Oct. 6, 1970 S. B. McFARLANE 3,532,422

METHOD AND APPARATUS FOR ELECTROSTATIC COLOR REPRODUCTION

Filed July 14, 1966

3 Sheets-Sheet 1

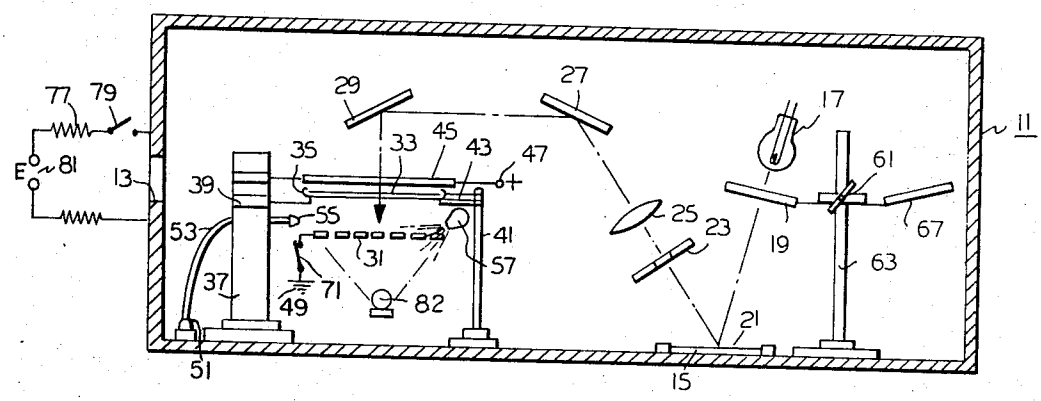


FIG. 1

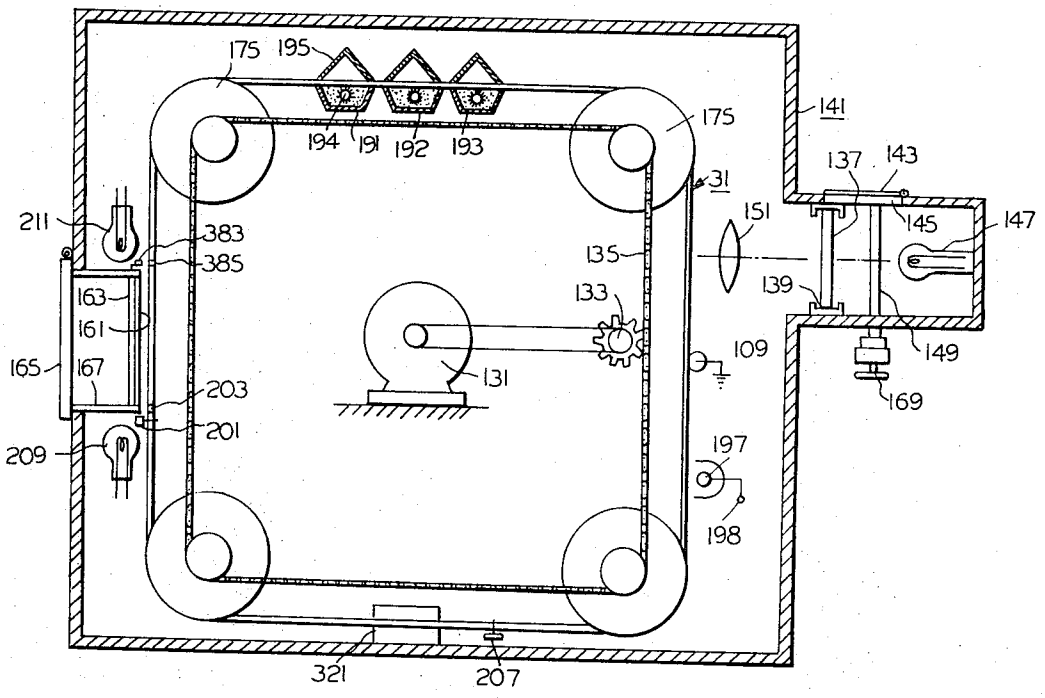


FIG. 2

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Filed July 14, 1966 3 Sheets-Sheet 2

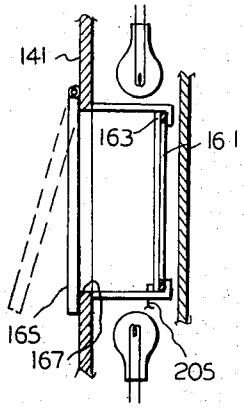


FIG.3

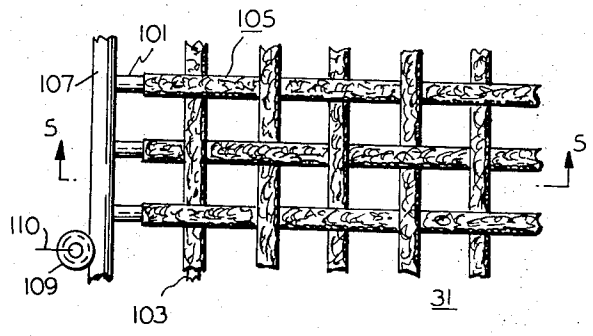


FIG.4



FIG.5

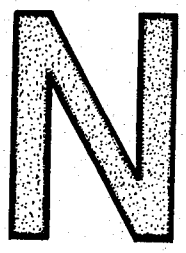


FIG.6

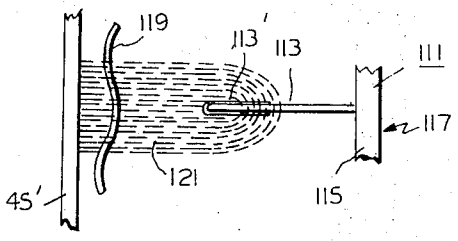


FIG.7

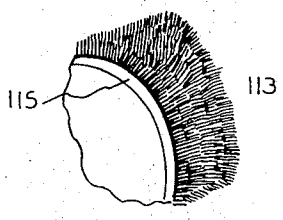


FIG.8

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METHOD AND APPARATUS FOR ELECTROSTATIC COLOR REPRODUCTION

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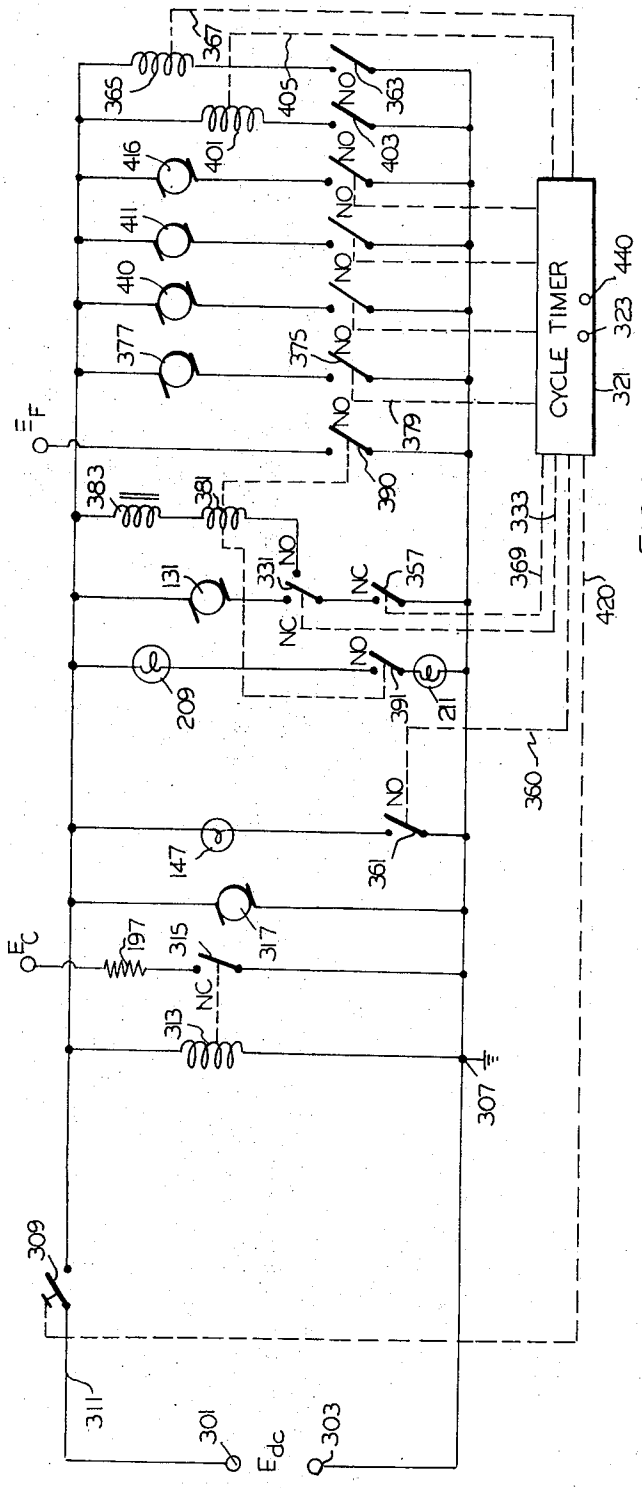


FIG. 9

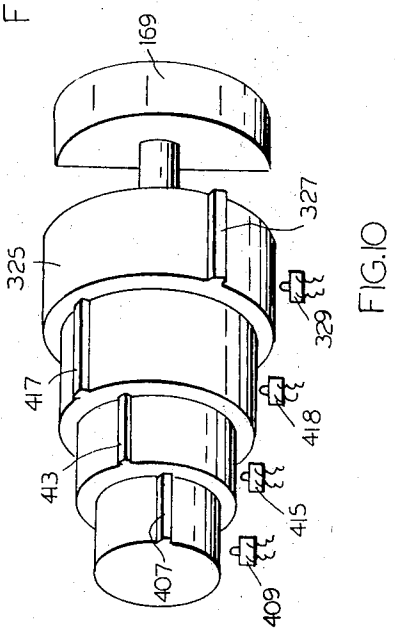


FIG. 10

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3,532,422

METHOD AND APPARATUS FOR ELECTROSTATIC COLOR REPRODUCTION

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Filed July 14, 1966, Ser. No. 565,284
Int. Cl. G03g 13/22
U.S. Cl. 355—4 17 Claims

ABSTRACT OF THE DISCLOSURE

This color printing invention relates to the use of a latent electrostatic charged image formed on a photoconductive interrupted surface such that the charges are laid down and the color powders are accumulated in discrete areas. Color contamination is avoided through the use of a common or single exposure station at a given location as well as a single development station for projection for the marking material across an air gap onto a print receiving medium. The "in situ" color separations using the same interrupted-type screens or other surfaces permit the colors to be laid down similar to half-tone dot on dot impingement to avoid moire patterns.

The present invention relates to apparatus and a method for electrostatic color printing. It is an improvement over the inventions of my U.S. Pats. 3,220,831 and 3,220,833, issued Nov. 30, 1965 and entitled "Electrostatic Printing Method and Apparatus Using Developer Powder Projection Means" and "Electrostatic Printing Method."

The preferred method comprises the steps of exposing a uniformly charged photosensitive surface to light images of selected color to be reproduced, an electrostatic latent image or charged pattern being thus produced. The charged pattern is powdered with suitable dry ink printing or marking material of the requisite color and the ink material image is projected through an air gap onto a medium to be printed, the latter then preferably passing through fixing means to set the transferred powder material.

In the preferred arrangement, printing in the primary colors is sequentially accomplished, in order that color contamination is avoided. The photoconductive surface is uniformly charged and a first primary color image projected thereon. The image is powdered in a first color and the powder transferred by the air gap, and fixed on the paper or other material to be printed. Then the second and third primary color images are layed down in the same manner so that the resulting reproduction exhibits all colors, shadows and highlights of a true process print.

For office reproduction machines, under some circumstances, better reproduction is obtained if a black image is included in the foregoing sequence, thereby reproducing fine printing and the like with extreme detail.

For ordinary office copy printing, it has been found that truer copies are produced if the following sequence is performed: black, blue, red, yellow. The color image corresponding to the most opaque (black) printing ink is first projected on the screen, followed by development with suitable toner. The second, third and fourth color images are projected onto the photoconductive surface and suitably developed with dry printing materials, the most transparent one being the last in the sequence.

The arrangement is also compatible for reproducing color transparencies, and for this type of work it has been found that the same sequence provides optimum printing. Usually the black color may be omitted.

A feature of the invention enables the elimination of edge effects so commonly encountered in color reproduction, particularly where solid blocks or elements of color are required to be duplicated. The apparatus and method of this invention eliminate hollows or voids in printing of block areas because the photoconductive surface is interrupted, as a grid, screen or the like, so that effectively color incremental area printing (similar to half-tone) is obtained rather than relying on the principle of large area printing.

Suitable interrupted photoconductive surfaces are generally described in my referenced patents. One comprises a wire screen or mesh coated with conventional photoconductive material. The wire mesh or scheen forms one electrode of the air gap printing apparatus in which a further, preferably planar, conductive plate is spaced therefrom to comprise the other electrode. Thus, an electrostatic field is established in the air to receive a paper or other material to be printed upon. The material intercepts the marking material which is projected from the photoconductive surface toward the planar conductor along the electrostatic lines of force. Such a screen or mesh may be used as a mechanical selecting means for insuring that only fine granular marking material is passed therethrough to powder the charged image developed on the opposite side of the screen. Alternatively, of course, the image may be directly powdered from the same side on which it is produced but without the sifting feature.

An alternative photoconductor surface comprises a plurality of electrically conductive wires embedded in an insulative backing and tipped with photoconductive material such that the needle tips support the image charges. With this type construction it is necessary to employ a conductive backing, such as foil or the like, on the base or supporting insulative backing in order that the photoconductive electrode may form one boundary for the electrostatic printing field.

The method and apparatus of this invention are compatible with commercially available materials. The color images are produced, for example, by employing Wratten filters in the form of thin pieces of gelatin per se, without resort to cemented or glass filters. The image projection arrangement and the transfer of the material from the photoconductor to the paper are compatible to produce a direct image reproduction. The transfer itself provides a reversal of the image which is compensated for by an odd number of reversals in the projection or optical system. As will be explained in detail, the so-called reverse filters are employed for the individual monochrome images to overcome the problem of background color printing.

The arrangement is capable of being carried out with printing plates or in automatic manner, as for use in office reproduction machines. In the latter arrangement, the photoconductor is in the form of an endless belt, conveyor or drum, which receives the image charge pattern, presents it to a powder station and then to the electrostatic printing field where it is transferred to the medium being printed, with fixing being achieved thereafter by a simple heat source.

An advantage of this approach resides in the fact that corrugated or rough textured paper, cardboard or cloth, or other materials may be continuously printed because the electrostatic latent images may be continuously produced and the air gap transfer avoids contact between the image carrier and the material being printed, thereby eliminating smudging, distortion and color contamination.

With the foregoing in mind, it is an object of this invention to provide a novel sequential color reproducing method and apparatus employing electrostatic printing.

It is a further object of the invention to provide such method and apparatus utilizing electrostatic latent images and air gap marking material transfer.

A still further object of the invention resides in such method and apparatus capable of accurate process printing without color contamination.

Another object of the invention is the provision of color reproduction, which eliminates edge effects.

Other and further objects and advantages of the invention will become apparent to those skilled in the art from a reading of the following detailed description thereof when taken in the light of the accompanying drawings in which:

FIG. 1 is a schematic view of apparatus for manual control in color reproduction.

FIG. 2 is a view partly in side elevation and partly in section of apparatus for automatically or semi-automatically carrying out color process printing.

FIG. 3 is a detailed sectional view of a portion of the apparatus of FIG. 2.

FIG. 4 is a detailed view in plan of a portion of one image carrier.

FIG. 5 is a sectional view of FIG. 3 taken along the plane of 5—5.

FIG. 6 illustrates prior art type block printing.

FIG. 7 is a detailed view of a portion of an alternate carrier.

FIG. 8 shows a portion of the alternate carrier in perspective.

FIG. 9 is the circuit diagram for automatic or semiautomatic control of the apparatus of FIG. 2, and

FIG. 10 shows the selector knob for the apparatus of FIG. 2.

The method can best be understood from a consideration of the schematic manually operated device of FIG. 1. A light tight box **11** houses all the necessary components with entrance gained by opening **13** and the paper slot **15**. The original to be reproduced in color is inserted in slot **15** and light from any conventional source **17** passes through filter **19** and is reflected from the original **21** via an apertured plate **23**, focusing lens **25** and mirrors **27** and **29** to the image carrier **31**, illustrated as of the screen or grid type. The paper, cardboard, cloth, or other material, to receive the color reproduction is depicted at **33** retained by paper holder **35**, which is a rectangular frame and is pivotally attached to post **37** by collar **39**. A vertical upriser **41** carries one or more stops **43** to insure that the paper is returned to its precise location for each color step.

The paper **33** and holder **35** are pivoted out of the light path via opening **13** for each exposure of grid **31**.

A transparent conductive backing plate **45** forms one plate of the electrostatic field, with the grid **31** forming the other conductor thereof. Positive DC potential, of the order of 1500 volts per $\frac{1}{10}$ inch gap, is applied between terminal **47** and ground **49** to produce an electrostatic field in the air between screen **31** and plate **45**. It is this field which projects the marking material across the air gap to be intercepted by material **33** to be printed.

The marking material is supplied by separate blower motors **51** (only one of which is shown) via conduits **53** and venturi nozzle **55**. The marking material may be charged in known manner and the screen may be subjected to corona discharge from source **57**, for uniform charging thereof.

In operation, the preferred first filter is selected by the operator by turning knob **61** on standard **63** which supports 3 or 4 color filters, such as **19** and **67**. By way of example, assume that the three primary colors—blue, red and yellow—will be used to reproduce a processed print. It is preferable to select first, the blue filter which in the Kodachrome minus arrangement is filter #47B for which yellow toner, in the form of dry marking material will be used.

The source **17** directs light through the blue filter and

the image is projected onto the uniformly charged screen **31**, with paper **33** being revolved out of the box or housing or at least the light path. The screen **31** becomes discharged in accordance with the light impinging thereon and the dusting is effected by appropriate motor **51** for the yellow toner. The paper **33** is rotated back to the position shown and switch **79** is closed to apply the projection or electrostatic field to the air gap so that the charged image pattern of yellow toner ink particles is transferred to paper **33**.

Screen **31** is coated with commercially available photographic substances and by way of example, if selenium is used, then negatively charged powder is employed, but for zinc oxide coating, positively charged powder is used. A further source of corona, similar to source **57**, is included in conduit **53** to effect the proper powder charge. As a practical matter, it is easier to charge the powder negatively so that the selenium or other equivalent photoconductor is preferred.

Next the paper **33** is moved out of the housing (or light path) and the marking material is fixed by heat generated in the resistance wire **77**, through closure of switch **79** for heating source of potential **81**.

During this time the red filter is moved into position, below light source **17**, by knob **61** and the appropriate blower motor **51** is selected for cyan toner. The preferred red filter in this example is #25 minus.

The screen **31** is cleaned of powder material by vacuum motor **82** and is uniformly charged by corona source **57**. Then exposure takes place, the cyan toner material is applied to the electrostatic latent image, and the paper **33** returned to its former position against stop **43**.

Registration within $\frac{1}{1000}$ of an inch provides a satisfactory copy without color contamination.

Electrostatic field, produced by source **47**, then transfers the marking material and this color is fixed while selecting screen filter #58 for use with magenta toner powder through its appropriate source, such as **51**. When the third color has been applied and fixed in the foregoing manner, the reproduced copy contains all the colors and hues, highlights and shadows of the original.

Owing to the internal electrostatic lines of force established in the latent image due to the charge distribution, the prior art sytems have experienced great difficulties with the development step in attempting to overcome concentrated charges, which result in the copies reproduced having hollow centers and emphasized edges, as for example, see the N of FIG. 6. Usually, some form of a development electrode is required. Such electrodes have at least a surface of a conductive material biased slightly or held at the same potential as the plate or backing conductive member to establish electrostatic fields outwardly of the image and away from its backing plate, to minimize the distortion.

The present invention essentially avoids these problems by providing a strong development field with definite lines of force established through the air gap between at least the image and the transfer medium or material to be printed. The problem is further minimized by avoiding intermediate transfers of the electrostatic latent image, thereby eliminating handling of the charged images which heretofore caused smudging.

By using an electrostatic latent image, the present invention eliminates stencils and hence permits continuous printing of repetitive patterns or images of printed or pictorial matter. In addition to this advantage, the use of an air gap for image transfer avoids the disadvantages of pressure transfer which requires uniform contact and the attendant use of wetting agents, resulting in more uniform printing without bleeding, even on a corrugated transfer medium.

On unusual feature presented by the air gap charge tarnsfer arrangement, permitting printing on rough or corrugated paper, is the facility to create an illusion of depth. Embossed or specially indented paper can be

printed on the indentations to present the appearance of a three-dimensional scene.

Thus it will be appreciated that another object is the provision of such apparatus which minimizes the mechanical elements and relies upon electrostatic transfer through an air gap to the transfer medium without the necessity of wetting agents, and is capable of very heavy printing.

The foregoing process may be carried out in a continuous manner or in step-by-step fashion for individual image reproduction. In the former, a pattern is printed on a fabric or a film of images is reproduced continuously. In the latter, images are reproduced intermittently, as in office business machines or the like.

The described process is capable of being carried out by hand or partially or fully by machine to produce xerographic plates for use in other arrangements.

The grid or screen **31** may take the form of either of the carriers shown in FIGS. 4 and 5, or FIGS. 7 and 8. Both carriers are described in detail in my prior patents, above referenced, and for purposes of this application the following brief discusion should be adequate.

In FIG. 4 a wire mesh forms the basis of the carrier and preferably is characterized by 133 lines per inch in each direction. However, the mesh may be substantially increased to 250 or greater for higher resolution printing or reduced for coarser printing. The individual conductive wires are shown at **101** and **103** and a photoconductive coating applied thereto is illustrated at **105**. A conductor **107** is provided in order that the screen or grid may be at uniform potential. Electrical contact to the conductor **107** is established by roller **109** and lead **110** which extends to ground **49** (FIG. 1).

In the embodiment of FIG. 1, the grid **31** is static and roller **109** may comprise simply a clamp, but in the endless belt conveyor apparatus of FIG. 2, the roller **109** is employed.

In the alternative arrangement of FIGS. 7 and 8, either a xerographic plate **111** or an endless belt carrier **113** is formed from a plurality of needles **113** affixed in a pliable plastic or other non-conductive member **115**, having an aluminized film or conductive material **117** deposited on the opposite side thereof. Here again the resolution desired is increased proportionately to the number of needles or rods **113** per square inch. The preferred range is 150 to 250 needles, each electrically isolated from the rest, but of metal or other conductive material. The needle tips are coated with photo-conductive material **113'** (same as **105**) and the electrostatic latent imge is formed on the needle coatings.

In FIG. 7 it may be seen that the paper to be printed on is of corrugated configuration **119** and the conductive planar member **45'** is disposed in spaced relation to the needle tips. The lines of electrostatic force are shown at **121** and basically provide parallel paths for the charged particles to be transferred or projected toward plate **45'** and intercepted by paper **119**.

While the embodiments of FIGS. 7 and 8 are compatible with either of the apparatus of FIGS. 1 and 2, it will be appreciated that plate **111** is particularly suited for the apparatus of FIG. 1 and endless carrier **115** is designed for use with the apparatus of FIG. 2.

An automatic or semi-automatic color reproducing apparatus is shown in FIG. 2. The endless conveyor belt **31** is of the same type as screen **31** in FIG. 2, shown in detail in FIGS. 4 and 5. The motor **131** supplies driving power for the belt **31** through a sprocket gear **133** (by way of suitable gear reducers, not shown) which engages a sprocket belt **135**. The sprocket drive connection is employed for purposes of registration, along with further mechanism to be described.

While the machnie of FIG. 2 may comprise a regular office copy machine (using the optics of FIG. 1), it has been illustrated for reproducing color transparencies. Thus, a color transparency **137** is placed in a holder **139** with access through light tight housing **141** being available via hinged cover **143** and opening **145**. The light source **147** is supported by housing **141** and adapted to flood transparency **137**, by way of appropriate color filter **149**. A simple focusing lens **151** is disposed between transparency **137** and belt **31** thus comprising a very simple optical arrangement but one capable of producing a positive print through a reversal by lens **151** and compensating reversal at the electrostatic image transfer gap where the particles are transferred to the receiving material, such as paper **161**.

The paper, cloth or other material **161** to be printed on is placed in holder **163** (FIG. 3) and inserted in housing **141** via hinged cover **165** and opening **167**. The appropriate filter **149** is selected by knob **169** and motor **131** is stopped for the exposure of belt **31** through transparency **137**.

The electrical controls will be described in connection with FIGS. 9 and 10, but in the meantime it is sufficient to known that the drive is intermittent, with the belt stopped for both exposure and transfer of the marking material. The belt **31** is supported by the four drums **175** with the sprocket drive belt **135** being coupled to the sprocket driving extensions **177**. The drums **175** are supported from the housing **141** in conventional manner.

In the preferred arrangement of FIG. 2, the rectangular configuration is best suited to the method of this invention because of the two vertical reaches for exposure and transfer. However, it should be pointed out that a triangular configuration, a drum arrangement (with the simple two-pulley deployment shown in my Pat. 3,220,-831) or other configurations may be utilized in lieu of the ararngements depicted.

In operation, the transparency **137** is inserted in position, as is the material **161**, to receive the color reproduction thereof. Exposure takes place and the belt moves with the appropriate powder moter being energized. The bins **190**, **192** and **193** are provided for the separate color toners and of course the fourth one may be utilized if black is to be included in the process.

The roller brushes **194** in the bins are independently rotated to agitate the powder which is confined by the funnel-shaped troughs **195** so that the powdered inking material is actually dusted through the belt **31** and is retained in the appropriate charged areas for the particular image being developed. Additional charging of the powder may be achieved with a suitable corona source, when necessary.

The belt **31** itself is uniformly charged by the corona tube **197** connected to a source of potential **198**, of the order of 8 to 12 thousand volts, the spacing between corona tube **197** and belt **31** being of the order of ¼ to ½ inch.

A microswitch **201** is fixed to the housing at a position near the transfer gap and is adapted to be actuated by lever **203** carried by the belt **31** to stop motor **131** in the position for particle field, provided by a source of potential applied to lead **205** (FIG. 3), being grounded by roller **109** to transfer the material in registration to the paper **161**.

Similarly, a further micro-switch **207** is positioned at a different location, relative to belt **31**, such that the belt carried lever **203** will actuate micro-switch **207** to stop the conveyor in a second position for exposure. Alternately, exposure may be achieved in one color while a transfer is achieved in another color such that the conveyor is arrested only once for each color. However, the preferred arrangement depicted insures that the belt **31** is uniformly charged from corona source **197** just prior to exposure.

Following each transfer of the material, the heating lamps **209** and **211** are flashed to fix the material prior to the laying down of the next color.

The details of a suitable electrical control circuit will now be described, along with a positive registration means in an automatic arrangement, such as for use in

an office copy machine or the like, but it will be understood that the embodiment of FIG. 2 may comprise such a standard type office machine, but capable of color, with the optics of FIG. 1 substituted for the color transparency optics.

In FIG. 9 an operating source of potential E_{dc} of, for example, 110 volts DC is present at terminals **301** and **303**. Ground conductor **305** is designated as being grounded at **307**. An on-off switch **309** in lead **311** is provided for manual (if desired) initiating operation of the machine, after a transparency or original is inserted in the machine.

Closure of switch **309** energizes relay coil **313** to close switch **315** for corona wire **197** to activate corona source E_c, being an independent source of high voltage for the corona charging of belt **31**. At the same time, vacuum motor **317** is energized so that vacuum chamber **321** (FIG. 2) is continuously effective to clean belt **31** of any excess powder. The vacuum chamber **321** simply comprises a brush or matting on the inner side of belt **31** and a funnel or suction on the lower side of the belt so that the vacuum is effective to draw off the particles and discharge them from the apparatus.

The foregoing apparatus is operative all during operation of this machine while switch **309** is in its closed position.

The remaining operation is sequential, primarily under the control of cycle timer **321** which is commercially available item in the form of a conventional timer or sequencer, usually employing stepping switches or interconnected relays.

The apparatus ultimately comes to rest at stop **201** (FIG. 2) where it is shut off by the cycle timer after the last of the three or four step color reproduction. Thus, beginning with the apparatus in the arrested condition at stop **201**, the cycle timer is initiated by depressing start button **323** of timer **321**. This automatically closes switch **309** for the entire operation. It also turns the selector knob **169** until drum **325** is revolved to a position where its upriser **327** operates switch **329** for the first color. Switch **329** causes cycle timer **321** to close motor switch **331** from main drive motor **131** to its normally closed position over dotted control line **333**. Closure of switch **331** causes the belt to advance to stop **207** where normally closed motor switch **357** is mechanically opened by arm **207** to again stop the motor. This amount of movement of belt **31** insures that the belt will be uniformly charged by corona source **197** in the exposure area.

Thus, while the motor **131** is stopped with arm **203** against stop **207**, exposure takes place. Light **147** has its normally open switch **361** closed mechanically by stop **207** in order that light source **147** is illuminated during the arrested motion of belt **31**.

Cycle timer **321** opens the exposure circuit for light **147** by control lead **360** to switch **361** through the same signal sent to it from slow pull-in relay **365**.

Signal switch **363** is also mechanically closed by arm **203** at stop **207**. This action energizes slow pull-in relay **365** which provides a signal over dotted control line **367** to cycle timer **321**. The reason that relay **365** is of the slow pull-in type is to permit full exposure before restarting motor **131**. The cycle timer **321** responds to the signal from relay **365** to close switch **357**, over dotted control lead **369**, thereby initiating movement. Also, cycle timer **321** closes switch **375** over dotted control lead **379** for powder motor **377** which drives one of brushes **191**, **192** or **193** for the appropriate toner for the first color. Thus, the electrostatic latent image formed during the exposure step is automatically powdered and carried by belt **31** to stop **201**. When arm **203** strikes stop **201**, main motor switch **331** is opened and motor **131** is deenergized. However, switch **331** closes a second circuit marked normally open which energizes slow pull-in relay **381** and electromagnet **383**. The electromagnet **383** is fast operating and instantly homes on an indexing piece of soft iron **385** carried at a fixed location in belt **31**. This effects exact registration (within $\frac{1}{1000}$ of an inch) for the electrostatic latent image relative to the paper **167** for each color cycle so that color contamination is avoided.

Once the image is registered, relay **381** (FIG. 9) closes normally open switch **390** for the electrostatic field to cause air gap transfer of the image to the paper **161**. Also, fixing lamps **209** and **211** are energized by closure of normally open switch **391** to fix the transferred image. Slow pull-in relay **381** also closes switch **391** for heat fixing lamps **209** and **211**.

The operation just described completes one full revolution of belt **31** and this fact is signaled by slow pull-in relay **401** when it is energized by mechanical closure of its normally open switch **403**. The slow operation of relay **401** enables timer for transfer of the marking material and fixing of the same before relay **401** signals over control lead **405** to cycle timer **321** to start the next partial revolution of belt **31**.

Cycle timer **321** releases switch **375** for powder motor **377** when arm **203** strikes stop **201**. The contacts are physically separated and switch **375** remains open until its cycle in the production of the next copy which, of course, is initiated by selector knob **167** thereof, when upriser **327** strikes switch **329**.

Accordingly, cycle timer **321** moves the drum **325** of selector knob **169** so that upriser **407** actuates switch **409** to repeat the cycle described for the second color. The same sequence is carried out for the second color with powder motor **410** being appropriately energized and, thereafter for the third toner with powder motor **411** being energized as a result of upriser **413** initiating its cycle through switch **415** and the fourth powder motor **416** is automatically energized as a result of upriser **417** striking its associated switch **418** to initiate operation of cycle timer **321**.

At the conclusion of all four printing cycles, cycle timer **321** opens main switch **309** over control lead **420** to signify that the copy has been reproduced and may be removed from the machine.

The switches **409**, **415**, **418** and **329** of selector knob **169** light different colored neon lamps (not shown) corresponding to the color being printed, in order that the operator may know the color and the stage of color reproduction at any given time.

The circuit may be overridden by master switch **440** in cycle timer **321** in order that single colors or 2 or 3 colors only may be selected for use. Similarly, manual operation is afforded through selector knob **169**.

While the invention has been illustrated and described as to its preferred embodiments, it should be understood that equivalent structures will occur to those skilled in the art based upon the principles hrein disclosed; and, accordingly it is intended that the scope of this invention be limited only by the appended claims wherein:

What is claimed is:

1. The method of electrostatic color printing comprising the steps of: producing at a first location a latent electrostatic charged image corresponding to a first color on a photoconductive surface comprising elements of a grid; powdering the image with marking material; introducing the so-powdered image into an electrostatic field established in the air at a defined position to project the marking material along the lines of electrostatic force onto a transfer medium opposite the defined position to be printed; fixing the so-projected marking material, repeating in sequence all of said steps for a second color image, followed by a third color image to effect color reproduction characterized by dot effects.

2. The method of electrostatic color printing empolying an interrupted photo-conductive surface and a conductive electrode spaced therefrom in a given location to form an air gap therewith, comprising the steps of uniformly charging the photo-conductive surface, sequentially

projecting different color light images onto the so-charged surface from a common projecting location to produce electrostatic latent image charged patterns; powdering each of said charged patterns with fine granular marking material; introducing the so-charged patterns in sequence to the air gap along with a material to be printed with said material being located opposite said given location; projecting the marking material into the air gap toward the conductive member to be intercepted by the material to be printed; and fixing the so-projected marking material following the project of the marking of each color thereby providing substantially contamination-free color printing.

3. Apparatus for electrostatic printing in color comprising, the combination of a flexible interrupted strip photo-conductive surfaced conveyor supported for movement along a predetermined path; means for uniformly charging the photo-conductive surface of said conveyor; means at a fixed location relative to the conveyor for sequentially projecting light images of material to be reproduced onto the photo-conductive surface in the three primary colors to produce electrostatic latent image charged patterns thereon corresponding to each color; means for powdering the respective charged pattern images with marking material corresponding to each color thereof; a conductive member spaced from said convey at a given location; means for establishing an electrostatic printing field between said conveyor and said conductive member to project the colored marking material toward said conductive member for interception by the material to be printed upon; and means for fixing the marking material so projected.

4. Apparatus for color reproduction comprising, in combination a photo-conductive interrupted surfaced carrier; means for uniformly charging the carrier; means for sequentially projecting light corresponding to different color exposures of a color image to be reproduced onto said carrier from a single location to produce an electrostatic latent image corresponding to each color exposure; means for sequentially powdering each electrostatic latent image with powdered marking material in accordance with each color exposure; means for establishing an electrostatic field with said carrier at a selected location and in spaced-apart relation thereto; means for introducing material to be printed to said field at said selected location; means for energizing said field to project the marking material onto said material to be printed; and means for sequentially controlling said apparatus for printing in each of said colors.

5. The apparatus of claim 4 wherein said photo-conductive carrier comprises an interrupted surface having substantially coplanar portions including voids therebetween to receive said charging and images substantially on said portions.

6. The apparatus of claim 5 wherein said carrier comprises a screen and said surface comprises a photo-conductive coating thereon.

7. The apparatus of claim 6 wherein said powdering means is disposed on one side of said screen and said latent image is formed on the other side of said screen whereby said marking material is sifted by said screen to powder said image.

8. The apparatus of claim 5 wherein said photo-conductive carrier comprises a non-conductive base; a plurality of closely spaced-apart needles set in the base; and a conductive layer affixed to the base on the side opposite the needles.

9. The apparatus of claim 5 wherein said surface comprises a plurality of spaced-apart islands of photo-conductive material.

10. The apparatus of claim 4 wherein the color image is one of a film negative and a transparency and the means for sequentially projecting light comprises a source of illumination for projection through the color image; selectable color filters; and light optics capable of selectively discharging the carrier to leave charged areas on the carrier in accordance with the reverse of the color exposure of the color image and wherein powdering of the reverse charged carrier returns the image sign of said color exposure of the color image.

11. The apparatus of claim 4 wherein the color image is an original color print and the means for sequentially projecting light comprises a source of illumination, means for scanning each color exposure of the print, selectable color filters, and light optics capable of discharging the carrier to leave charged areas on the carrier in accordance with the reverse of the color exposure of the color image, and wherein powdering of the reverse charged carrier returns the image sign of said color exposure of the color image.

12. The apparatus of claim 4 wherein said means for establishing an electrostatic field with said carrier comprises a light transmissive conductive plate.

13. The apparatus of claim 4 wherein said carrier comprises an endless interrupted member and said means for sequentially controlling said apparatus comprises timing means for sequentially controlling the projection of light corresponding to different color exposures, for sequentially powdering the latent images, and for sequentially energizing said field; and driving means for driving the endless member under control of the timing means.

14. The apparatus of claim 4 wherein said carrier comprises an endless belt adapted for intermittent movement; magnetizable means carried by said belt; and means comprising magnetizing means for registering said belt at a given position for transfer through attraction of said magnetizable means.

15. The apparatus of claim 4 wherein said carrier comprises driving means; an endless belt adapted for intermittent movement by the driving means; stop means deployed along the path of said belt; and means carried by the belt for engaging the stop means to arrest belt movement by rendering the driving means ineffective to drive the belt.

16. Apparatus for electrostatic color printing comprising:

an electrostatic latent image carrier having photo-conductive substantially coplanar portions for establishing an image and spaces between said coplanar portions;

means for uniformly charging the photo-conductive substantially coplanar portions of said carrier;

a single projection station comprising a fixed location for positioning said carrier, a light source, and means for sequentially projecting images of an object to be reproduced onto the carrier in a pluarity of colors thereby sequentially to produce electrostatic latent images corresponding to each color;

means for powdering the electrostatic latent image sequentially formed on the carrier by different color light with marking material corresponding to each color;

a single printing station comprising a fixed location for positioning said carrier, means for positioning a print receiving medium spaced from said fixed location, means for establishing an electrostatic field between said carrier positioned at the fixed location and a print receiving medium for projecting marking material from the carrier to the print receiving medium; and

means for sequentially positioning said carrier at the fixed location of the single projection station and the fixed location of the single printing station.

17. A method of electrostatic incremental area color contamination-free printing utilizing an electrostatic latent image carrier having photoconductive substantially coplanar portions for establishing an image and spaces between said coplanar portions comprising;

sequentially projecting images of an object to be reproduced onto the carrier in a plurality of colors

at a fixed location of a single projection station thereby sequentially to produce electrostatic latest images corresponding to each color;

powdering the electrostatic latent images sequentially formed on the carrier by different color light with marking material corresponding to each color;

projecting marking material from the carrier to a print receiving medium spaced from said carrier at a fixed location of a single printing station; and

sequentially positioning said carrier at the fixed location of said single projection station and the fixed location of said single printing station.

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