filed March 1, 1961 5 Sheets-Sheet 3

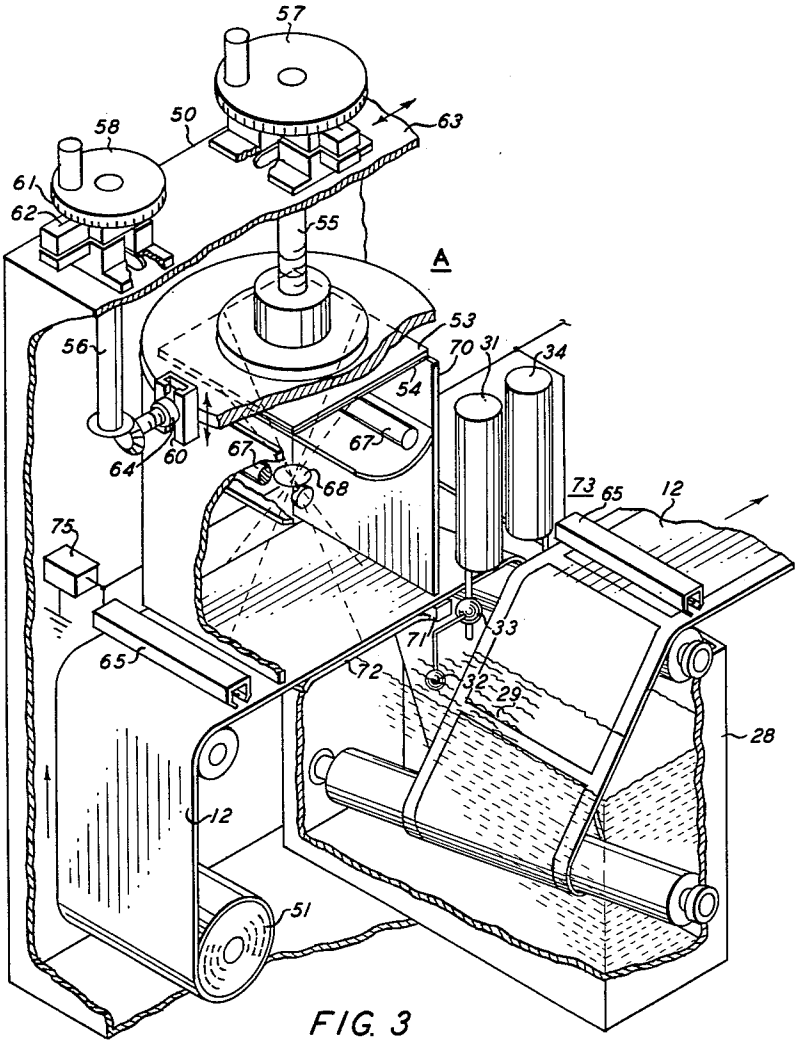


FIG. 3

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MULTIPLE IMAGE FORMING XEROGRAPHIC REPRODUCTION PROCESS

Original Filed March 1, 1961 5 Sheets-Sheet 4

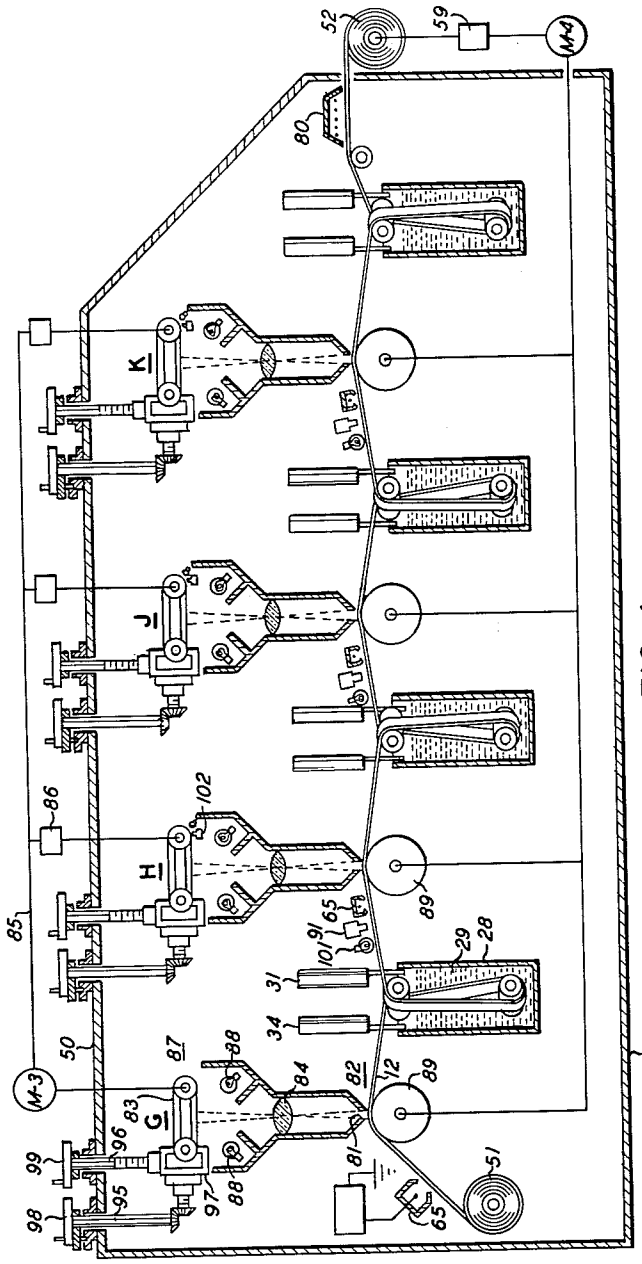


FIG. 4

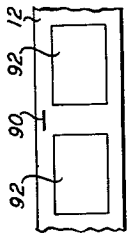


FIG. 5

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MULTIPLE IMAGE FORMING XEROGRAPHIC REPRODUCTION PROCESS

Original Filed March 1, 1961 5 Sheets-Sheet 5

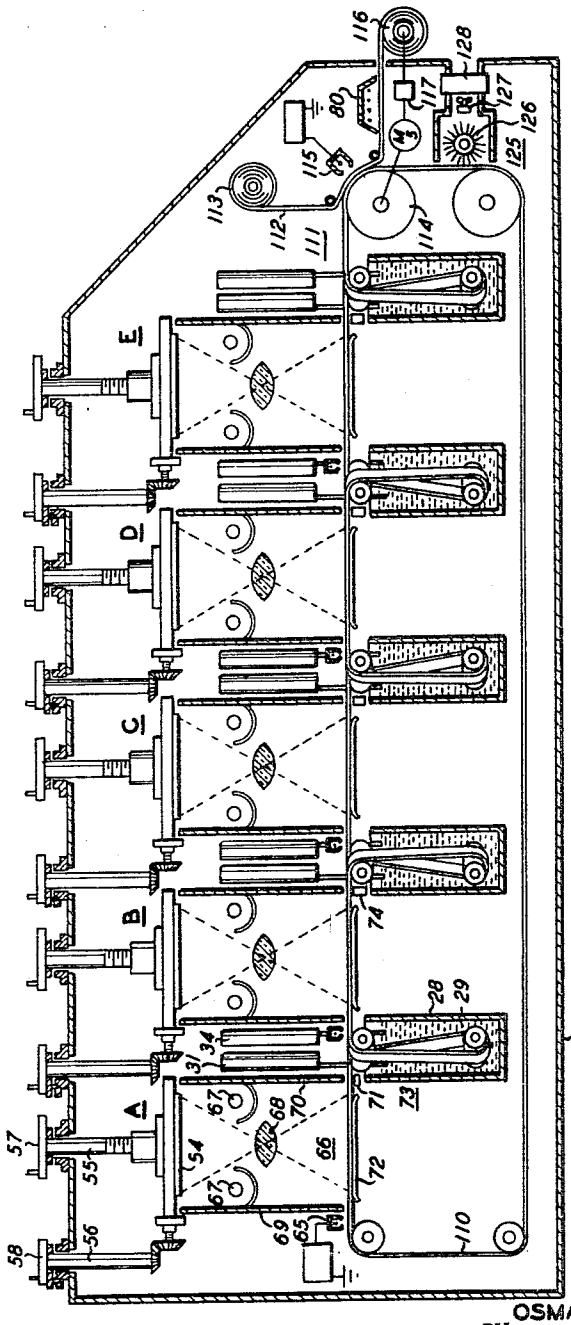


FIG. 6

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United States Patent Office

3,227,549

Patented Jan. 4, 1966

3,227,549

MULTIPLE IMAGE FORMING XEROGRAPHIC REPRODUCTION PROCESS

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Continuation of abandoned application Ser. No. 92,560, Mar. 1, 1961. This application Feb. 24, 1965, Ser. No. 435,016

13 Claims. (Cl. 96—1)

This application is a continuation of application Serial No. 92,560, filed March 1, 1961, now abandoned.

This invention relates to xerography and in particular to novel apparatus and method for the xerographic reproduction of multiple images in accurate registration from separation originals.

In the process of xerography, for example, as first disclosed in Carlson patent U.S. 2,297,691, issued October 6, 1942, a xerographic plate comprising a layer of photoconductive insulating material on a conductive backing is given a uniform electric charge over its surface and is then exposed to the subject matter to be reproduced, usually by conventional projection techniques. This exposure discharges the plate areas in accordance with the intensity of activating radiation that reaches them, and thereby creates an electrostatic latent image on or in the photoconductive layer. Development of the latent image is effected with an electrostatically charged, finely divided material such as an electroscopic powder that is brought into surface contact with the photoconductive layer and is held thereon electrostatically in a pattern corresponding to the electrostatic latent image. Thereafter, the developed image may be affixed by any suitable means to the surface on which it has been developed or may be transferred to a secondary support surface to which it may be affixed or may be utilized by means known to the art.

It is usual in forming reproduction by means of xerography to effect formation from whole copy, as contrasted to a composite or the like formed in registration from separation originals, and which whole copy reproduction is formed on a xerographic plate with one cycle of the xerographic process. That is, for each whole reproduction formed there has been performed a single step each of charging, exposing, developing (and optionally, transfer and fusing) in the manner of Carlson cited above. The copy thus produced is ready for utilization after one such cycle and may be utilized for any of a variety of purposes including optical projection with or without transfer and/or fusing as for example, for optical projection as disclosed in Clark et al copending application S. N. 738,520 filed May 28, 1958, now abandoned.

The color of the reproduction image is dependent on the color of developer employed and for which there is commercially available a wide choice of colored pigmented resins of the type disclosed in Walkup patent U.S. 2,618,551. This type of resin developer is referred to as "toner" which is used in combination with a granular bead termed "carrier" and together are cascaded over an electrostatic latent image previously formed on a xerographic plate in a developing technique appropriately termed "cascade development." The carrier functions to triboelectrically charge the toner particles and deliver the toner to the image areas of the plate to be developed. An extensive detailed discussion of cascade development as to function, properties and performance may be found in copending application Serial No. 747,247, filed July 8, 1958 in the name of Bixby now U.S. Patent No. 3,013,890.

Recently there has been introduced another developing technique for developing electrostatic latent images that

utilizes an insulating liquid containing developer material and referred to in the art as "liquid development" as disclosed in several U.S. patents including Mayer patent U.S. 2,877,133 but first disclosed in copending application Serial No. 380,285 filed September 15, 1953 in the name of Mayer. A variety of liquids have been found suitable and among those preferred is an odorless aliphatic hydrocarbon available commercially as Sohio Odorless Solvent No. 3440, marketed by Standard Oil Company of Ohio. The developer materials of the type most commonly contained in the liquid are either a pigment suspension, dye dispersion, emulsion, or finely divided pigmented resins dispersed in the liquid. In liquid development a plate bearing an image to be developed is brought into contact with the liquid and the developer therein adheres to the image charges on the plate to render the image visible or optionally, reversal development can be effected by selection of developers that are repelled by the charges in the image areas to the non-image areas.

As with cascade development, developer in liquid development is also available to effect development in a variety of selected colors and in either cascade or liquid development, after development the image is loosely supported on the plate surface on which it has been formed. Thereafter, as aforesaid, the developed image is usually affixed thereto or transferred by known methods of electrostatics, contact, or adhesion to a secondary support surface to which it may be affixed.

With previous xerographic reproduction systems, formation of a composite of multiple images, even though in different colors, required separate fusing or transferring following development in order to retain the quality of the developed image. Whereas by these means, previous methods were able to retain image quality, they suffered from the practical defect of inaccurate registration between the multiple images. For example, when using reusable xerographic plates, of the type to be described, in which vitreous selenium is the photoconductor, multiple image reproduction has heretofore been achieved with accurate registration but only when the plates were supported stationary during exposure. In automatic machines it is customary to use a plurality of plates on which images are conventionally formed separately and then to effect registration, the separate images are transferred consecutively to a secondary support surface. Whereas accurate registration is achieved in a stationary process on rigid flat plates in the manner described assiduous adjustment is required to effect the registration and which is necessarily slowly limiting the application of such a process. In automatic units utilizing moving plates, considerable difficulty has been encountered in consecutive transfer without achieving reliability and accuracy of registration. When using disposable xerographic plates, termed "binder plates," as for example, disclosed in Middleton patent U.S. 2,663,636 and Van Dorn patent U.S. 2,937,944, it has been necessary to affix each image after cascade development to prevent image distortion on subjecting the previously developed image to subsequent development.

Thus, for example, in Jacob patent U.S. 2,752,833, multicolor reproduction is dependent upon a developer absorbent paper and for full frame exposure, the apparatus which is otherwise continually operative is momentarily stopped. This apparatus is therefore slow and unsuitable for rapid reproduction. In Jacob patent U.S. 2,808,328 a procedure is described for color correction or masking which is time consuming and cumbersome and generally limited to hand operated apparatus.

Disposable binder plates are usually comprised of a suitable photoconductor such as zinc oxide in a binder material on an electrically conductive flexible base, such as conductive paper, and are available commercially un-

der the tradename of Lectrox, marketed by Haloid Xerox Inc. of Rochester, New York. In order to affix a developed image to plates of this type, it is usual to apply heat which has the effect of causing the base paper to shrink, and where otherwise not objectionable, shrinking creates an unresolved problem for effecting successive registration. Solvent fusing as disclosed in Carlson patent U.S. 2,776,907 effects fusing without the shrinkage effect of heat, but is generally most suitable for infrequent usage and is objected to for large volume use because of solvent odor and toxicity which adversely affects the ambient atmosphere when using suitable solvents such as trichloroethylene. Therefore, the previous concepts have been unsuitable for commercial application where accuracy of registration is required.

It has now been discovered in accordance with the invention that when developing electrostatic images utilizing liquid development more than one image can be developed on the plate without the necessity of affixing loosely supported previously developed images. That is, a multiplicity of images can be formed in a manner to form a composite without the requirement to affix previously formed images to prevent their distortion or obliteration when subjected to additional xerographic cycles. The reason why subsequent development does not disturb earlier images is not understood but has nonetheless been found to occur. This offers decided advantages not obtainable heretofore, as for example, in topographic map reproduction in which it may be desired to illustrate points or items of interest superimposed in different colors in order to make them discernable at a glance, but requiring printing in accurate registration. By means of the invention therefore, it is possible to obtain precise xerographic reproduction with accurate registration of multiple images directly on a xerographic plate without the requirement of consecutive transfer or consecutive fusing and if desired transfer can be effected in one step after the composite has been formed.

It is therefore the principal object of the invention to provide improved xerographic method and apparatus for multiple image formation.

It is a further object of the invention to provide novel apparatus for effecting multiple image formation on a xerographic plate in accurate image registration relative to each other.

It is a further object of the invention to provide novel apparatus for effecting multiple image formation on a support surface without the need for consecutive transfer or fusing of a developed image.

It is a further object of the invention to provide novel apparatus for effecting multiple image formation directly on binder type xerographic plates in accurate image registration each to the other.

It is a further object of the invention to provide novel apparatus and method to effect superimposed images in different colors on a continuously moving xerographic plate and in accurate image registration each to the other.

It is a still further object of the invention to provide novel apparatus for forming xerographic images on continuously moving xerographic plates.

These and other objects of the invention are attained in one embodiment by utilizing a continuous web of binder plate that is advanced continuously at a uniform rate to pass sequentially through a series of process stations each containing means to charge the plate, means to full frame expose a separation original to the charged plate different from each other process station, and liquid development means containing color developer for developing an electrostatic latent image different in color from each other process station. A reference indicium placed on the plate at the first process station is utilized to actuate the exposure means in each of the subsequent process stations in registration to previously formed images on the plate. A single heat fusing apparatus affixes the images to the plate, after the composite has been fully formed.

Embodiments in accordance with the invention are illustrated in the following drawings in which:

FIG. 1 schematically illustrates a side sectional view of apparatus of an embodiment adapted for continuous reproduction from a whole original onto a disposable xerographic plate;

FIG. 2 schematically illustrates a side sectional view of apparatus of one embodiment for multiple image reproduction from separation originals and utilizing full frame exposure with disposable xerographic plates;

FIG. 3 isometrically illustrates a portion of the apparatus illustrated in FIG. 2;

FIG. 4 schematically illustrates a side sectional view of apparatus of a second embodiment for multiple image reproduction from separation originals and utilizing slit exposure with disposable xerographic plates;

FIG. 5 illustrates a xerographic plate bearing reference indicium of the type utilized in the apparatus of FIG. 4;

FIG. 6 schematically illustrates an apparatus embodiment similar to FIG. 2 but adapted for using reusable xerographic plates.

Referring now to the drawings, there is schematically illustrated in FIG. 1 an apparatus **10** constructed in accordance with the invention and generally contained in a light-tight housing **11**. A supply of binder type xerographic plate **12**, in the form of a continuous web, is contained on a supply reel **13** mounted for rotation and from which a length of plate is continually drawn to pass through the apparatus to outside the housing onto a takeup reel **14** also mounted for rotation. The takeup reel is driven from motor M-1 through a suitable slip-clutch **15** to drive the takeup reel in a manner to effect web takeup at a uniform lineal rate. As the web is removed from the supply reel it passes over guide and tension rolls to a charging station **16** at which a suitable charging device **19** applies electrostatic charge to the plate surface. As illustrated at least one but preferably two or more corona generating devices **19**, which may be of a type disclosed in Vyverberg patent U.S. 2,836,725, are connected to a source of high potential **17** for application of the charge as the plate passes over grounded guide roll **20**. Other charging devices such as disclosed in Gundlach patent U.S. 2,885,556 or DeWitt patent U.S. 2,934,650 may also be used. For Lectrox type binder plates, applied surface potential is usually in the order of 200 to 300 volts and of negative polarity, whereas vitreous selenium plates conventionally utilize surface potentials of about 300 to 1000 volts and of positive polarity.

After passing the charging station, the web continues to advance over two metal rods **21** and **22** which are spaced a finite distance apart to define an exposure station **23** whereat the plate is selectively exposed to activating radiation. At the exposure station the web while moving, is supported flat in a focal plane for a full frame exposure from an original copy **24**. The original to be reproduced **24** is supported in a projector generally designated **25** that conveniently could be adapted for projection of either or alternatively both opaque or transparent originals. The exposure is full-frame in a manner disclosed in Schwertz copending application Ser. No. 664,136 filed June 6, 1957 now U.S. Patent No. 3,045,644 and is illuminated from a brilliant light source **26** of short duration such as a high speed gas discharge lamp of the electronic flash type used in photography and which is energized in timed relation to movement of the web. Suitable light shields **43** and **44** prevent stray light from reaching the plate other than at the exposure station.

After exposure the web advances to developing station **27** being comprised of a tank **28** containing insulating liquid **29**, as in the Mayer patent cited, and in which there is a suspension of electroscopic material **30** that is attracted to the plate in the image areas to effect de-

velopment. The plate is presented to the liquid for a predetermined time and in the preferred embodiment is routed through the tank for a sufficient time period to effect development, the time of which is largely dependant upon factors such as developer concentration, and usually requires on the order of ½ to 1 second. A reserve quantity of developing liquid is contained in a reservoir 31 for replenishing liquid to the tank consumed in development and is supplied to the tank under control of a float 32 adapted to operate a float-valve 33. Developer material may be added to the liquid periodically or at regulated intervals from a dispenser 34 adapted to feed metered amounts of the material into a conduit 35 connected to the tank below the liquid level. Suitable means such as a lever arm or push button control unit may be utilized to activate the dispenser unit by agitation or the like. Alternatively, the dispenser can be operative by monitoring either optical transmission of the developer or the reflection of a small test area printed on the surface of the reproduction.

Following development the web passes into a fusing station 40 for affixing the loosely supported developed image to the plate and constituted by a plurality of uniformly spaced strip heaters 41 (one shown) that are energized from potential source 17 under control of a surface thermostat 36 that is supported in a manner to sense the back-surface temperature of web 12 on leaving the fusing station. A suitable venting means (not shown) may be provided to minimize vapor concentration within the apparatus. With the image affixed, the web emerges from the housing through a slot 42 and in the embodiment shown is removed onto takeup reel 14 from which the composite reproduction may be utilized for a desired function.

In the event that it is desired to sever the reproductions emerging through slot 42, such as into cut sheets of predetermined or composite length, a suitable cutter such as disclosed in copending application Ser. No. 839,839 filed September 14, 1959 now U.S. Patent No. 3,075,493 in the name of Cerasani, et al. may be employed in place of takeup reel 14 and a drive mechanism such as a capstan or feed rolls installed past the fusing station to maintain advancing of the web.

Referring to FIGS. 2 and 3, there is schematically illustrated xerographic apparatus adapted for reproduction of multiple images in accurate registration with each other reproduced from separation originals.

The apparatus is generally contained in an elongated light-tight housing 50 in which a web of flexible xerographic plate 12 which may be of the binder type as aforesaid, is continually advanced from a supply reel 51 onto a takeup reel 52 driven by motor M–2 through a slip-clutch 59 operative similarly as clutch 15 above. Between the supply reel and takeup reel the web passes in operative relation to a plurality of process stations designated A, B, C, D and E. Each process station has separate utility and is novel in itself. Included in each process station is a support frame 53 supporting an original 54 to be reproduced, which in this instance is a separation original with which in combination with others will be utilized for forming a composite reproduction. As used in this specification the term "separation original" is intended to encompass an elemental part of an original document or copy supported separately, as distinctively by color, or separation from one whole original effected by optics or filters as is known to those in the lithographic and photographic arts. An original is secured to the support frame which is adapted to be adjusted vertically or laterally by means of screw leads 55 and 56 connected as shown to the support frame and operative by handwheels 57 and 58 respectively. Each handwheel contains index marks 61 disposed to pass over a reference mark 62 such that the position of the support frame can be set or changed. Handwheel 57 is supported on a slidable base 63 to permit it to accompany the support frame when moved laterally by handwheel 58. T-slot 60 permits vertical movement of the support frame which slides over the T-end of bolt 64.

As the web advances from the supply reel it first encounters process station "A" whereat a corona generating device 65, similar to generator 19 mentioned above, and connected to a source of potential 75 uniformly charges the plate surface. After charging the plate passes into an exposure station 66 having a plate support platform 72. At the exposure station the plate is exposed in full frame to an original that is illuminated by a pair of brilliant light sources 67 that may be the same as light 26 mentioned above and projected through an objective lens 68 onto the moving plate. Light shields 69 and 70 prevent stray light from striking the plate other than at the exposure station.

Operative at station A in conjunction with the exposure mechanism is a suitable marking device 71 for placing a reference mark on the plate in the form of a reference indicium that preferably is placed on the back of the plate in order not to detract from the reproduction. The indicium must be capable of being subsequently detected for purposes of effecting registration in the composite reproduction to be formed and must also be of a material composition not susceptible to distortion in any way in the course of its movement through the apparatus, as for example, not subjected to dissolvement when it passes through the developing liquid. A mark suitable for this purpose has been found to be one of graphite placed on the backside of the plate by a graphite wheel of a type illustrated in Cerasani et al. copending application cited above or alternatively, a mark found suitable is one xerographically formed in the manner disclosed in Cerasani et al. copending application Ser. No. 803,800 filed April 2, 1959, now U.S. Patent No. 3,105,425, or modifications thereof.

After passing the exposure station, the web advances to a developing station 73 that functions similarly to developing station 27 described above. Following development the web advances to process station B at which the web is charged again by a corona generating device 65 and is exposed to a different separation original 54 than it was exposed to in process station A.

To effect projected registration of the exposure at station B with the image previously formed from exposure at station A, the exposure lights 67 are energized momentarily when the indicium mark placed on the web by marker 71 is detected by a photocell 74 that is connected in circuit to the lights. A time delay may be utilized if required depending on the location of the components relative to the position of the indicium when detected and their relationship to the position at which registration is to be effected. By this means, registration between multiple images may be maintained to within 0.015 inch with web speeds of 6 inches per second and in some cases, up to 12 inches per second. The electrostatic latent image formed at station B is then developed similarly as in station A and may optionally be of a different color for distinguishing purposes. Thereafter, the web continues to pass any feasible number of process stations until the entire composite reproduction has been formed. When the formation has been completed the composite can then be utilized for optical projection in the manner of Clark, in the copending application cited above, or may permanently be affixed to the plate by passing the plate with the loosely supported developed image through a controlled high temperature medium such as a heat fuser 80 which may for example, be of a type disclosed in Crumrine et al. patent U.S. 2,852,651, although other known forms of fusing or fixing may be used, as for example, a self fixing emulsion as disclosed in Canadian Patent 608,901 to Metcalfe issued November 15, 1960.

The web bearing a fully formed composite is wound

onto takeup reel 52 that operates similarly as takeup reel 14 or the web may be cut in the manner aforesaid into any predetermined length. Where the plate is of the reusable type, as illustrated in connection with FIG. 6, rather than the binder type, it is usually cleaned before recycling after the image formed thereon has been utilized or transferred to a secondary support surface whereon it may be utilized as desired.

Instead of a continuous web of flexible plate, the plate can be precut to any desired size and, in a similar manner of feeding ordinary paper sheets fed from a stack to the process stations at a controlled rate of feed as disclosed in Eichler patent U.S. 2,945,434. Once fed, the cut sheets are conducted past the various process stations by a suitable gripper mechanism (not shown) adapted to grip and advance the plate without flexing the surface, such as disclosed in copending application Ser. No. 77,956 filed December 23, 1960 in the name of R. Eichorn now U.S. Patents No. 3,100,109. The gripper is adapted to grip the cut sheets and move each sheet past the process stations and then release the sheet at an opportune position. Since operation of all the exposure mechanisms other than at station A are dependent on an indicium formed at station A, registration when utilizing precut sheets is maintained accurate since each sheet bears its own indicium necessary to effect the operation of the exposure mechanism. A simplified version of the apparatus might include recycling the plate past the same process station after changing the separation original with optics or the like.

Referring to FIGS. 4 and 5, there is schematically illustrated apparatus utilizing slit exposure instead of full frame for effecting multiple image reproduction in accurate registration. As in FIG. 3, there is illustrated a plurality of process stations past which the web 12 is continuously advanced at a uniform rate to effect a composite reproduction formed of multiple images in registration.

Four process stations are illustrated, designated G, H, J and K in which the separation original contained in each of the process stations are exposed through an exposure slit 81. As in FIGS. 2 and 3 each process station includes a corona generating device 65 for charging the xerographic plate to an image forming potential prior to exposure. The exposure station is designated 82 at which a separation original 83 is projected onto the previously charged plate surface. The original is illustrated in endless form although it need not be, and is adapted to be advanced by a motor M–3 through a transport mechanism 87 past the optical axis of an objective lens 84 at a predetermined rate proportional to the rate of movement of xerographic plate 12. For a 1:1 reproduction, the rate of both the xerographic plate and the original will be identical whereas for a magnified reproduction the original is advanced at a rate inversely proportional to the magnification ratio employed. Each of the originals are driven through a common motor M–3 driving a timing belt 85 or the like which, through a solenoid clutch 86, is adapted to selectively connect the drive of the belt to the individual transport mechanism.

One or more duplicate originals may be contained on the endless web of original 83 and are continually illuminated by a pair of brilliant lamps 88 that may be of the incandescent type. The position of the transport mechanism is adjustable by means of screw leads 95 and 96 connected to a mounting bracket 97 of the support frame and operative by handwheels 98 and 99 respectively similarly as in FIG. 3. The xerographic plate moves over rotating cylinder 89 having its axis of rotation substantially aligned with the opening of slit 81.

Formation of a reference indicium on the xerographic plate is effected at station G from preplaced marks on the original that are xerographically reproduced onto the plate, and may, for example, be solid image areas 90 in the form of a line of predetermined length spaced in the margins between reproductions 92. Obviously other forms and means to form indicium may be utilized. Since to obtain accurate registration is of primary importance, it is necessary to control the projection position of the original being advanced by the transport mechanism in relation to position of the web at stations H, J and K. Operation of the transport mechanism at these stations is controlled from a sensing of mark 90 by a suitable detecting device such as photocell 91 positioned over the moving plate in the path of the marks. As the plate advances, a narrow beam of light is projected by a light source 101 onto the path of the marks so that the photocell can discern a change in the reflected light on sensing the mark 90. An embodiment found to effect the accuracy of registration utilizes a second photocell 102 to stop the transport mechanism by disengaging the clutch 86 at a predetermined position when sensing a reference, which may for example be a duplicate mark corresponding in kind and position to the original at station G from which the mark 90 was formed. On detecting a drop in illumination, that is, on photocell 102 sensing the leading edge of the duplicate mark in the direction of movement, the solenoid clutch 86 is de-energized unless a previous signal is received from photocell 91 on sensing the leading edge of the reproduced mark 90 within a calculable preset time difference depending on the relative speeds of the two webs and position of the respective photocells to the optical axis. A lag in receipt of the signal from cell 91 delays operation of the transport mechanism for a period of time corresponding to the lag time less a time calculated to effect acceleration of the web 83 to operating speed. These time differences referred to are in the order of microseconds. After exposure the images are developed similarly as described in connection with FIGS. 2 and 3 and after passing any feasible number of processes stations the composite image formed can be utilized or affixed in the manner described in connection with FIG. 2.

Referring to FIG. 6, there is illustrated an apparatus similar to that of FIG. 2 but adapted to accommodate a reusable xerographic plate designated 110. The plate is arranged in endless form having a photoconductive surface such as selenium on a flexible conductive backing which may be foil, conductive plastic, conductive paper, or the like. The plate is adapted to be driven at a uniform rate by motor M–5 and suitable guide and tension rolls are provided to direct the plate through the apparatus in operative relation to the process stations. The composite image is formed similarly as in FIG. 2 until passing process station E after which the plate passes to transfer station designated 111.

At the transfer station, the composite image is transferred by any suitable means to a secondary support surface 112 which may be paper web or the like. In the illustrated embodiment the paper web is drawn from a supply reel 113, and engages the plate surface while moving over guide roll 114. While in contact with the plate, an electrostatic charge is applied to the rear of the paper by means of corona generating device 115 that may be similar to device 19 above and whereby the composite image on the plate is electrostatically transferred from the plate to the paper. However, other transfer means known in the art such as contact or adhesive transfer may be employed or the composite may be transferred in the developing station of process station E by a technique known as "Immersed Roller Electrostatic Transfer" disclosed in copending application Serial No. 86,524 filed February 1, 1961 in the name of Hunter and entitled "Image Transfer, now U.S. Patent No. 3,120,446." If used for projection purposes as in the Clark application cited, image transfer can optionally be dispensed with.

After transfer, the paper passes through a fusing apparatus 89 as above wherein the transferred image is permanently affixed to its surface and wherefrom the paper advances onto a takeup reel 116 being driven by

motor M–5 through a slip-clutch **117** to advance the web at the same lineal rate as the plate. A suitable cutter mechanism may be employed to sever the paper into predetermined lengths.

The xerographic plate after passing the transfer station advances to a cleaning station designated **125** whereat its photoconductive surface is cleaned before being recycled. To achieve cleaning, the surface may be brushed by a rotating brush **126** from which the removal is exhausted by a fan **127** to a filter bag **128**. Instead of brushing, the plate may be squeezed or the like, or may be wiped in a manner disclosed in copending application Serial No. 110,281 filed December 27, 1960 in the names of Graff and Gundlach and entitled "Web Cleaning Apparatus" now U.S. Patent No. 3,186,838.

Of the exposure methods known for exposing copy to a moving plate, flash exposure is preferred for accuracy. For full frame exposure, i.e. with a stationary original, flash produces approximately 0.001 of an inch distortion on plates moving at speeds of approximately 12 inches per second. When viewed with the naked eye this distortion is imperceptible and can be tolerated in the majority of reproduction applications. To achieve this limit of distortion requires an effective flash duration of approximately 83 microseconds, although the total flash time may exceed the effective flash time because of lamp characteristics of rapid rise in light intensity to a maximum which then diminishes slowly to extinguishment. Lamps of this type are commercially available, typical of which is a General Electric Model FT–220 which has a time light output of approximately 2800 lumenseconds with an 80 microsecond flash duration on an input of 80 watt seconds and with which images are produced having a resolving power of greater than 10 lines per millimeter on plate speeds of 12 inches per second.

Liquid development as disclosed in Mayer above cited, utilizes an insulating liquid containing developer particles which deposit on a xerographic plate as aforesaid. To effect development it is necessary to present the developer contained liquid in contact with the plate surface which may be by immersion as illustrated in the accompanying drawings or by other forms of presentation as, for example, by roller contact disclosed in the Mayer patent cited. Another form of development found to produce satisfactory results is a "powder cloud" as disclosed in Matthews patent U.S. 2,911,945, but because of the relatively complex apparatus required therefore, liquid development is preferred.

Whereas registration has been discussed in connection with a composite on one side of a webbed surface it obviously can be applied in the manner of the invention to both sides of a web surface. Further, registration has been discussed primarily in connection with its attainment in the direction of plate movement, it being understood that suitable edge control means such as an electronic edge control unit marketed by Automatic Timing and Controls, Inc. of King of Prussia, Pennsylvania, will maintain a web in its proper course and accurately aligned in registeration in a direction lateral to its direction of movement.

As used in the specification, the term "activating radiation" is understood to include any form of electromagnetic radiation which when acting on a photoconductive member renders the member increasingly conductive to holes, electrons or both. Thus for example, activating radiation includes visible light, infra-red, ultra-violet, X-ray and gamma radiation.

In the above description there is disclosed process and apparatus suitable for producing multicolor xerographic reproductions, as for example, topographic maps, in a compact, automatic, high speed machine from micromap originals. The reproductions are brilliant, sharp, with good contrast and freedom from background depositions while achieving the object of accurate image registration.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the drawings and specification, shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A process for xerographically reproducing images from different originals in accurate registration on a xerographic plate comprising the steps of: subjecting a xerographic plate to treatment that includes charging a xerographic plate to an image forming potential; exposing the charge plate to an activating radiation image of a first original to form an electrostatic latent image of the exposed original on the plate; developing the electrostatic latent image with a substantially electrically insulating liquid containing discrete developer particles; with the previously developed image remaining and before complete fusing thereof again subjecting the same plate at least partially in the confines of the existing image area thereof to said treatment while exposing a different original to the plate for each subsequent treatment to which it is subject; and controlling each subsequent exposure to be operative in accurate registration to the image reproduced from each preceding exposure.

2. The process of claim **1** in which the developer of each subsequent development is of at least one other color than developer of prior developments.

3. A process for xerographically forming a composite reproduction from separation originals comprising the steps of: subjecting a xerographic plate to treatment that includes charging a xerographic plate to an image forming potential; exposing the charged plate to an activating radiation image of a separation original to form an electrostatic latent image of the exposed original on the plate; developing the formed electrostatic latent image with a substantially electrically insulating liquid containing discrete developer particles; with the previously developed image remaining and before complete fusing thereof at least once again subjecting the same plate at least partially in the confines of the existing image area thereof to said treatment while exposing a different separation original to the plate to be developed in different colors for each subsequent treatment to which it is subjected; and controlling each subsequent exposure to be operative in accurate registration to the image reproduced on the exrographic plate from each preceding exposure.

4. The process of claim **1** in which the xerographic plate is continuously moved while being subjected to said treatment and control of subsequent exposures in registration is achieved by operatively energizing the exposure means in response to detection of a reference indicium formed on the xerographic plate in spaced registration to the first formed image.

5. The process according to claim **1** in which the xerographic plate comprises a particulate photoconductor dispersed in a resinous binder coated on a paper backing.

6. The process according to claim **3** in which the xerographic plate comprises a particulate photoconductor dispersed in a resinous binder coated on a paper backing.

7. The method according to claim **1** including the step of collectively transferring all of said developed images after completing the last development thereof.

8. A method of producing a reproduction in a plurality of colors comprising the steps of: forming a pattern on the coated surface of a recording element comprising a particulate photo-conductor dispersed in a resinous binder coated on a paper backing, said pattern consisting of electrostatically charged areas and of substantially reduced charge areas in substantial configuration with one color of the reproduction to be formed; applying to said pattern a mixture comprising discrete electroscopic particles of said one color dispersed in an insulating liquid to develop on said coated surface an image of said par-

ticles of said one color; and, with said developed image remaining and before complete fusing thereof, repeating the aforesaid steps at least once to produce an image of electroscopic particles of another of said plurality of colors on said coated surface.

9. The method according to claim 8 including the added step of collectively fusing all of said produced colors after the last of said colors has been produced.

10. A process for xerographically reproducing images from different originals in accurate registration on a xerographic plate comprising subjecting a xerographic plate to treatment that includes charging a xerographic plate to an image forming potential, exposing the charged plate to an activating radiation image of a first original to form an electrostatic latent image of the exposed original on the plate, developing the electrostatic latent image with a high resistance liquid containing developer particles, again subjecting the same plate at least partially in the confines of the area thereof containing the previously developed untransferred image substantially unfused to completely unfused thereto of the prior exposure to said treatment while exposing a different original to the plate for each subsequent treatment to which it is subjected, and controlling each subsequent exposure to be operative in accurate registration to the image formed from each preceding exposure.

11. The process of claim 10 in which the developer of each subsequent development is of at least one other color than developer of prior developments.

12. A process for xerographically forming a composite reproduction from separation originals comprising subjecting a xerographic plate to treatment that includes charging a xerographic plate to an image forming potential, exposing the charged plate to an activating radiation image of a separation original fixedly supported to form an electrostatic latent image of the exposed original on the plate, developing the formed electrostatic latent image with a high resistance liquid containing developer particles, at least once again subjecting the same plate at least partially in the confines of the area thereof containing the previously developed untransferred image substantially unfused to completely unfused thereto of the prior exposure to said treatment while exposing a different separation original to the plate to be developed in different colors for each subsequent treatment to which it is subjected, and controlling each subsequent exposure to be operative in accurate registration to the image formed on the xerographic plate from each preceding exposure.

13. The process of claim 10 in which the xerographic plate is continuously moved while being subjected to said treatment and control of subsequent exposures in registration is achieved by operatively energizing the exposure means in response to detection of a reference indicium formed on the xerographic plate in spaced registration to the first formed image.

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