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(54) Method of controlling the transfer of an image.

(57) An improved method is provided to control the transfer of an image from an original (22) to a carrier (26) and from the carrier (26) to photosensitive material. Intermediate images (26a,6) corresponding to the originals are formed on the carrier. Radiation is transmitted through the intermediate images to form projected images which correspond to the originals. At least a portion of an intermediate image is inspected to determine if the actual characteristic of the intermediate image corresponds to a desired characteristic. If the actual characteristic of the intermediate image is different than the desired characteristic, a control function is undertaken to change a variable in the step of sequentially forming the intermediate image. In one specific embodiment, the original has a test area of known density. After a corresponding test area has been formed on the carrier, the test area on the carrier is inspected to determine if its density corresponds to the density of the original. If the density of the test area on the carrier does not correspond to the density of the test area on the original, the process of forming an intermediate image on the carrier is revised before a next succeeding intermediate image is formed on the carrier.

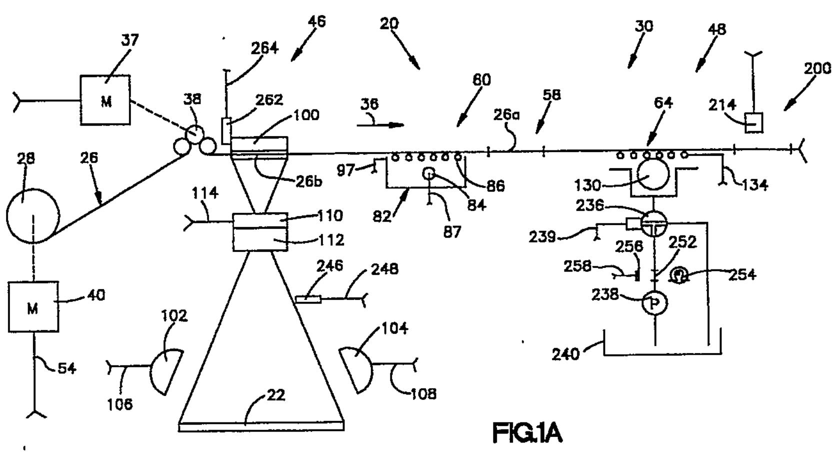

FIG.1A

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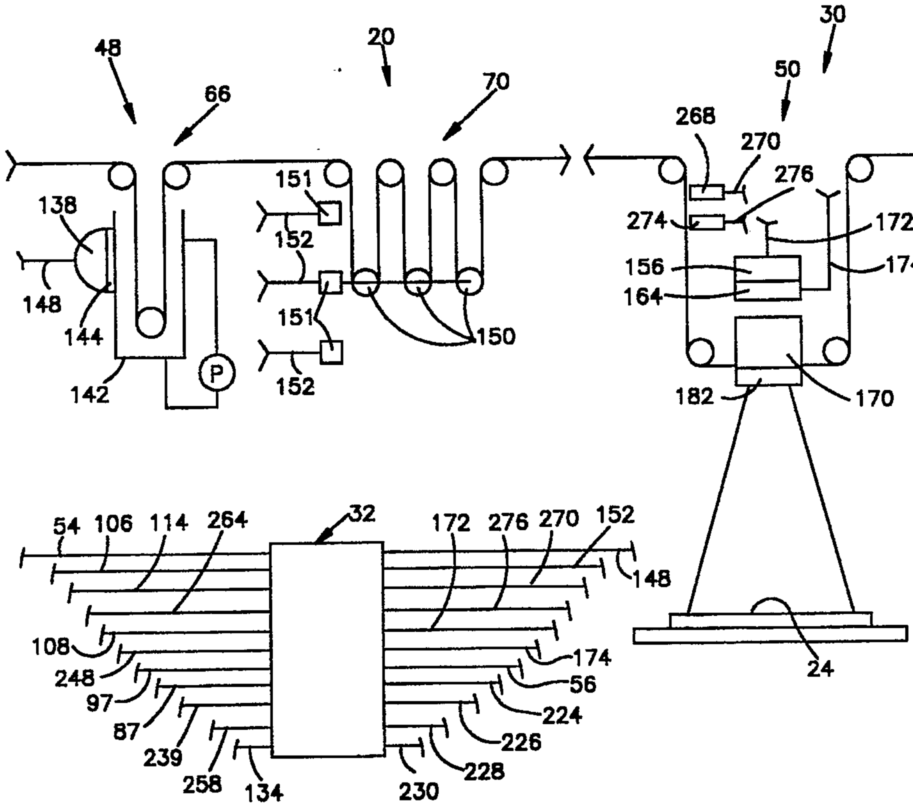
48
66
20
70
30
50
26
268
270
276
274
172
31
42
M
156
164
174
138
148
144
142
P
151
152
150
182
170
56
54
106
114
264
32
172
276
270
152
148
108
248
97
87
239
258
134
174
56
224
226
228
230
24

FIG.1B

Background of the Invention

The present invention relates to a method of controlling the transferring of an image of an original to photosensitive material.

Current plate making practice in many printing plants is to make a paste-up copy which is photographed to produce a full sized image on film as a negative. The silver halide film must be developed in a separate processor. The developed film negative must then be placed in contact with the unexposed plate in a vacuum frame. The plate is then exposed to high intensity ultraviolet radiation which causes a photochemical reaction to take place on the surface of the plate. The film is then removed and the plate is further prepared by developing (offset lithography) or wash out (letterpress/flexo) operation.

Another known method of making printing plates includes providing a plate which is coated with an organic photoconductive layer. The photoconductive layer is charged and then exposed to a paste-up copy which is projected onto the plate surface. Background areas of the image reflect light and discharge the plate. As soon as the plate exposure· is finished, the plate is moved into a processor where a liquid dispersant containing positively charged toning particles is applied to the surface of the plate. The toner particles adhere to negatively charged areas of the plate. After being dried, the toner particles on the plate are fused together and bonded to the surface of the plate. After decoating, rinsing and gumming, the plate is ready for use in a printing press.

EP-A-0345010 discloses a method and apparatus for use in transferring an image from an original to photosensitive material. The photosensitive material may be disposed on a base or plate and used in the making of an article such as a printing plate or printed circuit board. To transfer the image from an original to the photosensitive material, a film strip or other carrier is moved along a path which extends through an array of stations. An image of an original is formed on the carrier by electrophotographic methods.

When the method and apparatus disclosed in the afore-mentioned EP-A- 0345010 are used to transfer an image, it has been determined that process variables may result in the image transferred to the photosensitive material having characteristics which are different than the original image. Any difference between the original image and the image transferred to the photosensitive material could be the result of many different process variables. Regardless of what process variable result in the difference between the original image and the image transferred to the photosensitive material, the existence of such a difference may be, to some extent at least, objectionable.

Brief Description of the Invention

The present invention provides a new and improved method for controlling the transfer of an image in such a manner as to minimize any differences between the transferred image and an original. In transferring the image, a series of intermediate images are formed on a carrier. At least a portion of an intermediate image is inspected to determine if an actual characteristic of the intermediate image corresponds to a desired characteristic of the intermediate image. If the actual characteristic of the intermediate image is different than the desired characteristic, a change is made in a variable in the process of forming the intermediate images.

In one specific instance, the intermediate image is inspected to determine whether or not the actual density of an area of known desired density of the intermediate image is the same as the desired density. If the density of the area of known desired density is different than the desired density, a control function is undertaken. This control function is advantageously undertaken before the next succeeding intermediate image is formed. When electrostatic methods are used to form the intermediate image, the control function which is undertaken may include changing the quantity of particles which are electrostatically attracted to the carrier by changing: an electrostatic charge applied to the carrier, a toner bias voltage, projector shutter speed, and/or intensity of light to which originals are exposed.

Accordingly, it is an object of this invention to provide a new and improved method wherein intermediate images corresponding to originals are formed on a carrier and the intermediate images are inspected to determine if an actual characteristic of an intermediate image corresponds to a desired characteristic, a variable in the forming of the intermediate images being changed if the actual characteristic of an intermediate image is different than the desired characteristic.

Another object of this invention is to provide a new and improved method wherein intermediate images corresponding to originals are formed on a carrier, at least one intermediate image is inspected and a variable in the forming of the intermediate images is changed before a next succeeding intermediate image is formed if an actual characteristic of the one intermediate image is different than a desired characteristic.

Another object of this invention is to provide a new and improved method of transferring images of an original and wherein at least a portion of an intermediate image is inspected to determine whether or not the actual density in the inspected portion of the intermediate image is the same as a desired density.

Brief Description of the Drawings

The foregoing and other objects and features of the invention will become more apparent upon a consideration of the following description taken in connection with the accompanying drawings wherein:

Figs. 1A and 1B are a schematic illustration of an apparatus which is used to transfer images of originals to photosensitive material;

Fig. 2 is a highly schematicized illustration depicting the manner in which a photoconductive layer on a film strip is charged at a charging station;

Fig. 3 is a highly schematicized illustration depicting the manner in which portions of the photoconductive layer are rendered conducting by exposure to an original at an exposure station;

Fig. 4 is a highly schematicized illustration depicting the manner in which toner particles are attracted to conducting areas of the photoconductive layer on the film strip at a developing station;

Fig. 5 is a highly schematicized illustration depicting the manner in which toner particles are fused with the conductive layer at the developing station;

Fig. 6 is a schematic illustration depicting the manner in which a plurality of densitometers are used to inspect portions of an intermediate image; and

Fig. 7 is a schematic illustration of an apparatus utilized to determine the amount of toner particles in a toner solution being conducted through a conduit.

Description of Specific Preferred Embodiments of the Invention

General Description

An apparatus 20 for transmitting an image of an original 22 to photosensitive material 24 is illustrated schematically in Figs. 1A and 1B. A carrier 26 is used in transferring an image from the original 22 to the photosensitive material 24 (Fig. 1B). In the illustrated embodiment of the invention, the carrier is a continuous film strip 26 which extends from a cylindrical supply roll 28 (Fig. 1A) through a linear array 30 of processing stations to a cylindrical storage roll 31 (Fig. 1B). It should be understood that the carrier 26 could be one or more plates or sheets of material or other articles having a structure which is different than the film strip. However, the film strip is the presently preferred embodiment of the carrier 26.

The linear array 30 of processing stations facilitates constructing the apparatus 20 in modules. The modules can be interconnected and in a minimum of space in many different environments. The relatively compact apparatus 20 can be automated by the use of computer controls 32 (Fig. 1B) to allow the apparatus to be operated by a minimum number of personnel having relatively little training.

Although the apparatus 20 can be used for making many different articles, it is advantageously used for making printing plates. The printing plates are mounted in a press and used to print newspapers or other sheet material items in a known manner. When the apparatus 20 is used to form printing plates, the original 22 will be paste-up copy and the photosensitive material 24 will be a layer of photosensitive material supported on a base or plate. However, it should be understood that the apparatus 20 can be used to produce printed circuit boards and other items. It should also be understood that the body of photosensitive material 24 can be supported in other ways if desired.

The film strip 26 is indexed in both a forward direction (indicated by an arrow 36 in Fig. 1A) and a reverse direction from the supply roll 28 along a path extending through the linear array 30 of stations to the storage roll 31 by operation of reversible motors 37 connected with drive sprockets, including a drive sprocket 38. The drive sprocket 38 is rotated to sequentially index segments of the film strip 26 through each of the stations in the linear array 30 of stations. The speed and direction of rotation of the drive sprocket 38 can be varied to vary the speed of movement of the film strip 26. A pair of motors 40 and 42 (Figs. 1A and 1B) are continuously energized to tension the film strip by urging the supply and storage rolls 28 and 31 in their windup directions.

A reduced size image of the original 22 is projected onto a segment of the film strip 26 at an exposure station 46 (Fig. 1A). The image of the original 22 is developed on the film strip 26 at a developing station 48 (Figs. 1A and 1B) to form a visible intermediate image on the film strip. An enlargement of the intermediate image on the film strip is projected onto the plate 24 of photosensitive material at a transfer station 50 (Fig. 1B). After passing through the transfer station 50, the film strip 26, with the intermediate image of the original thereon, is wound onto the storage roll 31.

The operation of the apparatus in the linear array 30 of stations 46, 48, 50 is regulated by the computer controls 32. In addition, the operation of the motors 40 and 42 is regulated by the computer controls 32 to control the tension in the film strip 26. Thus, the motor 40 is connected with the computer controls 32 by a lead indicated schematically at 54 and the motor 42 is connected with the computer controls by a lead indicated schematically at 56. The computer controls 32 regulate the direction and speed of operation of the motor 37 connected to the main drive sprocket 38 to move the film strip 26 against the influence of one of the motors 40 or 42 with the assistance of the other motor.

The film strip 26 can be used to subsequently produce another printing plate having an image corresponding to a selected original 22 without re-exposing the selected original. When this is to be done, the computer controls 32 operate the motor connected to the main drive sprocket 38 to rotate the sprocket at a high speed in the reverse direction. During reverse rotation of the drive sprocket 38, the motors 40 and 42 rapidly unwind the film strip 26 from the storage roll 31.

The film strip 36 is moved at a relatively high rate of speed through the linear array 30 of stations until the film segment upon which a copy of a selected original is disposed is at the transfer station 50. An image of the selected original is then transferred, for a second time, from the film strip 26 to photosensitive material 24. The controls 32 then effect rotation of the drive sprocket 38. to quickly wind the film strip 26 back onto the storage roll 31.

During operation of the apparatus 20 to sequentially transfer images of a plurality of originals 22 to a plurality of plates 24 of photosensitive material, the film strip 26 is incrementally indexed by and maintained under a constant tension by operation of the main drive sprocket 38 and motors 40 and 42. This sequentially moves adjacent segments of the film strip 26 from the supply roll 28 through each of the stations 46, 48, and 50. Therefore, there is continuous series of equal size segments in a side-by-side relationship on the film strip 26. Each segment of the film strip 26 contains a reduced size intermediate image corresponding to a different original 22.

However, it is contemplated that the apparatus 20 could be operated in such a manner as to transfer only an image of a single original 22 to the film strip 26 at the exposure station 46 and to then index the film strip to move this image through the developing station 48 to the transfer station 50. At the transfer station 50, the image would be transmitted to photosensitive material 24 to form a single printing plate or other article. The film strip would then be wound onto the storage roll 31. Of course, this would result in a substantial portion of the film strip 26 being blank between adjacent images.

During operation of the apparatus 20 to sequentially expose printing plates 24 of photosensitive material to images of different originals 22 at the exposure station 46, the film strip 26 is indexed in the forward direction 36 and in the opposite or reverse direction in a stepwise manner by rotation of the main drive sprocket 38 at a relatively low rate of speed. However, when the film strip is to be quickly indexed relative to the linear array 30 of stations, the motor 37 for rotating the main drive sprocket 30 is operated by the controls 32 to move the film strip 26 in either a forward or reverse direction at relatively high speed.

An image of an original 22 is transferred to and from the film strip or other known carrier 26 by electrophotography, that is, by using electricity and radiation. During operation of the illustrated apparatus 20, an electrostatic latent image is formed on each segment of the film strip 26 in turn as the film strip is indexed through the exposure station 46 and a charging station 60 (Figs. 1A and 2). In order to prevent dissipation of the charge on a segment of the film strip while the apparatus 20 is inactive, a segment of the film strip 26 is moved from an initial or holding location 58 back through the charging station 60 to the exposure station 46. As the segment of the film strip 26 moves through the charging station 60 in the reverse direction, a charge is applied to the segment of the film strip. This eliminates the possibility of a previously charged segment of the film strip 26 becoming patially discharged while it is at the exposure station 46 and the apparatus 20 is inactive.

As a segment of the film strip moves back through the charging station 60, a uniform positive electrostatic charge is applied to the segment of the film strip 26. At the exposure station 46, the positively charged segment of the film strip 26 is exposed to a light pattern corresponding to a selected original 22. Wherever the exposing light beam strikes the film strip 26, the electrostatic charge applied at the charging station 60 is discharged. This results in the formation of a latent electrostatic image of the original 22 on a segment of the film strip 26.

The extent to which portions of a segment of the film strip 26 are discharged at the exposure station 46 depends upon the intensity of the light which strikes each portion of the film strip. The greater the intensity of the light which strikes a portion of the film strip 26 the greater is the reduction in the magnitude of the charge on that portion of the film strip. This enables continuous tone images to be subsequently formed on a segment of the film strip.

After the latent electrostatic image of the original 22 has been formed on a segment of the film strip 26 at the exposure station 46, the film strip is indexed in a forward direction to move the exposed segment of the film strip through the charging station 60 and initial or holding location 58 to the developing station 48. As the film strip is moved in a forward direction through the charging station 60, the charging station is inactive. Therefore, the electrostatic charge on the exposed segment of the film strip remains constant to maintain the latent electrostatic image of the original.

Although the charging station 60 has been shown as being downstream or after the exposure station 46 in Figs. 1A and 2, it is contemplated that the charging station could be ahead of the exposure station if desired. If a segment of the film strip 26 is indexed through charging station 60 in a forward direction to the exposure station 46, a positive electrostatic charge would be applied to the segment of the film strip before it reached the exposure station. If the apparatus 20 is inactive for a substantial period of time, the charge on the segment of the film strip disposed at the exposure station 46 may tend to dissipate with the passage of time. Of course, this will tend to adversely effect the quality of the image projected onto the photosensitive material 24 at the transfer station 50.

The electrostatic latent intermediate image which is applied to a segment of the film strip at the exposure station 46 and charging station 60 is made visible and permanent at the developing station 48. The developing station 48 includes a toner substation 64 and a fusing substation 66. Positively charged toner particles are electrically attracted to discharge areas of the film strip 26 at the toner substation 64.

The quantity of toner particles attracted to a portion of a segment on the film strip 26 is an inverse function of the magnitude of the charge remaining on that portion. Thus, lower charged portions receive more toner particle and higher charged portions receive less toner particles. The resulting toner particle density differences on different portions of a segment of the film strip may make up a continuous tone image.

The toner particles form a visible intermediate image which corresponds to and is smaller than the original 22. A dryer (not shown) is disposed between the toner substation 74 and fusing station 66. At the fusing substation 66, the toner particles are fused together and are fused with the material of the film strip 26 to form a permanent visible image corresponding to the original 22. The intermediate image formed by fusing the toner particles with the film strip 26 is durable and can be stored for a relatively long period of time on the storage roll 31. This enables the film strip 26 to be indexed from the storage roll 31 and used at a later time for forming a second printing plate 24.

A temporary storage station 70 is provided between the developing station 48 and transfer station 50. The temporary storage station 70 functions to temporarily hold a variable length of the film strip 26 until it is indexed to the transfer station 50. The length of the film strip 26 held at the storage station 70 can be increased from a relatively short length to a relatively long length during the exposure of a substantial number of originals 22 at the exposure station 46 with the transfer station 50 inactive. Subsequently, the length of the film strip 26 held at the storage station 70 can be reduced from a relatively long length to a relatively short length during transfer of a substantial number of images from the film strip to photosensitive material 24 of the transfer station 50 with the exposure station 46 inactive.

At the transfer station 50, an image on a segment of the film strip 26 is projected from the film strip onto photosensitive material 24. This is accomplished by transmitting radiation through the film strip 26 onto the plate 24 of photosensitive material. The radiation trasmitted through the film strip 26 projects an enlarged image of the intermediate image on a segment of the film strip to the plate 24 of photosensitive material. The image projected onto the photosensitive material 24 corresponds to and may be larger, smaller or the same size as an original 22. The image projected onto the photosensitive material 24 may be smaller than the image on the film strip 26.

In order to enhance the quality of the image formed on the plate 24 of photosensitive material, ultraviolet radiation is transmitted through the film strip 26 to the photosensitive material 24. Although light of various wavelengths could be used, the ultraviolet light includes light of a wavelength between 365 and 450 nanometers. At the surface of the photosensitive material 24, the ultraviolet radiaticn has an energy level of at least 500 ergs per square centimeter. The quality of the image formed on the photosensitive material 24 is enhanced by using very high quality projection optics to transmit the image. Since the conventional offset plates 24 of photosensitive materials are relatively inexpensive, the consumable materials used to make a printing plate are relatively inexpensive.

The plate 24 of photosensitive material can be any one of many known, commercially available, plates intended for use in the forming of printing plates. When the surface of the plate 24 of photosensitive material is exposed to ultraviolet radiation having an energy level of at least 500 ergs per square centimeter, the plate undergoes a photochemical reaction which causes a permanent change in physical properties of a polymeric composition or diazo compound forming an upper (as viewed in Fig. 1B) layer on the plate. Development of the printing plate 24 is then completed in a known manner. The fully developed printing plate 24 is mounted in a printing press and used to print. copies of an original on sheet material in a known manner.

Film Strip

In the illustrated embodiment of the invention, the carrier for an intermediate image of an original 22 is a film strip 26. The film strip 26 is a 105 mm organic photoconductor film. The film strip 26 has two series of openings along its opposite edges to receive sprockets at the supply roll 28, drive sprocket 38, and storage roll 32. This enables the film strip to be accurately indexed by rotation of the drive sprocket 38.

The film strip 26 includes a transparent and electrically insulating base 74 (Fig. 2) formed of a polyester material. A transparent conductive layer 76 is disposed over the base 74 and is connected to ground, in the manner indicated schematically in Fig. 2, at the supply roll 28 (Fig. 1A). Thus, one end of the film strip 26 is mechanically clinched to a metal spool for the supply roll 28. The metal spool is grounded during the film loading step. The transparent conductive layer 76 acts as a ground electrode during the processing of the film strip 26 at the charging station 60, at the exposure station 46 and at the developing station 48.

A transparent photoconductive layer 78 (Fig. 2) of organic material is applied over the conductive layer 76. The purpose of the photoconductive layer 78 is to accept and hold an electrostatic charge in the dark, and then to discharge areas which are struck by an exposing light beam. Prior to being exposed to a light beam at the exposure station 46, the photoconductive layer 78 is electrically insulating. However, portions of the photoconductive layer which are struck by a light beam at the exposure station 46 are rendered conducting. The extent to which portions of the photoconductive layer 78 are rendered conducting varies as a direct function of the intensity of the light beam to which the portions of the photoconductive layer is exposed. The greater the intensity of the portion of a light beam striking a spot on the photoconductive layer 7, the greater is the conductivity of that spot on the photoconductive layer.

When the photoconductive layer 78 on a segment of the film strip 26 is exposed at the exposure station 46 to a light pattern which corresponds to the original 22, the photoconductive layer is rendered electrically conducting in areas having a configuration which corresponds to the configuration of an image on the original 22. The lighter an area on the original, the greater is the conductivity of the corresponding area on the segment of the film strip. Conversely, the darker an area on the original, the less is the conductivity of the corresponding area on the segment of the film strip.

The photoconductive layer 78 is a solid solution of a suitably sensitized organic photoconductor. This transparent homogeneous layer 78 does not have any of the crystalline structure associated with the emulsion layer of silver halide photographic materials. In one specific embodiment of the invention, the film strip 26 was KODAK EKTAVOLT (Trademark) recording film sold by the Eastman Kodak Company. Of course, equivalent film strips of a somewhat different construction and/or material could be utilized if desired. It should be understood that the photoconductive layer 78 faces downwardly in the embodiment of the invention shown in Figs. 1A and 1B even though the photoconductive layer 78 is shown facing upwardly in Figs. 2-5.

While it is preferred to use the film strip 26 as the carrier for an intermediate image of an original, other known carriers could be used if desired. Thus, a transparent plate covered by a thin coating of aluminum or carbon could be used as the carrier. If this was done, a laser could be used at the exposure station 46 to form an image of the original 22 on the transparent plate by vaporizing or melting the coating where a laser beam is directed against the coating. While it is preferred to use a single element as a carrier for an image, the carrier could include a series of elements and the image could be transferred from one element of the carrier to succeeding element of the carrier. Of course, other known carriers could be used if desired.

Charging Station

A uniform electrostatic charge is applied to the electrically insulating photoconductive layer 78 (Fig. 2) on the film strip 26 at the charging station 60. The charge is applied in the dark by a charger 82 having a corona wire 84 and a control grid 86. The corona wire is connected with a high voltage source 88, that is a source of 4,000 to 6,000 volts. The corona wire 84 produces positively charged ions. The positively charged ions, indicated schematically in Fig. 2, are electrically attracted to the photoconductive layer 78.

The corona charger 82 has a grounded shield 92 which improves control of the charging process by attracting corona current and providing stability. The control grid 86 modulates corona current. The operation of the power supplies for the corona charger 82 and control grid 86 are controlled by the computer controls 32 (Fig. 1B). Thus, the high voltage source 88 is connected with the computer controls 32 by lead 96. The control grid 86 is connected with the controls 32 by lead 97.

Although the corona charger 82 has been shown in Fig. 2 as being above the film strip 26, it should be understood that the charging unit 60 is disposed below the film strip 26 in a manner illustrated in Fig. 1A. The photoconductive layer 78 forms the lowermost or bottom layer of the film strip 26 and the base or supporting layer 74 is the upper layer. Although the charging station 60 has been illustrated herein as being after the exposure station 46, the charging station could be disposed before the exposure station if desired.

Exposure Station

At the exposure station 46 (Fig. 1A), a latent intermediate image which corresponds to and is smaller than an original 22 is formed on a segment of the downwardly facing photoconductive layer 78 of the film strip 26. To accomplish this, the film strip 26 is held flat by a vacuum head 100. Lamps 102 and 104 are then turned on by the computer controls 32 through leads 106 and 180.

The computer controls 32 then effect operation of a shutter assembly 110 to enable light to be projected through a lens 112 onto a segment of the film strip 26. To enable the shutter 110 to be actuated by the computer controls 32, the shutter is connected with the computer controls by a lead 114. Although the shutter cycle time will depend, in part at least, on the characteristics of a film strip 26, the shutter cycle time may range from 3 to 7.5 seconds.

When a light beam 118 from the original 22 strikes the photoconductive layer 78, in the manner indicated schematically in Fig. 3, the light beam causes the photoconductive layer to become electrically conductive to an extent corresponding to the intensity of the light beam where the light beam strikes the photoconductive layer. The areas of the photoconductive layer 78 not struck by the exposing light 118 remain electrically nonconducting. In areas where the photoconductive layer 78 is rendered conducting by the exposing light pattern from the original 22, positive charges on the surface of the photoconductive layer 78 are attracted to the ground conducting layer 76. The greater the conductivity of a specific area on a segment of the film strip 26, the greater is the extent to which the positive charges on the surface of the photoconductive layer 78 are attracted to the grounded conducting layer 76. Negative charges on the conducting layer 76 are attracted to the surface of the photoconductive layer 78 in the manner indicated schematically in Fig. 3.

The resulting charge pattern on the photoconductive layer 78 forms a latent intermediate image of reduced size and having a configuration which corresponds to the light pattern formed by the original 22 (Fig. 1A). The magnitude of the charge at any point on the charge pattern will be an inverse function of the ink density at a corresponding point on the original. Although the exposing light pattern 118 is illustrated schematically in Fig. 3 as originating from above the film strip 26, the exposing light pattern actually originates from below the film strip in the manner shown in Fig. 1A.

Developing Station

At the developing station 48, the latent intermediate image of the original 22 on a segment of the photoconductive layer 78 is made visible and permanent. Thus, positively charged toner particle are electrically attracted to conducting areas on a segment of the photoconductive layer 78 to form a visible intermediate image. The toner particles are fused with the material of the photoconductive layer 78 to make the visual image permanent.

At the toner substation 64 (Figs. 1A and 4), positively charged toner particles are transmitted from a toner head 130 to a segment of the photoconductive layer 78 on the film strip 26. The toner head 130 functions as a positively charged development electrode (Fig. 4) . An electrostatic field is established between the toner head 130 and the conducting layer 76 at areas where the photoconductive layer 78 was rendered electrically conducting by exposure to the light pattern 118 (Fig. 3).

The positively charged toner particles from the toner head 130 (Fig. 4) are electrically attracted to discharged areas of a segment of the photoconductive layer 78. This is because the discharged areas of a segment of the photoconductive layer 78 are adjacent to the conducting layer 76. The toner particles are repelled by the positively charged areas of a segment of the photoconductive layer 78 in the manner indicated schematically in Fig. 4. Thus, the toner particles adhere to a segment of the film strip 26 only in areas where light impinged against the film strip at the exposure station 46.

The density with which the toner particles are attracted to a particular area in a segment of the film strip 26 is an inverse function of the optical density at the corresponding area of the original 22. This is because different levels of charge will remain on the photoconductive layer 78 depending upon the intensity of the light to which the photoconductive layer is exposed. The different charge levels will result in the attraction of different amounts of toner particles. Thus, lower charged areas will attract more toner particles and higher charged areas will attract less toner particles.

The discharged areas of the photoconductive layer 78 have a configuration corresponding to the configuration of the light pattern 118 transmitted from the original 22. Therefore, the opaque toner particles form a visible pattern which corresponds to the original 22 when the toner particles adhere to the conducting areas of the photoconductive layer 78. The computer controls 32 are connected with the toner substation 64 by a lead 134 to enable the controls to regulate the strength of the electrical field between the development electrode 130 and the film strip 26. In addition, the computer controls 32 turn the toner head 130 off when the film strip 26 is being indexed in the reverse direction and/or when toner is not to be applied to a segment of the film strip at the toner substation 64.

At the fusing substation 66 (Figs. 1B and 5), toner particles 136 are fused together and are fused with the material of the photoconductive layer 78 in the manner illustrated schematically in Fig. 5. Thus, an infrared lamp 138 at the fusing station 66 heats the toner particles to melt or fuse the toner particles together. During the fusing process, the toner particles also melt slightly into and fuse with the conductive layer 78 in the manner illustrated schematically in Fig. 5.

As the film strip 26 moves into the fusing substation 66, the film strip enters a fusing water tank 142 (Fig. 1B). The film strip 26 is then exposed to the infrared lamp 138 by opening a shutter 144. Operation of the shutter 144 is controlled by the computer controls 32 over a lead 148.

When the shutter 144 is opened, the heat from the infrared lamp 138 fuses the particles of toner together. In addition, the heat from the infrared lamp fuses the particles of toner with the material of the film strip 26. This results in the formation of a permanent image on the film strip 26. It should be understood that the film strip 26 is transparent at locations where the opaque toner particles 136 do not block transmission of light through the film strip. Although the infrared lamp 138 is shown in Fig. 5 as exposing an upper side surface of the film strip 26, the infrared lamp 138 is exposed to a lower side of the film strip when it is in a vertical orientation in the fusing water tank 142 (Fig. 1B).

Storage Station

After the film strip 26 leaves the fusing substation 66, the film strip is indexed to the temporary storage station 70 (Fig. 1B). An open loop of the film strip 26 engages vertically movable festoon rolls 150 at the temporary storage station 70. An output from one of a plurality of festoon roll position sensors 151 is conducted over leads 152 to the computer controls 32. This provides the computer controls 32 with an indication of the length of film awaiting advancement to the transfer station 50.

The festoon rolls 150 enable the apparatus 20 to be operated to expose a large number of originals 22 at the exposure station 46 while the transfer station 50 remains inactive. Similarly, the apparatus 20 can be operated to transfer a large number of intermediate images from the film strip 26 to photosensitive material 24 while the exposure station 46 remains inactive.

Thus, if the apparatus 20 is operated to expose originals 22 while the transfer station 50 remains inactive, the length of the film strip 26 at the storage station 70 increases. If the apparatus 20 is then operated to transfer images from the film strip 26 to photosensitive material 24 while the exposure station 46 remains inactive, the length of the film strip at the storage station 70 decreases. If the apparatus is operated to expose originals 22 at the exposure station 46 at substantially the same rate as the transfer of images to photosensitive material 24 at the transfer station 50, the length of the film strip at the storage station 70 remains substantially constant.

The computer controls 32 regulate the operation of stepper motors (not shown) for film drive sprockets on opposite sides of the storage station 70 to control the feeding of the film strip 26 into and out of the storage station. Thus, the film strip 26 is fed into the storage station under the influence of the weight of the festoon rolls and/or a drive sprocket on the input side of the storage station. When the film strip 26 is to be fed out of the storage station 70, a drive sprocket on the input side of the storage station is stationary and the film strip is fed out of the storage station against the weight of the festoon rolls 150 by the drive sprocket on the output side of the storage station.

Transfer Station

At the transfer station 50, light from a source 156 (Fig. 1B) is projected through transparent portions of the film strip 26 to the plate 24 of photosensitive material. The light activates the photoresist materials on the printing plate 24 to form an image corresponding to the original 22. As was previously mentioned, the plate 24 of photosensitive material can be either a printing plate, printed circuit board or other article. The photosensitive material 24 can be a photopolymer or diazo compound disposed on a suitable base. A photochemical reaction is initiated when the surface of the photopolymer or diazo compound is exposed to radiant energy of a magnitude of at least 500 ergs per square centimeter.

In the embodiment of the invention illustrated in Fig. 1B, the high intensity source 156 of light is a mercury xenon short arc lamp. The radiant energy from the lamp 156 is focused into a conical beam by a polished reflector. The light beam is transmitted from the polished reflector to a dichroic mirror which transmits infrared light and reflects the desired ultraviolet light. Thus, although the lamp 156 provides both ultraviolet radiation and radiation of a wavelength different than ultraviolet, only the ultraviolet radiation is reflected by the dichroic mirror.

The ultraviolet radiation is reflected from the mirror through a shutter assembly 164 to a lens systems which homogenizes the light such that a nearly uniform plane of illumination is produced at a collector lens 170. Energization of the light sources 156 and operation of the shutter 164 is controlled by the computer controls 32 (Fig. 1B). Thus, the light source 156 is connected with the computer controls 32 by lead 172 and the shutter assembly 164 is connected with the computer control by lead 174.

After the radiant energy leaves the homogenizing lens system, it encounters a second dichroic mirror which transmits infrared light and reflects ultraviolet light to the collecting lens 170. The ultraviolet light is transmitted from the collecting lens 170 through transparent areas of a segment of the film strip 26 to an imaging lens 182. The ultraviolet light from the imaging lens 182 is directed onto the plate 24 of photosensitive material.

The imaging lens 182 projects an enlarged image of the intermediate image on a segment of the film strip onto the photosensitive material 24. Although the projected image on the photosensitive material is larger than the intermediate image on the film strip 26, the projected image may be larger than, the same size as, or smaller than an original 22. For certain purposes, such as making integrated circuitry, the image projected onto the photosensitive material may be smaller than the intermediate images on the film strip. The ultraviolet radiation pattern transmitted from the film strip 26 through the imaging lens 182 to the plate 24 of photosensitive material has an energy level of at lest 500 ergs per square centimeter at the flat upper surface of the photosensitive material 24. This radiant energy causes the photosensitive material on the plate to undergo a photochemical reaction and form an image of the original 22.

The photosensitive layer on the plate 24 is a photopolymerizable system wherein the ultraviolet light triggers the spontaneous reaction of monomers to form long polymer chains with a corresponding change in many physical properties of the system. The basic formulation of the photosensitive material may include a monomer, polymeric thickener, a photoinitiator, and thermal stabilizer. An acrylate or methacrylate may be used as a monomer. A sharp and high quality image, corresponding to the image on the original 22, is formed on the photosensitive material on the plate 24.

Rather than being a photopolymer, the photosensitive layer on the plate 24 could be a diazo compound. The unexposed diazo compound is initially insoluble and becomes soluble in areas exposed to ultraviolet radiant energy at a level of at least 500 ergs per square centimeter. Therefore, a positive image results when soluble areas are washed away by developer.

At the transfer station 50, the film strip 26 moves through a body of water or other liquid (Figs. 3 and 4). The body of water conducts heat away from the film strip 26, the film strip is cooled by the body of liquid. This prevents excessive heating and distortion of the film strip.

Although the foregoing description has considered each station in the linear array 30 of stations separately, it should be understood that operations may be simultaneously occurring, on different segments of the film strip 26, at each of the stations. The computer controls 32 coordinate operations at all of the stations to provide the resulting high quality image on the plate 24. When the plate 24 of photosensitive materials is a printing plate, the plate is subsequently mounted on the cylinder of a printing press. When the plate 24 of photosensitive material is a printed circuit board, electrical circuitry is subsequently connected with the plate in a known manner.

Control Features

In accordance with one aspect of the present invention, at least a portion of an intermediate image formed on the film strip 26 is inspected at an inspection station 200. The inspection station 200 is located between the toner substation 64 and fusing substation 66. Thus, the film strip 26 is indexed to stop each intermediate image in turn at the inspection station 200 where at least a portion of each intermediate image is inspected to determine if an actual characteristic of the intermediate image is the same as or different than a desired characteristic of the intermediate image.

If an actual characteristic of an intermediate image being inspected at the inspection station 200 is different than a desired characteristic of the intermediate image, a control function is immediately undertaken to change one or more variables in the process of forming intermediate images on the film strip 26. Changing one or more variables in the process of forming the intermediate images on the film strip 26 may either directly or indirectly change the quantity of toner particles which are electrostatically attracted to each segment of the film strip at the toner substation 64. The variables which may be changed include: the magnitude of the voltage potential applied at the charging station

60, the speed of movement of the film strip 26 through the charging station, the toner bias voltage at the toner substation 64, the shutter speed at the exposure station 46, the intensity of the light at the exposure station 46, the quantity of toner particles in the toner solution at the toner substation 64, and/or other variables.

After an intermediate image has been inspected and a variable in the process of forming intermediate images changed, a next subsequent intermediate image is formed and inspected to determine if the intermediate images are being formed with the desired quality. If inspection of any one of the series of intermediate images formed on the film strip 26 indicates that a characteristic of the intermediate images is not up to the desired quality, one or more variables in the process of forming the intermediate images is changed. This process of inspecting the intermediate images and, if necessary, changing variables in the process of forming the images, is repeated throughout the process of transferring images from the originals 22 to the film strip 20. Therefore, the quality of the intermediate images formed on the film strip 26 is continuously monitored during the exposure of originals to the film strip and the forming of the intermediate images.

Although many different characteristics of an intermediate image may be sensed by inspecting the image, it is preferred to determine whether or not areas of known desired toner particle density actually have the desired density. Thus, a series 204 (Fig. 6) of inspection areas 206, 208, 210 and 212 of known desired toner particle density are scanned by a series 214 of densitometers 216, 218, 220 and 222 located at the inspection station 200 (Fig. 6). Output signals are conducted from the densitometers 216-222 over leads 224, 226, 228 and 230 to the computer controls 32. The computer controls 32 determine whether or not the actual density sensed by a densitometer is equal to, less than, or greater than the desired actual density of an inspection area. If the computer controls 32 determine that the actual density of an inspection area 206, 208, 210 or 212 differs from a desired density, a control function is undertaken to change at least one variable in the step of forming intermediate images on the film strip 26 in order to make the actual toner particle density for subsequent intermediate images equal to the desired toner particle density.

The inspection areas 206-212 have different desired toner particle densities. Thus, when an inspection area 206 has the desired toner particle density, the inspection area is completely filled with toner particles, that is, the inspection area has a 100% toner particle density. When the inspection area 208 has the desired toner particle density, the inspection area is only partially filled and contains 70% of the toner particle density of the inspection area 206. When the inspection area 210 has the desired density, it has only 30% of the toner particle density of the inspection area 206. Finally, when the inspection area 212 has the desired toner particle density, it is free of toner particles, that is, it has a 0% toner particle density.

In the illustrated embodiment of the invention, the series 204 of inspection areas 206, 208, 210 and 212 correspond to areas formed on an original. Thus, an original will have four inspection areas, each of which corresponds to one of the inspection areas 206-212 on the intermediate image. Since the inspection areas on the original are subjected to the same processing as the main image on the original, defects in the intermediate main image formed on the film strip 26 will also appear at the inspection areas 206-212.

The toner particle density at the inspection areas 206-212 is a negative or inverse function of the optical density at the corresponding inspection areas on the original. Thus, the fully dense inspection area 206 on the film strip 26 corresponds to an empty inspection area, that is an inspection area which is free of ink, on the original 22. The inspection area 208 on the film strip 26 corresponds to an inspection area on the original 22 which has a 30% optical density. Similarly, the inspection area 210 on the film strip 26 corresponds to an inspection area on the original 22 which has a 70% optical density. Finally, the inspection area 212 on the film strip 26 corresponds to an inspection area on the original 22 which is completely dense or has a 100% optical density.

The densitometers 216-222 sense the test areas 206-212 on the film strip 26. Thus, each segment of the film strip 26 in turn is stopped at the inspection station 200 with the inspection areas 206-212 disposed directly beneath the densitometers 216-222. The densitometers 216-222 then sense the optical density at the inspection areas 206-212 and provide an output which corresponds to the actual toner particle density. The manner in which the densitometers 216-222 cooperate with the inspection areas 206-212 is known and may be similar to that disclosed in U.S. Patent No. 3,756,725.

The output from the densitometers 216-222 is transmitted to the computer controls 32. The output from each of the densitometers corresponds to and is indicative of the actual toner particle density of a corresponding inspection area on the film strip 26. Thus, the output from the densitometer 216 over the lead 224 corresponds to the actual toner particle density at the inspection area 206. Similarly, the output from the densitometer 218 over the lead 226 corresponds to the actual toner particle density at the inspection area 208. The output from the densitometer 220 over the lead 228 corresponds to the actual toner particle density at the inspection area 210. The output from the densitometer 222 corresponds to the actual toner particle density at the inspection area 212.

The computer controls 32 compare the toner particle densities sensed by the densitometers 216-222 with the desired toner particle densities. The computer controls 32 then determine if the actual toner particle density is equal to, greater than, or less than the desired toner particle density at each of the inspection areas 206-212. This may be accomplished in many known ways, including in a manner similar to that disclosed in U.S. Patent No. 3,835,777.

If the output from the densitometers 216-222 corresponds to the desired toner particle density at the inspection areas 206-212, the computer controls 32 do not initiate a control function. However, if the output from the densitometers 216-222 correspond to a toner particle density which is less than a desired density, the computer controls 32 initiate a control function to increase the toner particle density. Similarly, if the output from the densitometers 216-222 indicates that the toner particle density at the inspection areas 206-212 is greater than the desired toner particle density, a control function is initiated to decrease the toner particle density.

Each segment of the film strip 26 in turn is inspected by the densitometers 214 at the inspection station 200. After the inspection areas 206-212 on one segment of the film strip 26 have been inspected at the inspection area 200, if it is necessary to undertake a control function to change the toner particle density, the control function is completed before a charge is applied to a next succeeding segment of the film strip at the charging station 60.

If the output from the densitometers 214 indicates that the toner particle density should be increased or decreased, a control function is undertaken to change the toner particle density before a charge is applied to a film strip segment which is located next adjacent to the film strip segment being inspected at the inspection station 200. The segment of the film strip which next succeeds the segment of the film strip at the inspection station 200, is moved through the charging station 60 to the exposure station 46 after completion of any control functions which are to be undertaken. Therefore, the quality of the next intermediate image to be formed on the film strip is enhanced.

When an intermediate image is to be formed on a segment 26a of the film strip 26, that segment of the film strip is moved from an intermediate station 58 (Fig. 1A) in a reverse or backward direction, that is in a direction opposite to the arrow 36, through the charging station 60 to the exposure station 46. As the film strip segment 26a moves from the intermediate station 58 through the charging station 60, the corona wire 84 and control grid 86 cooperate to apply a uniform charge to the segment 26a of the film strip. As the segment 26a of the film strip 26 is being moved to the exposure station 46, a next succeeding segment 26b of the film strip is moved from the exposure station back toward the supply reel 28.

After being moved to the exposure station 46, the charged segment 26a of the film strip 26 is exposed to an original 22 to form a latent image on the film strip. The original 22 includes inspection or test areas corresponding to the inspection areas 204 of Fig. 6. Therefore, a latent image of these inspection areas is formed on the segment 26a of the film strip at the exposure station 46.

When the charged segment 26a of the film strip 26 is exposed to the original 22, including the inspection areas, the photoconductive layer 78 on the segment of the film strip is at least partially discharged to form a latent image. The magnitude of the charge at any point on the latent image will be a direct function of the optical density of the corresponding point on the original. Thus, the greater the optical density of an area on the original 22, the greater will be the charge remaining in the corresponding area on the segment 26A of the film strip.

The inspection area on the original 22 which corresponds to the fully dense inspection area 206 (Fig. 6) on the segment 26a of the film strip will have a very low or zero optical density. This will result in the light which is reflected from this area having a relatively high intensity. Therefore, the inspection area 206 on the segment 26a of the film strip 26 being exposed is almost completely discharged. Conversely, the inspection area on the original which corresponds to the inspection area 212 on the film strip 26 will have a very high optical density. The very high optical density of the inspection area on the original will result in the intensity of the light which is reflected to the inspection area 212 on the segment of the film strip being of a relatively low intensity. This will result in most, if not all, of the charge being maintained on the film strip segment 26a in the inspection area 212.

After the segment 26a of the film strip has been exposed to an original 22 at the exposure station 46, the film strip 26 is moved in a forward direction, that is in the direction of the arrow 36. This forward movement continues until the exposed segment 26a has been moved through the charging station 60, intermediate station 58 and toner substation 64 to the inspection station 200. As the exposed segment 26a of the film strip moves through the charging station 60, the charger 82 is inactive and does not alter the charge on the exposed segment of the film strip. Therefore, after the exposed segment 26a of the film strip has moved through the charging station 60, the charge on the exposed segment of the film strip will be the same as when the exposed segment of the film strip left the exposure station 46.

Immediately before the exposed segment 26a of the film strip 26 moves through the toner substation 64, a three-way valve 236 is actuated to enable a pump 238 to move toner solution from a reservoir 240 to the toner head 130. Positively charged toner particles are attracted from the toner head 130 to discharged areas of the exposed segment 26a of the film strip 26 as it moves through the toner substation 64. Since the inspection area 206 will have been almost completely discharged as a result of the relatively intense light beam being reflected from a corresponding inspection area which is free of ink or other material on the original 22, a large number of toner particles will be attracted to the inspection area 206 to almost completely fill the inspection area in the manner indicated schematically in Fig. 6. Similarly, the charge on the inspection area 212 of the exposed segment 26a will remain intact since very little or no light will have been reflected from the optically dark or dense corresponding inspection area on the original 22. Therefore, no toner particles will be attracted to the test area 212.

When the exposed segment 26a of the film strip 26 reaches the inspection station 200, forward movement of the film strip stops. The densitometers 216-222 detect the toner particle density at the stationary test areas 206-212 and transmit corresponding signals over the leads 224-230 to the computer controls 32. If the computer controls 32 determine that the actual toner particle density corresponds to a desired toner particle density, no corrective action is undertaken. However, if the actual toner particle density differs from the desired toner particle density, corrective action is undertaken.

The magnitude of the charge applied to the film strip at the charging station 60 is increased if the actual toner particle density on the film strip segment 26a is less than the desired toner particle density. Similarly, the magnitude of the charge applied to the film strip 26 at the charging station 60 is reduced if the toner particle density on the film strip segment 26a is greater than the desired density. In addition, the biasing voltage applied by the grid 134 to the toner particles at the toner substation 64 may be either increased or decreased to vary the toner particle density on a segment of the film strip.

A next succeeding or second segment 26b of the film strip 26 is not charged at the charging station 64 and exposed at the exposure station 46 until after completion of any corrective action which is determined to be necessary as a result of inspecting the preceding film segment 26a at the inspection station 200. Thus, while a first segment 26a of the film strip 26 is being inspected at the inspection station 200, the next succeeding or second segment 26b of the film strip is stationary at the intermediate station 58. There are no segments of the film strip 26 between the first segment 26a at the inspection station 200 and the second segment 26b at the intermediate station 58. At this time, the second segment 26b of the film strip, at the intermediate station 58, is in an unprocessed condition which is the same as when it came off the supply reel 28. Thus, the segment 26b of the film strip 26 has not been charged.

After a first or leading segment 26a of a film strip 26 has been inspected at the inspection station 200 and any necessary control functions to change one or more variables in the forming of the intermediate images have been made, the next succeeding or second segment 26b of the film strip is moved from the intermediate station 58, through the charging station 60, to the exposure station 46. As the second segment 26b of the film strip 26 moves from the intermediate station 58 through the charging station 60, a uniform charge is applied across the surface of the second segment 26b of the film strip. The leftward (as viewed in Fig. 1A) movement of the second segment 26b of the film strip 26 is stopped when this segment is at the exposure station 46.

During movement of the next succeeding or second segment 26b of the film strip from the intermediate station 58 to the exposure station 46, the preceding or first segment 26a of the film strip moves from the inspection station 200 to the intermediate station. Immediately before the first segment 26a moves through the toner substation 64, the computer controls 32 actuate the valve 236 to direct a flow of toner solution from the pump 238 back to the reservoir 240. In addition, the computer controls 32 turn off the biasing voltage to the toner head grid. Therefore, additional toner particles are not attracted to the first segment 26a of the film strip as it moves from the inspection station 200 through the toner substation 64 to the intermediate station 58.

After exposure of the next succeeding or second segment 26b of the film strip at the exposure station 46 has been completed, the film strip is advanced, that is moved toward the right (as viewed in Fig. 1A). This moves the first segment 26a of the film strip from the intermediate station 58 through the toner substation 64. As this occurs, the toner substation remains deactivated. In addition, the second segment 26b of the film strip moves from the exposure station through the charging station 60. As this occurs, the charging station is also deactivated so that the charge on the second segment of the film strip remains constant.

After the first segment 26a of the film strip has moved back to the inspection station 200 and the next succeeding or second segment 26b of the film strip has moved from the exposure station 46 back to the intermediate station 58, the three-way valve 236 is again actuated to direct toner solution to the toner head 130 and the toner biasing voltage is established. Therefore, as the second segment 26b of the film strip moves from the intermediate station 58 to the inspection station 200, toner particles are attracted to the second segment of the film strip. As this is occurring, the segment 26a of the film strip is being moved through the fusing substation 66.

In the foregoing description, if inspection of a segment of the film strip results in a determination that the process of forming intermediate images needs to be changed, the charge applied to the next segment of the film strip at the charging station 60 is adjusted. However, it is contemplated that one or more other variables in the process of forming intermediate images on segments of the film strip could be changed if desired. For example, the speed of movement of a segment of the film strip through the charging station 60 could be increased to effect a reduction in the magnitude of the charge applied to a segment of the film strip or decreased to effect an increase in the magnitude of the charge applied to a segment of the film strip. The toner bias voltage which charges toner particles can be either increased to increase the toner particle density on a segment of the film strip or decreased to decrease the toner particle density.

If desired, the speed of operation of the shutter 110 at the exposure station 46 could be changed to effect a change in toner particle density on segments of the film strip 26 subsequently exposed to originals 22. Thus, if the toner particle density was to be decreased, the shutter speed would be increased. Similarly, if the toner particle density was to be increased, the shutter speed would be decreased.

By changing the amount of light reflected from the original 22 through the shutter 110 to a segment of the film strip 26, a change is made in the extent to which the charge on a segment of the film strip is discharged. Thus, increasing the intensity of the light from the lamps 102 and 104 will increase the amount of light reflected from the original 22 onto a segment of the film strip 26. Increasing the intensity of the light to which the film strip is exposed increases the extent to which the electrostatic charge on the segment of the film strip is discharged. Similarly, decreasing the intensity of the light from the lamps 102 and 104 decreases the extent to which the charge on the segment of the film strip is discharged. A light meter 246 is connected with the computer controls 32 by a lead 248 to provide an indication of the intensity of the light reflected from the original 22 to the segment of the film strip 26.

The amount of toner particles in the toner solution conducted from the pump 238 (Fig. 1A) to the toner head 130 also effects the density with which toner particles are attracted to a segment of the film strip 26. Thus, if the amount of toner particles in the toner solution is below normal, the density of the toner particles in the segment of the film strip will be less than normal. Therefore, it is necessary to maintain a predetermined minimum amount of toner particles in the toner particle solution.

In order to provide an indication of a reduction in the amount of toner particles in the toner particle solution, the toner particle solution is conducted through a transparent section 252 of conduit as the toner particle solution flows from the pump 238 to the valve 236. A light source 254 (Fig. 7) on one side of the transparent conduit section 252 directs light through the toner particle solution to a photocell 256. The output from the photocell 256 is conducted over a lead 258 to the computer controls 32.

After the toner solution has been used for a period of time, the amount of toner particles in the solution will be reduced. This will result in an increase in the intensity of the light received by the photocell 256. When the amount of toner particles in the toner solution has been reduced below a predetermined minimum, the output signal conducted from the photocell 256 over the lead 258 to the computer controls 32 will cause the computer controls to provide an output indicating that it is necessary to increase the concentration of toner particles in the solution. Once this has been done, the toner particles will again impede the transmission of light between the source 254 and photocell 256 as the toner solution passes through the transparent section 252 of conduit.

When a segment of the film strip 26 is at the transfer station 50 and light is to be transmitted through the segment of the film strip to the printing plate 24, it is necessary to have the segment of the film strip in the same position relative to the printing plate 24 as the segment had relative to the original 22 when the segment was exposed at the exposure station 46. In order to be certain that the position of a segment of the film strip relative to the printing plate 24 at the transfer station 50 is the same as the position of the segment of the film strip relative to the original 22 at the exposure station 46, a marker 262 at the exposure station (Fig. 1A) forms index indicia on the segment of the film strip. When a segment of the film strip has been moved to the exposure station 46 and aligned with an original 22, the computer 32 activates the marker 262 over a lead 264 to cause the marker 262 to form index indicia on the film strip in a predetermined location relative to the segment of the film strip to be exposed to the original.

When the segment of the film strip has been moved to the transfer station 50 and before the film strip moves into the position in which ultraviolet light is projected through the film strip onto a printing plate, a sensor 268 detects the presence of the index indicia formed by the marker 262. When the sensor 268 detects the index indicia, a signal is sent over a lead 270 to the computer controls 32 to indicate that the next segment of the film strip is in a predetermined position relative to the transfer station 50. The computer controls 32 then effect operation of the film strip drive motors to move the film strip through a predetermined distance to accurately align the next segment of the film strip with the lens 170 at the transfer station 50. Although the sensor 268 could have many different constructions, it may be constructed in the manner disclosed in U.S. Patent No. 3,604,941.

Although it is preferred to use the marker 262 to form index indicia on the film strip adjacent to each segment of the film strip, one or more of the inspection areas 206-212 could be used as the index indicia. Thus, the fully dense inspection area 206 is located in a predetermined position relative to a segment of the film strip. Therefore, the sensor 268 could be used to detect the presence of the inspection area 206. This would result in the inspection area 206 being used for two different purposes, that is, as an indicator of toner particle density in a segment of the film strip and as an indicator of the position of the same segment of the film strip.

When a segment of the film strip 26 is at the transfer station 50, ultraviolet radiation is transmitted through a segment of the film strip to the plate 24 of photosensitive material. This results in the projecting of the intermediate image on the segment of the film strip onto the photosensitive material. the inspection areas 206-212 are positioned so that ultraviolet radiation is not transmitted through the inspection areas. This results in the image which is formed on the photosensitive material 24 being free of areas corresponding to the inspection areas 206-212. However, if desired, the inspection areas 206-212 on a segment of the film strip could be positioned in locations such that ultraviolet radiation is transmitted through the inspection areas. Corresponding areas are then formed on the plate 24 of photosensitive material.

At any given time, a large number of exposed segments of the film strip 26 may be located at the storage station 70. In addition, a substantial number of exposed segments of the film strip may be disposed on the storage roll 31. In order to enable a particular segment of a film strip to be identified, the intermediate image on each of the segments of the film strip includes a code which identifies the subject matter of the intermediate image. Although many different types of codes could be used if desired, a bar code may advantageously be used. A bar code reader 274 is provided at the transfer station 50 to read the code on an intermediate image before the intermediate image is moved to the lens 170. The reader 274 is connected with the computer controls 32 by a lead 276.

Conclusion

The present invention provides a new and improved method for controlling the transfer of an image in such a manner as to minimize any differences between the transferred image and the original. In transferring the image, a series of intermediate images corresponding to originals 22 are formed on a carrier 26. At least a portion 206-212 of an intermediate image is inspected to determine if an actual characteristic of the intermediate image corresponds to a desired characteristic of the intermediate image. If the actual characteristic of the intermediate image is different than the desired characteristic, a change is made in a variable in the process of forming the intermediate images.

In one specific instance, the intermediate image is inspected to determine whether or not the actual density of an area 206-212 of known desired density of the intermediate image is the same as the desired density. If the density of the area of known desired density is different than the desired density, a control function is undertaken. This control function is advantageously undertaken before the next succeeding intermediate image is formed. When electrophotographic methods are used to form the intermediate image, the control function which is undertaken may include changing the quantity of toner particles which are electrostatically attracted to the carrier 26 by changing either the electrostatic charge applied to the carrier at the charging station 60, a toner bias voltage at a toner substation 64, shutter speed at an exposure station 46, and/or the intensity of light to which originals 22 are exposed at the exposure station.

Claims

1. A method comprising the steps of sequentially exposing a carrier to a series of originals,

sequentially forming on the carrier a series of intermediate images corresponding to the originals, transmitting radiation through the intermediate images to form projected images which correspond to the originals, inspecting at least a portion of at least one of the intermediate images to determine if an actual characteristic of the one intermediate image corresponds to a desired characteristic, and prior to completion of said step of forming a series of intermediate images, changing at least one variable in said step of sequentially forming intermediate images if the actual characteristic of the one intermediate image is different than the desired characteristic.

2. A method as set forth in claim 1 wherein said step of sequentially forming a series of intermediate images includes forming the one intermediate image with an area of known desired density, said step of inspecting the one intermediate image includes determining whether or not the actual density in the area of known desired density of the one intermediate image is the same as the desired density, said step of changing at least one variable in said step of sequentially forming intermediate images being performed if the density in the area of a known desired density of the one intermediate image is different than the desired density.

3. A method as set forth in claim 1 wherein said step of sequentially forming a series of intermediate images on the carrier includes electrostatically attracting particles to the carrier, said step of changing at least one variable in said step of sequentially forming intermediate images includes changing a variable which results in a change in the quantity of particles which are electrostatically attracted to the carrier.

4. A method as set forth in claim 1 wherein said step of sequentially forming a series of intermediate images includes applying an electrostatic charge to the carrier, said step of changing at least one variable in said step of sequentially forming intermediate images includes changing the magnitude of the electrostatic charge applied to the carrier.

5. A method as set forth in claim 1 wherein said step of sequentially forming a series of intermediate images includes moving the carrier through a charging station and applying an electrostatic charge to the carrier as it moves through the charging station, said step of changing at least one variable in said step of sequentially forming intermediate images includes changing the speed of movement of the carrier through the charging station.

6. A method as set forth in claim 1 wherein said step of sequentially forming a series of intermediate images includes establishing a voltage potential between portions of the carrier, said step of changing at least one variable in said step of sequentially forming intermediate images includes changing the magnitude of the voltage potential established between portions of the carrier.

7. A method as set forth in claim 1 wherein said step of exposing a carrier to a series of originals includes providing an area of known density on at least one of the originals and exposing the carrier to a light pattern which forms an image of the one original and which includes one segment corresponding to the area of known density on the one original, said step of sequentially forming on the carrier a series of intermediate images includes developing on the carrier one intermediate image which corresponds to the light pattern and which contains an area corresponding to the one segment of the light pattern, said step of inspecting the one intermediate image includes sensing the optical density of the area of the one intermediate image which corresponds to the one segment of the light pattern.

8. A method as set forth in claim 7 wherein said step of transmitting radiation through the intermediate images includes transmitting radiation through the area of the one intermediate image which corresponds to the one segment of the light pattern.

9. A method as set forth in claim 7 wherein said step of transmitting radiation through the intermediate images includes transmitting radiation through an area of the one intermediate image which does not include the area which corresponds to the one segment of the light pattern.

10. A method as set forth in claim 1 wherein said step of exposing a carrier to a series of originals includes providing an area of known density on at least one of the originals and exposing the carrier to a light pattern which varies in intensity as a function of the one original, the light pattern including one segment having an intensity which is a function of the density of the area of known density on the one original, said step of sequentially forming on the carrier

a series of intermediate images includes exposing a photoconductive layer of material on the carrier to the light pattern which varies in intensity as a function of the one original to render the phctoconductive layer of material conductive to an extent which is a function of the intensity of the light pattern, said step of exposing a photoconductive layer of material includes exposing one portion of the photoconductive layer of material to the one segment of the light pattern to expose the one portion of the photoconductive layer to light of an intensity which is a function of the density of the area known density on the one original, applying an electrostatic charge to the photoconductive layer, retaining on the photoconductive layer a charge which varies in magnitude across the surface of the photoconductive layer as a function of the extent to which the photoconductive layer was rendered conductive by the light pattern, said step of retaining a charge on the photoconductive layer includes retaining on the one portion of the photoconductive layer a charge of a magnitude which is a function of the extent to which the photoconductive layer was rendered conductive by the one segment of the light pattern, and electrically attracting particles to the surface of the photoconductive layer with a density which varies across the surface of the photoconductive layer as a function of variations in the magnitude of the charge retained on the photoconductive layer, said step of electrically attracting particles to the surface of the photoconductive layer includes electrically attracting particles to the one portion of the photoconductive layer with a particle density which is a function of the magnitude of the charge retained on the one portion of the photoconductive layer, said step of inspecting at least a portion of at least one of the intermediate images including generating a signal which is a function of the magnitude of the particle density on the one portion of the photoconductive layer.

11. A method as set forth in claim 10 wherein said step of changing at least one variable in said step of sequentially forming intermediate images includes the step of increasing the magnitude of the electrostatic charge applied to the photoconductive layer if the signal which is a function of the magnitude of the particle density corresponds to a particle density which is less than a particle density corresponding to the density of the area of known density on the one original and the step of decreasing the magnitude of the electrostatic charge applied to the photoconductive layer if the signal which is a function of the magnitude of the particle density corresponds to a particle density which is greater than a particle density corresponding to the density of the area of known density on the one original.

12. A method as set forth in claim 10 wherein said step of applying an electrostatic charge to the photoconductive layer includes the step cf moving the photoconductive layer through a charging station and applying an electrostatic charge to the carrier as it moves through the charging station, said step of changing at least one variable in said step of sequentially forming intermediate images includes the step of decreasing the speed of movement of the carrier through the charging station if the signal which is a function of the magnitude of particle density corresponds to a particle density which is less than a particle density corresponding to the density of the area of known density on the one original and the step of increasing the speed of movement of the carrier through the charging station if the signal which is a function of the magnitude of particle density corresponds to a particle density which is greater than a particle density corresponding to the density of the area of known density on the one original.

13. A method as set forth in claim 10 wherein said step of applying an electrostatic charge to the photoconductive layer includes the step of establishing a voltage potential between portions of the carrier, said step of changing at least one variable in said step of sequentially forming intermediate images includes the step of increasing the voltage potential established between portions of the carrier if the signal which is a function of the magnitude of particle density corresponds to a particle density which is less than a particle density corresponding to the density of the area of known density on the one original and the step of decreasing the voltage potential established between portions of the carrer if the signal which is a function of the magnitude of particle density corresponds to a particle density which is greater than a particle density corresponding to the density of the area of known density on the one original.

14. A method as set forth in claim 10 wherein said step of changing at least one variable in said step of sequentially forming intermediate images includes changing a variable to increase the amount of particles electrically attracted to the surface of the photoconductive layer if the signal which is a function of the magnitude of particle density is less than a particle density corresponding to the density of the area of known density on the one original and the step of changing a variable to decrease the amount of particles electrically attracted to the surface of the photoconductive layer if the signal which is a function of particle density is greater than a particle density corresponding to the density of the area of known density on the one original.

15. A method as set forth in claim 1 further including the steps of moving the carrier along a path extending through an array of stations including an exposure station where said step of exposing the carrier to a series of originals is performed and a transfer station where said step of transmitting radiation through intermediate images to form projected images is performed, forming index indicia on the carrier at the exposure station, and detecting when the index indicia is in a predetermined location relative to the transfer station to determine when an intermediate image on the carrier is in a predetermined position relative to the transfer station.

16. A method as set forth in claim 1 wherein said step of sequentially forming on the carrier a series of intermediate images includes conducting a flow of toner solution through a conduit, electrostatically attracting toner particles from the toner solution to the carrier, and detecting a variation in the amount of toner particles in the toner solution conducted through the conduit, said step of detecting a variation in the amount of toner particles in the toner solution including directing a light beam through the flow of toner solution in the conduit and detecting a change in the intensity of the light transmitted through the flow of toner solution in the conduit.

17. A method as set forth in claim 16 wherein said step of changing at least one variable in said step of sequentially forming images includes changing the amount of toner particles in the toner solution.

18. A method as set forth in claim 1 wherein the carrier is a strip of material, said step of exposing a carrier to a series of originals includes exposing one segment of a series of segments on the strip of material to an original, said step of sequentially forming on the carrier a series of images including forming the one intermediate image on the one segment of the strip of material, said step of inspecting at least a portion of the one intermediate image includes inspecting the one intermediate image on the one segment of the strip of material, said step of exposing a carrier to a series of originals further includes exposing a segment of the strip of material which next succeeds the one segment of the film strip in the series of segments to an original after having performed said step of inspecting the one intermediate image on the one segment of the strip of material so that the one intermediate image on the one segment of the strip of material is inspected before the next succeeding segment of the strip of material is exposed to an original.

19. A method as set forth in claim 1 wherein the carrier is a strip of material, said method further including moving one segment of the strip of material through a charging station to an exposure station, applying an electrostatic charge to the one segment of the strip of material as it moves through the charging station to the exposure station, said step of exposing a carrier to a series of originals including exposing the one segment of the strip of material to an original while the one segment of the strip of material is at the exposure station, said step of exposing the one segment of the strip of material to an original including at least partially discharging the electrostatic charge on the one segment of the strip of material, moving the one segment of the strip of material from the exposure station through a toner station to an inspection station, said step of forming on the carrier a series of intermediate images including electrostatically attracting particles to the one segment of the strip of material as it moves through the toner station to the inspection station to thereby at least partially form the one intermediate image at the one segment of the strip of material, said step of inspecting at least a portion of the one intermediate image being performed while the one segment of the strip of material is at the inspection station, after inspecting the one intermediate image, moving a second segment of the strip of material which next succeeds the one segment of the strip of material through the charging station to the exposure station.

20. A method as set forth in claim 19 wherein said step of moving the one segment of the strip of material from the exposure station through the toner station to the inspection station includes moving the one segment of the strip of material through a first distance, said step of moving the second segment of the strip of material through the charging station to the exposure station includes moving the second segment of the strip of material through a second distance which is smaller than the first distance.

21. A method as set forth in claim 19 wherein said step of moving the one segment of the strip of material from the exposure station through the toner station to the inspection station includes moving the strip of material in a first direction, said step of moving a second segment of the strip of material which next succeeds the one segment of the strip of material through the charging station to the exposure station including moving the strip of material in a second direction opposite to the first direction.

22. A method as set forth in claim 19 wherein said step of moving the one segment of the strip of material from the exposure station through the toner station to the inspection station includes again moving the one segment of the strip of material through the charging station.

23. A method as set forth in claim 22 wherein said step of again moving the one segment of the strip of material through the charging station includes maintaining the electrostatic charge on the one segment of the strip of material constant.

24. A method as set forth in claim 19 further including the step of again moving the one segment of the strip of material through the toner station for another time during movement of the second segment of the strip of material through the charging station to the exposure station.

25. A method as set forth in claim 1 wherein said step of exposing a carrier to a series of originals includes directing light from a source of light against the original, said step of changing at least one variable in said step of sequentially forming intermediate images includes changing the intensity of the light directed from the source of light against the original.

26. A method as set forth in claim 1 wherein the carrier is a strip of material, said step of sequentially exposing a carrier to a series of originals includes sequentially exposing a series of equally spaced segments of the strip of material to originals, said steps of inspecting the one of the intermediate images and changing at least one variable in said step of sequentially forming intermediate images being completed prior to exposing to an original a segment of the strip of material which is next to the segment upon which the one intermediate image is formed.

27. A method as set forth in claim 1 wherein the carrier is a strip of material, said step of sequentially forming a series of intermediate images includes forming the one intermediate image on a first segment of the strip of material and forming a second intermediate image on a second segment of the strip of material, said second segment of the strip of material being located next to the first segment and being the next segment of the strip which is exposed to an original after exposure of the first segment, said step of forming the one intermediate image includes forming the one intermediate image with an area of known desired density, said step of inspecting the one intermediate image includes determining whether or not the actual density in the area of known desired density of the one intermediate image is the same as the desired density, said step of changing at least one variable in said step of sequentially forming intemediate images being performed before exposing the second segment of the strip of material to an original if the density in the area of a known desired density is different than the desired density.

28. A method as set forth in claim 1 wherein the carrier is a strip of material, said step of sequentially forming a series of intermediate images includes forming the one intermediate image on a first segment of the strip of material and forming a second intermediate image on a second segment of the strip of material, said second segment of the strip of material being located next to the first segment and being the next segment of the strip of material which is exposed to an original after exposure of the first segment, said step of sequentially forming a series of intermediate images on the carrier includes electrostatically attracting particles to the first segment of the strip of material and, thereafter, electrostatically attracting particles to the second segment of the strip of material, said step of changing at least one variable in said step of sequentially forming intermediate images including chaging a variable which results in a change in the quantity of particles which are electrostatically attracted to the strip of material after inspecting the one intermediate image and before exposing the second segment of the strip of material to an original if the actual characteristic of the one intermediate image is different than the desired characteristic.

29. A method as set forth in claim 1 wherein the carrier is a strip of material, said step of sequentially forming a series of intermediate images includes forming the one intermediate image on a first segment of the strip of material and forming a second intermediate image on a second segment of the strip of material, said second segment of the strip of material being located next to the first segment and being the next segment of the strip which is exposed to an original after exposure of the first segment, said step of sequentially forming a series of intermediate images on the carrier includes applying an electrostatic charge to the first segment of the strip of material and, thereafter, applying an electrostatic charge to the second segment of the strip of material, said steps of inspecting the one intermediate image and changing at least one variable in said step of sequentially forming intermediate images being performed before performing said step of applying an electrostatic charge to the second segment of the strip of material.

30. A method as set forth in claim 1 wherein the carrier is a strip of material, said step of sequentially forming a series of intermediate images includes forming the one intermediate image on a first segment of the strip of material and forming the second intermediate image on a second segment of the strip of material, said second segment of the strip of material being located next to the first segment and being the next segment of the strip of material which is exposed to an original after exposure of the first segment, said step of sequentially forming a series of intermediate images on the carrier includes applying an electrostatic charge to the first segment of the strip of material, and thereafter, applying an electrostatic charge to the second segment of the strip of material, said step of changing at least one variable in said step of sequentially forming intermediate images including changing a variable which results in a change in the magnitude of the electrostatic charge applied to a segment of the strip of material after inspecting the one intermediate image and before exposing the second segment of the strip of material to an original if the actual characteristic of the one intermediate image is different than the desired characteristic.

31. A method as set forth in claim 1 wherein the carrier is a strip of material, said step of forming a series of intermediate images includes forming the one intermediate image on a first segment of the strip of material and forming the second intermediate image on a second segment of the strip of material, said second segment of the strip of material being located next to the first segment and being the next segment of the strip of material which is exposed to an original after the exposure of the first segment, said step of sequentially forming a series of images on the carrier includes moving the first segment of the strip of material through a charging station and applying an electrostatic charge to the first segment of the strip of material, and, thereafter, moving the second segment of the strip of material through the charging station and applying an electrostatic charge to the second segment of the strip of material, said step of changing at least one variable in said step of sequentially forming intermediate images including changing the speed at which segments of the strip of material are moved through the charging station after inspecting the one intermediate image and before moving the second segment of the strip of material through the charging station if the actual characteristic of the one intermediate image is different than the desired characteristic.

32. A method as set forth in claim 1 wherein the carrier is a strip of material, said step of forming a series of intermediate images includes forming the one intermediate image on a first segment of the strip of material and forming the second intermediate image on a second segment of the strip of material, said second segment of the strip of material being located next to the first segment and being the next segment of the strip of material which is exposed to an original after exposure of the first segment, said step of sequentially forming a series of images on the carrier includes establishing a voltage potential between portions of the first segment of the strip of material and, thereafter, establishing a voltage potential between portions of the second segment of the strip of material, said step of changing at least one variable in said step of forming intermediate images including changing the magnitude of voltage potential established between portions of the segments of the strip of material after inspecting the one intermediate image and before establishing a voltage potential between portions of the second segment of the strip of material if the actual characteristic of the one intermediate image is different than the desired characteristic.

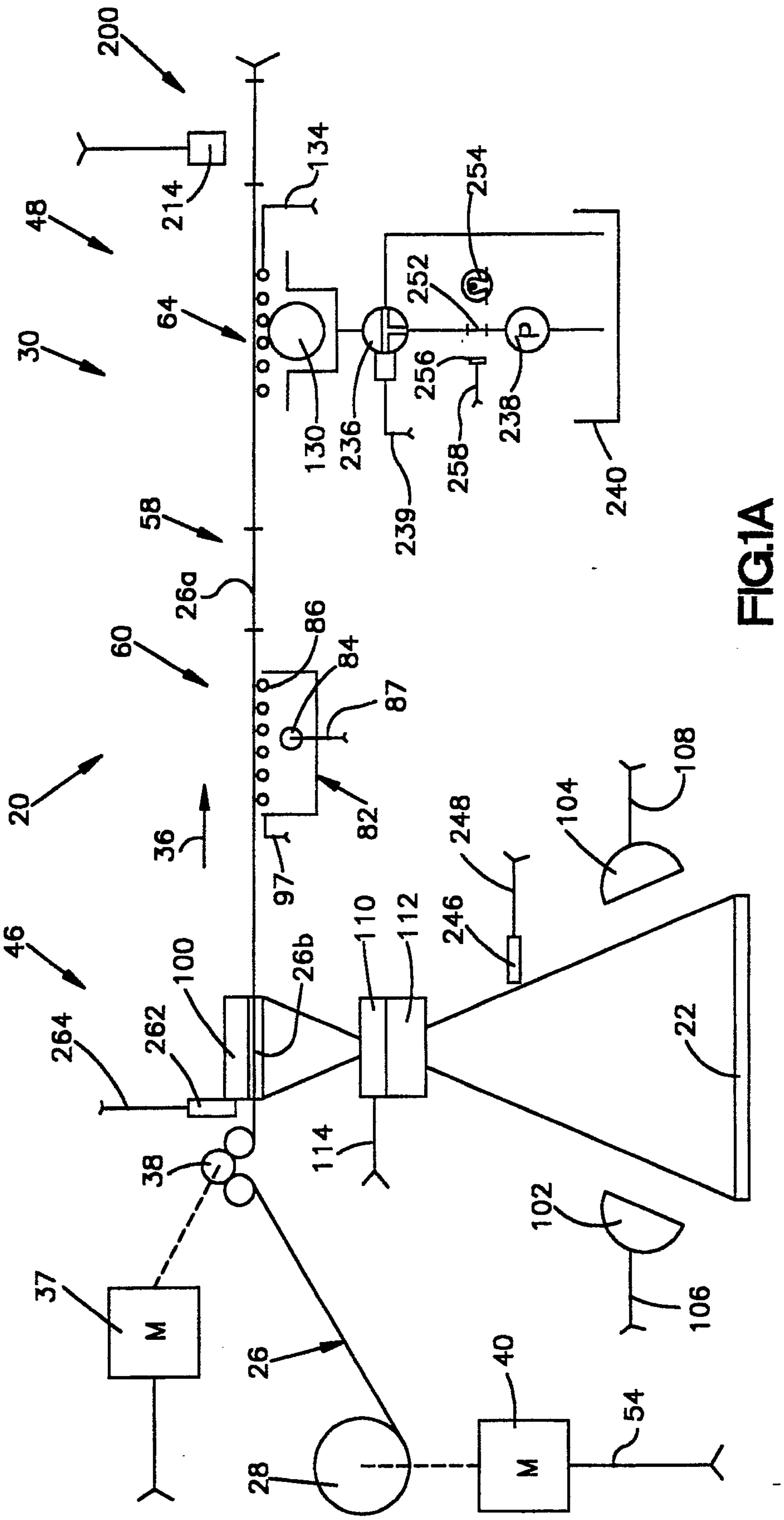
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FIG.1A

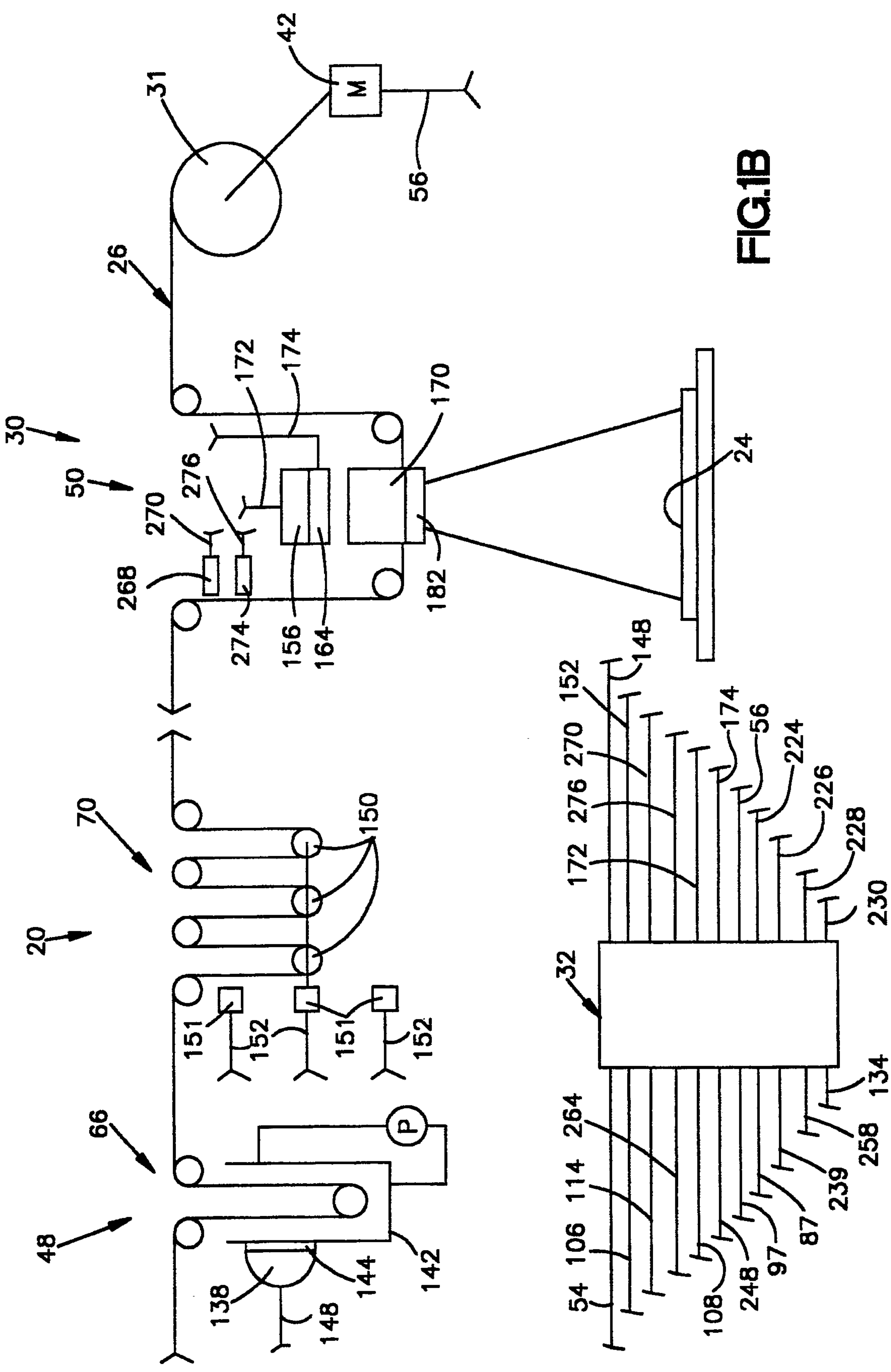
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FIG.1B

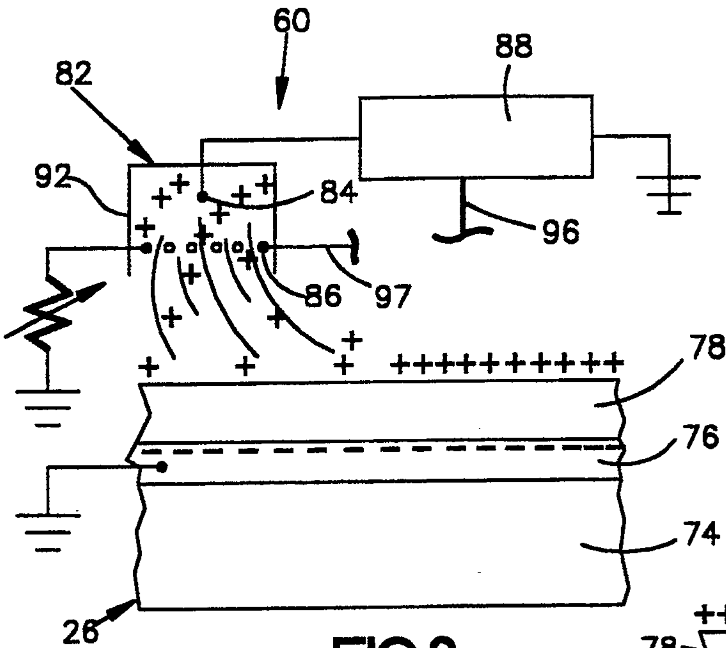

FIG.2

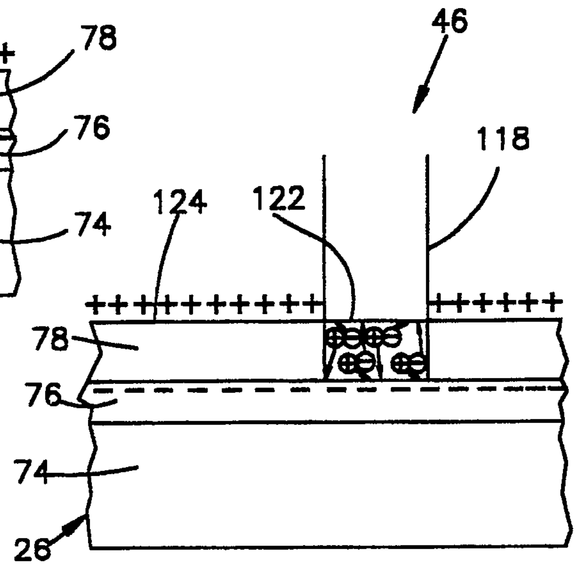

FIG.3

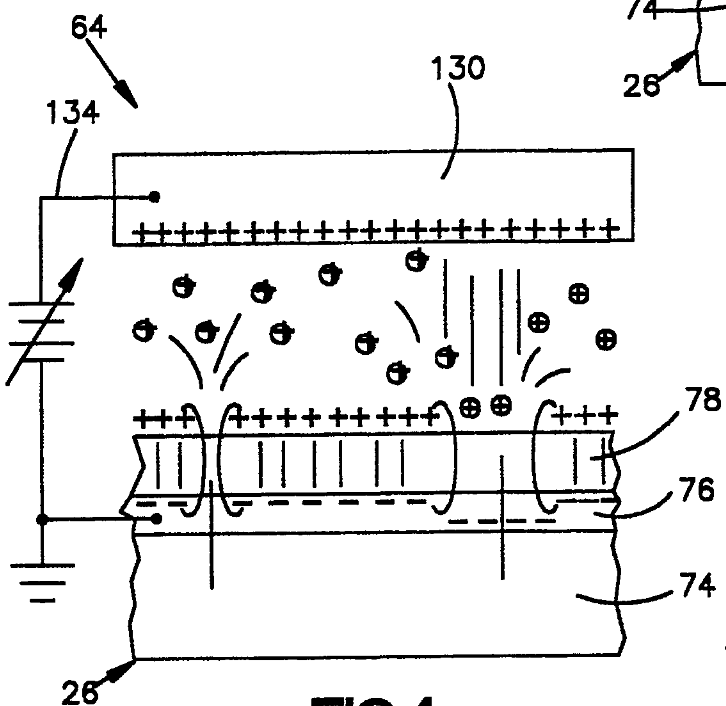

FIG.4

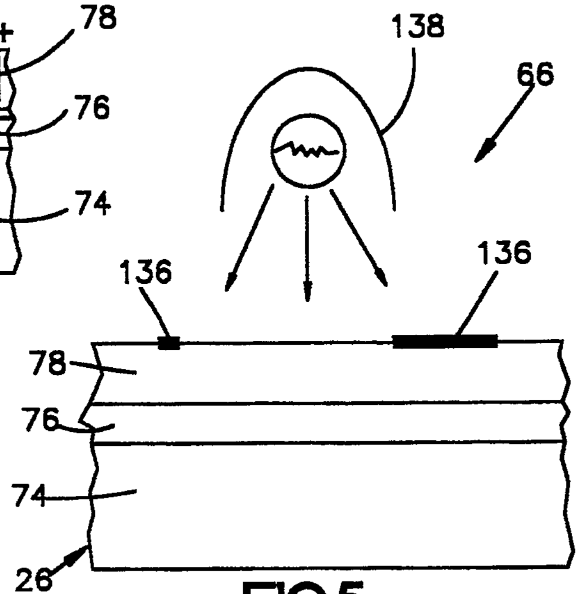

FIG.5

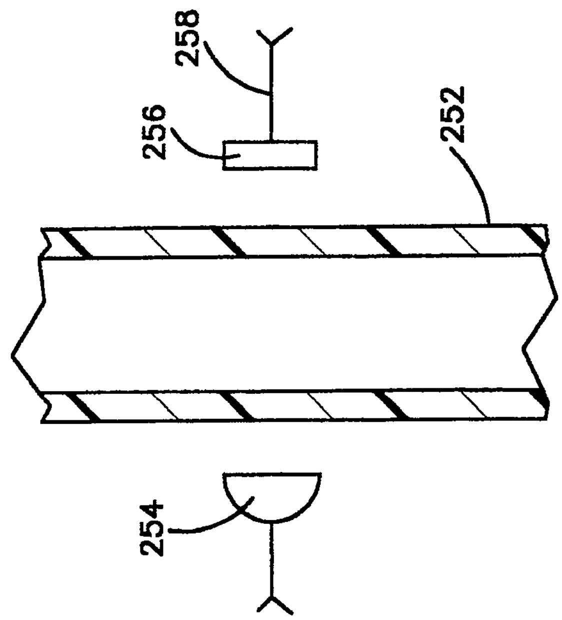
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FIG.7

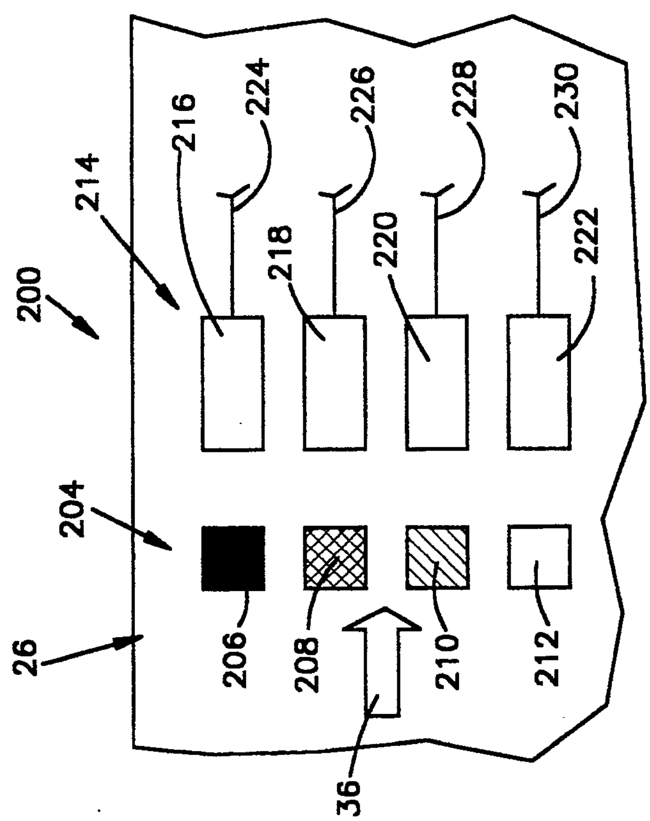
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FIG.6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 30 3744

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y,A,D	US-A-4 894 679 (ERWIN J. RACHWAL ET AL.) * the whole document & EP-A-0345010 (GRAPHICS LX CORP.) *	1-4,6, 18-19, 25-30,32, 16-17	G 03 G 15/00 G 03 G 15/22
Y,A	WO-A-8 707 043 (EASTMAN KODAK COMPANY) * page 1, line 10 - page 2, line 3 * * page 6, line 1 - page 7, line 32; figures 1, 7 *	1-4,6, 18-19, 25-30,32, 11,13-14	
A	US-A-4 780 744 (HOMER G. PORTER ET AL.) * column 5, line 12 - column 7, line 66; figure 4B *	1-4,11, 13,25-30	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

G 03 G

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	19 November 90	TREPP E.A.

CATEGORY OF CITED DOCUMENTS

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