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(54) **Maintaining precise electrostatic control using two esvs.**

(57) Erroneous voltage readings of Electrostatic Voltmeters (ESVs), which have become contaminated by charged particles (i.e. toner) from developer housings (58,60) used for developing latent images on a photoreceptor surface (10), are negated by adjusting the readings of the ESVs (ESV_1,ESV_2) to compensate for the contamination of the ESVs. Additionally, the developer housing biases (70,71) are adjusted by an amount equal to the difference between the voltages measured by the ESVs thereby insuring proper development and cleaning fields during development.

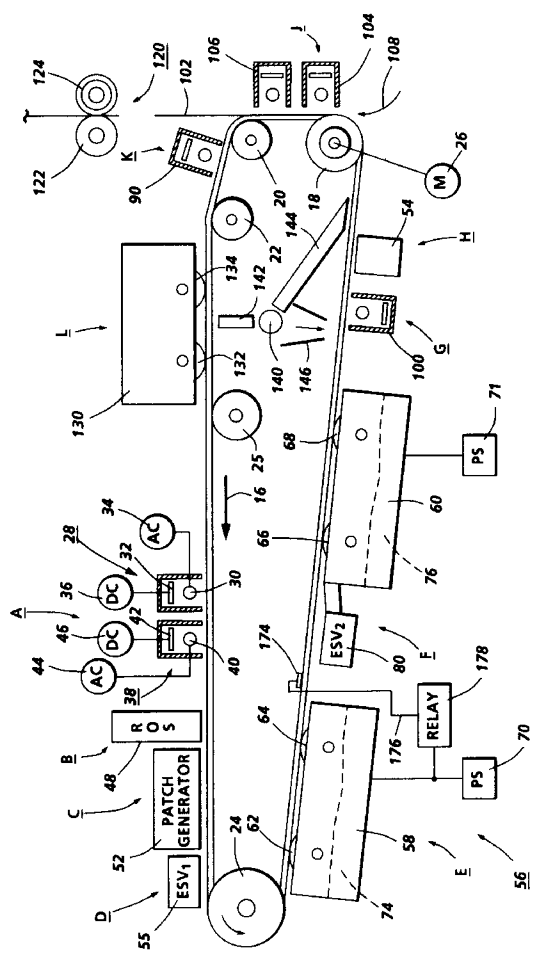

FIG. 3

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This invention relates generally to highlight color imaging and more particularly to the formation of tri-level highlight color images in a single pass, and can be utilized in the art of xerography or in the printing arts.

In the practice of conventional xerography, it is the general procedure to form electrostatic latent images on a xerographic surface by first uniformly charging a photoreceptor. The photoreceptor comprises a charge retentive surface. The charge is selectively dissipated in accordance with a pattern of activating radiation corresponding to original images. The selective dissipation of the charge leaves a latent charge pattern on the imaging surface corresponding to the areas not exposed by radiation.

This charge pattern is made visible by developing it with toner. The toner is generally a colored powder which adheres to the charge pattern by electrostatic attraction.

The developed image is then fixed to the imaging surface or is transferred to a receiving substrate such as plain paper to which it is fixed by suitable fusing techniques.

The concept of tri-level, highlight color xerography is described in U.S. Patent No. 4,078,929. The patent teaches the use of tri-level xerography as a means to achieve single-pass highlight color imaging. As disclosed therein the charge pattern is developed with toner particles of first and second colors. The toner particles of one of the colors are positively charged and the toner particles of the other color are negatively charged. In one case, the toner particles are supplied by a developer which comprises a mixture of triboelectrically relatively positive and relatively negative carrier beads. The carrier beads support, respectively, the relatively negative and relatively positive toner particles. Such a developer is generally supplied to the charge pattern by cascading it across the imaging surface supporting the charge pattern. In another case, the toner particles are presented to the charge pattern by a pair of magnetic brushes. Each brush supplies a toner of one color and one charge. In yet another case, the development systems are biased to about the background voltage. Such biasing results in a developed image of improved color sharpness.

In highlight color xerography as taught by that patent the xerographic contrast on the charge retentive surface or photoreceptor is divided into three levels, rather than two levels as is the case in conventional xerography. The photoreceptor is charged, typically to 900 + volts. It is exposed imagewise, such that one image corresponding to charged image areas (which are subsequently developed by charged-area development, i.e. CAD) stays at the full photoreceptor potential (V_{CAD} or V_{ddp}). V_{ddp} is the voltage on the photoreceptor due to the loss of voltage while the photoreceptor remains charged in the absence of light, otherwise known as dark decay. The other image is exposed to discharge the photoreceptor to its residual potential, i.e. V_{DAD} or Vc (typically -100 volts) which corresponds to discharged area images that are subsequently developed by discharged-area development (DAD) and the background area is exposed such as to reduce the photoreceptor potential to halfway between the V_{CAD} and V_{DAD} potentials, (typically -500 volts) and is referred to as V_{white} or V_w. The CAD developer is typically biased about 100 volts closer to V_{CAD} than Vwhite (about -600 volts), and the DAD developer system is biased about -100 volts closer to V_{DAD} than V_{white} (about 400 volts). As will be appreciated, the highlight color need not be a different color but may have other distinguishing characteristics. For, example, one toner may be magnetic and the other non-magnetic.

U.S. Patent No. 5,157,441 describes single pass tri-level imaging apparatus and method, in which compensation for the effects of dark decay on the background voltage, V_{Mod}, and the color toner patch, V_{tc} readings is provided using two ESVs (ESV_1 and ESV_2), the former located prior to the color or DAD housing and the latter after it. Since the CAD and black toner patch voltages are measured (using ESV_2) after dark decay and CAD voltage loss have occurred, no compensation for these readings is required. The DAD image voltage suffers little dark decay change over the life of the photoreceptor so the average dark decay can be built into the voltage target.

U.S. Patent No. 5,212,029 relates to toner patch generation for use in tri-level imaging which is effected using a laser ROS. Two toner patches are formed using a single toner patch generator of the type commonly used in the prior art. The patch generator, used by itself serves to form one toner patch latent image and together with the ROS exposure device of the imaging apparatus is used to form the other toner patch latent image.

European Patent application No. 0,531,063 relates to a pair of Electrostatic Voltmeters (ESV) which are utilized to control the photoreceptor charging voltage in a Tri-Level imaging apparatus. One of the ESVs is used to control the voltage increases of a charging device. The other ESV is used to monitor the charge level of the charged area image of a Tri-Level image. When a critical value is sensed the control of the charging device is shifted to the ESV that monitors the charged area image level and limits the output from the charging device to a predetermined target value.

U.S. Patent No. 5,227,270 relates to a single pass tri-level imaging apparatus, wherein a pair of Electrostatic Voltmeters (ESV) are utilized to monitor various control patch voltages to allow for feedback control of Infra-Red Densitometer (IRD) readings.

The ESV readings are used to adjust the IRD readings of each toner patch. For the black toner patch, readings of an ESV positioned between two developer housing structures are used to monitor the patch voltage. If the voltage is above target (high development field) the IRD reading is increased by an amount proportional to the voltage error. For the color toner patch, readings using an ESV positioned upstream of the developer housing structures and the dark decay projection to the color housing are used to make a similar correction to the color toner patch IRD readings (but opposite in sign because, for color, a lower voltage results in a higher development field).

U.S. Patent No. 5,210,572 relates to toner dispensing rate adjustment wherein the Infra-Red Densitometer (IRD) readings of developed toner patches in a tri-level imaging apparatus are compared to target values stored in Nonvolatile Memory (NVM) and are also compared to the previous IRD reading. Toner dispensing decisions (i.e. addition or reduction) are based on both comparisons. In this manner, not only are IRD readings examined as to how far the reading is from the target, they are examined as to current trend (i.e. whether the reading is moving away from or toward the target).

U.S. Patent No. 5,223,897 relates to a tri-level imaging apparatus wherein two sets of targets, one for use during cycle up convergence of electrostatics and one during runtime enable single pass cleaning of developed patches, during cycle up convergence. To this end, different targets from those used during runtime are used for the preclean, transfer and pretransfer dicorotrons during cycle up.

Proper charging of the photoreceptor during runtime and cycle up convergence is also enabled by the provision of two charging targets, one for each mode of operation.

U.S. Patent No. 5,208,632 relates to cycle up convergence of electrostatics in a tri-level imaging apparatus wherein cycle up convergence is shortened through the use of an image output terminal (IOT) resident image (on a pixel or control board) to obtain charge, discharge and background voltage readings on every pitch.

U.S. Patent No. 5,138,378 relates to recalculation of electrostatic target values in a tri-level imaging apparatus to extend the useful life of the photoreceptor. The increase in residual voltage due to Photoreceptor aging which would normally necessitate photoreceptor disposal is obviated by resetting the target voltage for the full ROS exposure when it reaches its exposure limit with current photoreceptor conditions. All contrast voltage targets are then recalculated based on this new target.

The new targets are calculated based on current capability of the overall system and the latitude is based on voltage instead of exposure.

U.S. Patent application No. 5,236,795 relates to the use of Infra-Red Densitometer (IRD) readings to check the efficiency of two-pass cleaning of the black toner patch in a tri-level imaging apparatus. The IRD examines the background patch of the tri-level image and declares a machine fault if excessive toner is detected.

U.S. Patent No. 5,132,730 relates to a single pass, tri-level imaging apparatus, machine cycle down which is initiated when the color developer housing is functioning improperly. The voltage level of the color image prior to its development is read using an electrostatic voltmeter (ESV). The voltage level thereof is also read after development. The difference between these two readings is compared to an arbitrary target value and a machine cycle down is initiated if the difference is greater than the target.

U.S. Patent No. 5,119,131 relates to a single pass, tri-level imaging apparatus, wherein erroneous voltage readings of an Electrostatic Voltmeter (ESV) which has become contaminated by charged particles (i.e. toner) are negated by using two ESVs.

During each cycle up following a normal cycle down, a pair of Electrostatic Voltmeters (ESVs) are utilized to measure the voltage level on a portion of relatively uncharged portion of a photoreceptor. Using one of the ESVs, which is less prone to contamination, as a reference, the zero offset of the other is adjusted to achieve the same residual photoreceptor voltage reading. The difference in the readings which is due to toner contamination is the zero offset between the two ESVs. The offset is used to adjust all subsequent voltage readings of the ESV until a new offset is measured.

While the '131 patent addresses the problem of erroneous voltage readings of electrostatic voltmeters used in a xerographic imaging process, the solution disclosed therein assumes a toner-free reference ESV. Ignoring the contamination of the reference ESV results in improper development and cleaning fields during development.

It is an object of the present invention to provide a tri-level imaging system and method which do not ignore the adverse affects of contamination of a reference ESV that has become contaminated with toner.

The present invention provides, in a method of creating tri-level images on a charge retentive surface during operation of a tri-level imaging apparatus, the steps including moving said charge retentive surface past a plurality of process stations including a charging station where said charge retentive surface is uniformly charged, a plurality of developer structures for developing latent images and an illumination station for discharging said charge retentive surface; applying electrical bias voltages to said developer structures; applying a reference voltage to an uncharged charge retentive surface; using a first sensor, sensing the voltage level of said charge retentive surface and generating a first signal representative of said voltage level; using a second sensor, sensing the voltage level of said charge retentive surface and generating a second signal representative of said voltage level; using one of said senors as a reference, adjusting the zero offset of the other of said sensors to achieve the same voltage reading as said one of said sensors and generating a signal representative of the amount of adjustment; storing said signal representative of the amount of adjustment in memory; and adjusting the electrical bias voltages applied to said developer structures by an amount equal to the voltage difference between said reference voltage applied to said uncharged charge retentive surface and the voltage sensed by said reference sensor.

In a method in accordance with the invention, the step of applying the reference voltage and the adjusting steps may be initiated during a cycle up period following a normal cycle down of said imaging apparatus and, preferably, during a cycle up period following each normal cycle down of said imaging apparatus.

The step of using one of the sensors may comprise locating said sensor in a position which is less sensitive to contamination than the location occupied by said other of said sensors. The steps of using first and second sensors may comprise using electrostatic voltmeters.

The present invention further provides apparatus for creating tri-level images on a charge retentive surface during operation of a tri-level imaging apparatus, said apparatus comprising means for applying electrical bias voltages to said developer structures; means for moving said charge retentive surface past a plurality of process stations including a charging station where said charge retentive surface is uniformly charged, a plurality of developer structures for developing latent images and an illumination station for discharging said charge retentive surface; means for sensing the voltage level of a relatively uncharged portion of said charge retentive surface and generating a first signal representative of said voltage level; means for sensing said relatively uncharged portion of said charge retentive surface and generating a second signal representative of said voltage level; means for adjusting the zero offset of the other of said sensors to achieve the same voltage reading as said one of said sensors and generating a signal representative of the amount of adjustment; means for storing said signal representative of the amount of adjustment in memory; and means for adjusting the electrical bias voltages applied to said developer structures by an amount equal to the voltage difference between said reference voltage applied to said uncharged charge retentive surface and the voltage sensed by said reference sensor .

Said means for applying a reference voltage may comprise applying said reference voltage to a ground plane of said charge retentive surface.

Said means for sensing and adjusting may be operable during a cycle up period following a normal cycle down of said imaging apparatus, and preferably, during a cycle up period following each normal cycle down of said imaging apparatus. Said signal representative of the amount of adjustment may be utilized for adjusting subsequent sensor measurements between successive normal cycle down periods.

In a method/apparatus in accordance with the invention erroneous voltage readings of Electrostatic Voltmeter (ESVs), which have become contaminated by charged particles (i.e. toner) from developer housings used for developing latent images on a photoreceptor surface, are negated by adjusting the readings of the ESVs to compensate for the contamination of the ESVs. Additionally, the developer housing biases are adjusted to insure proper development and cleaning fields during development.

In one embodiment of the invention, during each cycle up following a normal cycle down, the DC bias from one of the developer housings is routed to the ground plane of the photoreceptor for a brief period of time. Both ESVs read the voltage on the photoreceptor which is equal to the the combination of the developer housing bias on the ground plane plus the residual voltage on the photoreceptor. One of the pair of ESVs ($ESV_{1)}$ is utilized to measure the voltage level on a portion of the photoreceptor. This ESV is used as a reference and the zero offset of the other ESV (ESV_2) is adjusted to obtain the same reading. Additionally, the DC voltage supply outputs for both the color and black developer housings are adjusted by the difference between the bias voltage output that was placed on the the photoreceptor ground plane and the actual reading of the reference ESV.

As a result of the foregoing adjustments to ESV_2 and the developer housing biases, the combined voltage reading due to residual voltatge on the photoreceptor and any combination of charged particles within the probe housing of the reference ESV (ESV_1) is arbitrarily set to zero. All other voltages are now established relative to the reference ESV. Therefore, all of the systems electrostatic values are properly set with respect to each other thereby maintaining proper development and cleaning fields over the life of the machine.

By way of example only, an apparatus and method in accordance with the present invention will be described with reference to the accompanying drawings, in which:

Figure 1a is a plot of photoreceptor potential versus exposure illustrating a tri-level electrostatic latent image;

Figure 1b is a plot of photoreceptor potential illustrating single-pass, highlight color latent image characteristics;

Figure 2 is schematic illustration of a printing apparatus embodying the present invention;

Figure 3 a schematic of the xerographic process stations including the active members for image formation as well as the control members operatively associated therewith of the printing apparatus illustrated in Figure 2; and

Figure 4 is a block diagram illustrating the interaction among active components of the xerographic process module of Figure 2 and the control devices utilized to control them.

For a better understanding of the concept of tri-level, highlight color imaging, a description thereof will now be given with reference to Figures 1a and 1b. Figure 1a shows a PhotoInduced Discharge Curve (PIDC) for a tri-level electrostatic latent image. Here V_0 is the initial charge level, V_{ddp} (V_{CAD}) the dark discharge potential (unexposed), V_w (V_{Mod}) the white or background discharge level and V_C (V_{DAD}) the photoreceptor residual potential (full exposure using a three level Raster Output Scanner, ROS). Nominal voltage values for V_{CAD}, V_{Mod} and V_{DAD} are, for example, 788, 423 and 123, respectively.

Color discrimination in the development of the electrostatic latent image is achieved when passing the photoreceptor through two developer housings in tandem or in a single pass by electrically biasing the housings to voltages which are offset from the background voltage V_{Mod}, the direction of offset depending on the polarity or sign of toner in the housing. One housing (for the sake of illustration, the second) contains developer with black toner having triboelectric properties (positively charged) such that the toner is driven to the most highly charged (V_{ddp}) areas of the latent image by the electrostatic field between the photoreceptor and the development rolls biased at $V_{black\ bias}$ (V_{bb}) as shown in Figure 1b. Conversely, the triboelectric charge (negative charge) on the colored toner in the first housing is chosen so that the toner is urged towards parts of the latent image at residual potential, V_{DAD} by the electrostatic field existing between the photoreceptor and the development rolls in the first housing which are biased to $V_{color\ bias}$, (V_{cb}). Nominal voltage levels for V_{bb} and V_{cb} are 641 and 294, respectively.

As shown in Figures 2 and 3, a highlight color printing apparatus 2 comprises a xerographic processor module 4, an electronics module 6, a paper handling module 8 and a user interface (IC) 9. A charge retentive member in the form of an Active Matrix (AMAT) photoreceptor belt 10 including a ground plane is mounted for movement in an endless path past a charging station A, an exposure station B, a test patch generator station C, a first Electrostatic Voltmeter (ESV) station D, a developer station E, a second ESV station F within the developer station E, a pretransfer station G, a toner patch reading station H where developed toner patches are sensed, a transfer station J, a preclean station K, cleaning station L and a fusing station M. Belt 10 moves in the direction of arrow 16 to advance successive portions thereof sequentially through the various processing stations disposed about the path of movement thereof. Belt 10 is entrained about a plurality of rollers 18, 20, 22, 23 and 24, the former of which can be used as a drive roller and the latter of which can be used to provide suitable tensioning of the photoreceptor belt 10. Motor 26 rotates roller 18 to advance belt 10 in the direction of arrow 16. Roller 18 is coupled to motor 26 by suitable means such as a belt drive, not shown. The photoreceptor belt may comprise a flexible belt photoreceptor. Typical belt photoreceptors are disclosed in U.S. Patent No. 4,588,667, U.S Patent No. 4,654,284 and U.S. Patent No. 4,780,385.

As can be seen by further reference to Figures 2 and 3, initially successive portions of belt 10 pass through charging station A. At charging station A, a primary corona discharge device in the form of dicorotron indicated generally by the reference numeral 28, charges the belt 10 to a selectively high uniform negative potential, V_0. As noted above, the initial charge decays to a dark decay discharge voltage, V_{ddp}, (V_{CAD}). The dicorotron is a corona discharge device including a corona discharge electrode 30 and a conductive shield 32 located adjacent the electrode. The electrode is coated with relatively thick dielectric material. An AC voltage is applied to the dielectrically coated electrode via power source 34 and a DC voltage is applied to the shield 32 via a DC power supply 36. The delivery of charge to the photoconductive surface is accomplished by means of a displacement current or capacitative coupling through the dielectric material. The flow of charge to the photoreceptor 10 is regulated by means of the DC bias applied to the dicorotron shield. In other words, the photoreceptor will be charged to the voltage applied to the shield 32. For further details of the dicorotron construction and operation, reference may be had to US-A 4,086,650.

A feedback dicorotron 38 comprising a dielectrically coated electrode 40 and a conductive shield 42 operatively interacts with the dicorotron 28 to form an integrated charging device (ICD). An AC power supply 44 is operatively connected to the electrode 40 and a DC power supply 46 is operatively connected to the conductive shield 42.

Next, the charged portions of the photoreceptor surface are advanced through exposure station B. At exposure station B, the uniformly charged photoreceptor or charge retentive surface 10 is exposed to a laser based input and/or output scanning device 48 which causes the charge retentive surface to be discharged in accordance with the output from the scanning device. Preferably the scanning device is a three level laser Raster Output Scanner (ROS). Alternatively, the ROS could be replaced by a conventional xerographic exposure device. The ROS comprises optics, sensors, laser tube and resident control or pixel board.

The photoreceptor, which is initially charged to a voltage V_0, undergoes dark decay to a level V_{ddp} or V_{CAD} equal to about -900 volts to form CAD images. When exposed at the exposure station B it is discharged to V_c or V_{DAD} equal to about -100 volts to form a DAD image which is near zero or ground potential in the highlight color (i.e. color other than black) parts of the image. See Figure 1a. The photoreceptor is also discharged to V_w or V_{mod} equal to approximately minus 500 volts in the background (white) areas.

A patch generator 52 (Figures 3 and 4) in the form of a conventional exposure device utilized for such purpose is positioned at the patch generation station C. It serves to create toner test patches in the interdocument zone which are used both in a developed and undeveloped condition for controlling various process functions. An Infra-Red densitometer (IRD) 54 is utilized to sense or measure the reflectance of test patches after they have been developed.

After patch generation, the photoreceptor is moved through a first ESV station D where an ESV (ESV_1) 55 is positioned for sensing or reading certain electrostatic charge levels (i. e. V_{DAD}, V_{CAD}, V_{Mod}, and V_{tc}) on the photoreceptor prior to movement of these areas of the photoreceptor moving through the development station E.

At development station E, a magnetic brush development system, indicated generally by the reference numeral 56 advances developer materials into contact with the electrostatic latent images on the photoreceptor. The development system 56 comprises first and second developer housing structures 58 and 60. Preferably, each magnetic brush development housing includes a pair of magnetic brush developer rollers. Thus, the housing 58 contains a pair of rollers 62, 64 while the housing 60 contains a pair of magnetic brush rollers 66, 68. Each pair of rollers advances its respective developer material into contact with the latent image. Appropriate developer biasing is accomplished via power supplies 70 and 71 electrically connected to respective developer housings 58 and 60. A pair of toner replenishment devices 72 and 73 (Figure 2) are provided for replacing the toner as it is depleted from the developer housing structures 58 and 60.

Between the developer structures, the photoreceptor moves through second ESV station F wheren an ESV (ESV_2) 80 is positioned sensing or reading electrostatic charge levels in the photoreceptor prior to movement of the photoreceptor past the developer housing 60.

Color discrimination in the development of the electrostatic latent image is achieved by passing the photoreceptor past the two developer housings 58 and 60 in a single pass with the magnetic brush rolls 62, 64, 66 and 68 electrically biased to voltages which are offset from the background voltage V_{Mod}, the direction of offset depending on the polarity of toner in the housing. One housing e.g. 58 (for the sake of illustration, the first) contains red conductive magnetic brush (CMB) developer 74 having triboelectric properties (i. e. negative charge) such that it is driven to the least highly charged areas at the potential V_{DAD} of the latent images by the electrostatic development field (V_{DAD} - $V_{color\ bias}$) between the photoreceptor and the development rolls 62, 64. These rolls are biased using a chopped DC bias via power supply 70.

The triboelectric charge on conductive black magnetic brush developer 76 in the second housing is chosen so that the black toner is urged towards the parts of the latent images at the most highly charged potential V_{CAD} by the electrostatic development field (V_{CAD} - $V_{black\ bias}$) existing between the photoreceptor and the development rolls 66, 68. These rolls, like the rolls 62, 64, are also biased using a chopped DC bias via power supply 72. By chopped DC (CDC) bias is meant that the housing bias applied to the developer housing is alternated between two potentials, one that represents roughly the normal bias for the DAD developer, and the other that represents a bias that is considerably more negative than the normal bias, the former being identified as $V_{Bias\ Low}$ and the latter as $V_{Bias\ High}$. This alternation of the bias takes place in a periodic fashion at a given frequency, with the period of each cycle divided up between the two bias levels at a duty cycle of from 5-10 % (Percent of cycle at $V_{Bias\ High}$) and 90-95% at $V_{Bias\ Low}$. In the case of the CAD image, the amplitude of both $V_{Bias\ Low}$ and $V_{Bias\ High}$ are about the same as for the DAD housing case, but the waveform is inverted in the sense that the the bias on the CAD housing is at $V_{Bias\ High}$ for a duty cycle of 90-95%. Developer bias switching between $V_{Bias\ High}$ and $V_{Bias\ Low}$ is effected automatically via the power supplies 70 and 74. For further details regarding CDC biasing, reference may be had to U. S. Patent No. 5,080,988.

In contrast, in conventional tri-level imaging as noted above, the CAD and DAD developer housing biases are set at a single value which is offset from the background voltage by approximately -100 volts. During image development, a single developer bias voltage is continuously applied to each of the developer structures. Expressed differently, the bias for each developer structure has a duty cycle of 100%.

Because the composite image developed on the photoreceptor consists of both positive and negative toner, a negative pretransfer dicorotron member 100 at the pretransfer station G is provided to condition the toner for effective transfer to a substrate using positive corona discharge.

Subsequent to image development a sheet of support material 102 (Figure 3) is moved into contact with the toner image at transfer station J. The sheet of support material is advanced to transfer station J by conventional sheet feeding apparatus comprising a part of the paper handling module 8. Preferably, the sheet feeding apparatus includes a feed roll contacting the uppermost sheet of a stack copy sheets. The feed rolls rotate so as to advance the uppermost sheet from stack into a chute which directs the advancing sheet of support material into contact with photoconductive surface of belt 10 in a timed sequence so that the toner powder image developed thereon contacts the advancing sheet of support material at transfer station J.

Transfer station J includes a transfer dicorotron 104 which sprays positive ions onto the backside of sheet 102. This attracts the negatively charged toner powder images from the belt 10 to sheet 102. A detack dicorotron 106 is also provided for facilitating stripping of the sheets from the belt 10.

After transfer, the sheet continues to move, in the direction of arrow 108, onto a conveyor (not shown) which advances the sheet to fusing station M. Fusing station M includes a fuser assembly, indicated generally by the reference numeral 120, which permanently affixes the transferred powder image to sheet 102. Preferably, fuser assembly 120 comprises a heated fuser roller 122 and a backup roller 124. Sheet 102 passes between fuser roller 122 and backup roller 124 with the toner powder image contacting fuser roller 122. In this manner, the toner powder image is permanently affixed to sheet 102 after it is allowed to cool. After fusing, a chute, not shown, guides the advancing sheets 102 to a catch trays 126 and 128 (Figure 2), for subsequent removal from the printing machine by the operator.

After the sheet of support material is separated from photoconductive surface of belt 10, the residual toner particles carried by the non-image areas on the photoconductive surface are removed therefrom. These particles are removed at cleaning station L. A cleaning housing 100 supports therewithin two cleaning brushes 132, 134 supported for counter-rotation with respect to the other and each supported in cleaning relationship with photoreceptor belt 10. Each brush 132, 134 is generally cylindrical in shape, with a long axis arranged generally parallel to photoreceptor belt 10, and transverse to photoreceptor movement direction 16. Brushes 132, 134 each have a large number of insulative fibers mounted on base, each base respectively journaled for rotation (driving elements not shown). The brushes are typically detoned using a flicker bar and the toner so removed is transported with air moved by a vacuum source (not shown) through the gap between the housing and photoreceptor belt 10, through the insulative fibers and exhausted through a channel, not shown. A typical brush rotation speed is 1300 rpm, and the brush/photoreceptor interference is usually about 2 mm. Brushes 132, 134 beat against flicker bars (not shown) for the release of toner carried by the brushes and for effecting suitable tribo charging of the brush fibers.

Subsequent to cleaning, a discharge lamp 140 floods the photoconductive surface 10 with light to dissipate any residual negative electrostatic charges remaining prior to the charging thereof for the successive imaging cycles. To this end, a light pipe 142 is provided. Another light pipe 144 serves to illuminate the backside of the photoreceptor downstream of the pretransfer dicorotron 100 The photoreceptor is also subjected to flood illumination from the lamp 140 via a light channel 146.

Figure 4 depicts the the interconnection among active components of the xerographic process module 4 and the sensing or measuring devices utilized to control them. As illustrated therein, ESV_1, ESV_2 and IRD 54 are operatively connected to a control board 150 through an analog to digital (A/D) converter 152. ESV_1 and ESV_2 produce analog readings in the range of 0 to 10 volts which are converted by Analog to Digital (A/D) converter 152 to digital values in the range 0-255. Each bit corresponds to 0.040 volts (10/255) which is equivalent to photoreceptor voltages in the range 0-1500 where one bit equals 5.88 volts (1500/255).

The digital values corresponding to the analog measurements are processed in conjunction with a Non-Volatile Memory (NVM) 156 by firmware forming a part of the control board 150. The digital values arrived at are converted by a digital to analog (D/A) converter 158 for use in controlling the ROS 48, dicorotrons 28, 54, 90, 100 and 104 and the power supplies 70 and 71 for electrically biasing the developer structures 58 and 60. Toner dispensers 160 and 162 are controlled by the digital values. Target values for use in setting and adjusting the operation of the active machine components are stored in NVM.

Tri-level xerography requires fairly precise electrostatic control at both development stations. This is accomplished by using ESV_1 and ESV_2 to measure voltage states on the photoreceptor in test patch areas written in the interdocument zones between successive images. ESV_2 is provided because the color developer material reduces the magnitude of the black development field in a somewhat variable manner, making it necessary to read the electrostatics associated with the black development following the color housing 58.

In such a system it is necessary that the ESVs are reasonably precise in their readings. Although the ESVs can be calibrated to a common source by a service representative, the ESV output is known to drift over time if charged toner particles are deposited within the unit. A single ESV cannot distinguish between charge on the photoreceptor and charge on a toner particle sitting inside the ESV housing.

In the dual ESV control system such as disclosed herein, ESV_1 (which, because of its location, is less sensitive to contamination than ESV_2) is taken as the reference for calibration purposes. At each cycle up following a normal cycle down, the bias voltage output of one of the power supplies 70, 71 (in this case, the power supply 70) is routed to the photoreceptor ground plane connection 174 via conductor 176 and a high voltage relay 178 operatively conected to the electronic module 6. This output, which is used as a reference voltage, is applied for about 200 msec or just enough time for the ESV_1 and ESV_2 to read the voltage on the photoreceptor. ESV_2 is then adjusted to give the same reading as ESV_1, and a signal representative of the amount of adjustment is generated and stored in memory and may be utilized for adjusting subsequent ESV_2 measurements between successive normal cycle down periods. The adjustment of ESV_2 in the foregoing manner will keep the ESV readings precise with respect to each other. However, the development and cleaning fields associated with the development systems 58 and 60 will not be correct. This is because the bias voltages applied to the developer housings have not been adjusted according to the ESV readings. Thus, in addition to adjusting ESV_2 to compensate for the offset between it and ESV_1, the DC bias voltage supply outputs for both the color and the black developer housings are adjusted by the difference between the bias voltage output routed to the photoreceptor ground plane and the actual reading of the reference ESV, ESV_1.

As a result of the foregoing adjustments to ESV_2 and the developer housing biases, the combined voltage reading due to residual voltage on the photoreceptor and any combination of charged particles within the probe housing of the reference ESV (ESV_1) is arbitrarily set to set to zero. All other voltages are now established relative to the reference ESV. Therefore, all of the systems electrostatic values are properly set with respect to each other thereby maintaining proper development and cleaning fields over the life of the machine.

Claims

1. A method of creating tri-level images on a charge retentive surface during operation of a tri-level imaging apparatus, the method including the steps of:

moving said charge retentive surface past a plurality of process stations including a charging station where said charge retentive surface is uniformly charged, a plurality of developer structures for developing latent images and an illumination station for discharging said charge retentive surface;

applying electrical bias voltages to said developer structures;

applying a reference voltage to the uncharged charge retentive surface;

using a first sensor, sensing the voltage level of said charge retentive surface and generating a first signal representative of said voltage level;

using a second sensor, sensing the voltage level of said charge retentive surface and generating a second signal representative of said voltage level;

using one of said senors as a reference, adjusting the zero offset of the other of said sensors to achieve the same voltage reading as said one of said sensors; and

adjusting the electrical bias voltages applied to said developer structures by an amount equal to the voltage difference between said reference voltage applied to said uncharged charge retentive surface and the voltage sensed by said reference sensor.

2. A method according to claim 1, wherein said step of applying a reference voltage to an uncharged charge retentive surface comprises applying a voltage equal to one of said electrical bias voltages.

3. A method according to claim 1 or claim 2, wherein said reference voltage is applied to a ground plane of said charge retentive surface.

4. A method according to any one of the preceding claims, wherein said step of applying a reference voltage and said adjusting steps are initiated during a cycle up period following a normal cycle down of said imaging apparatus.

5. A method according to any one of the preceding claims, wherein a signal representative of the amount of adjustment of the zero offset of the said other sensor is generated and is stored, that signal being utilized for adjusting subsequent sensor measurements between successive normal cycle down periods.

6. Apparatus for creating tri-level images on a charge retentive surface during operation of a tri-level imaging apparatus, said apparatus comprising:

means for moving said charge retentive surface past a plurality of process stations including a charging station where said charge retentive surface is uniformly charged, a plurality of developer structures for developing latent images and an illumination station for discharging said charge retentive surface;

means for applying electrical bias voltages to said developer structures;

means for applying a reference voltage to a relatively uncharged portion of said charge retentive surface;

first sensor means for sensing the voltage level of said charge retentive surface when the bias voltage is applied and generating a first signal representative of said voltage level;

second sensor means for sensing the voltage level of said charge retentive surface when the bias voltage is applied and generating a second signal representative of said voltage level;

means for adjusting the zero offset of one of said sensor means to achieve the same voltage reading as the other of said sensor means; and

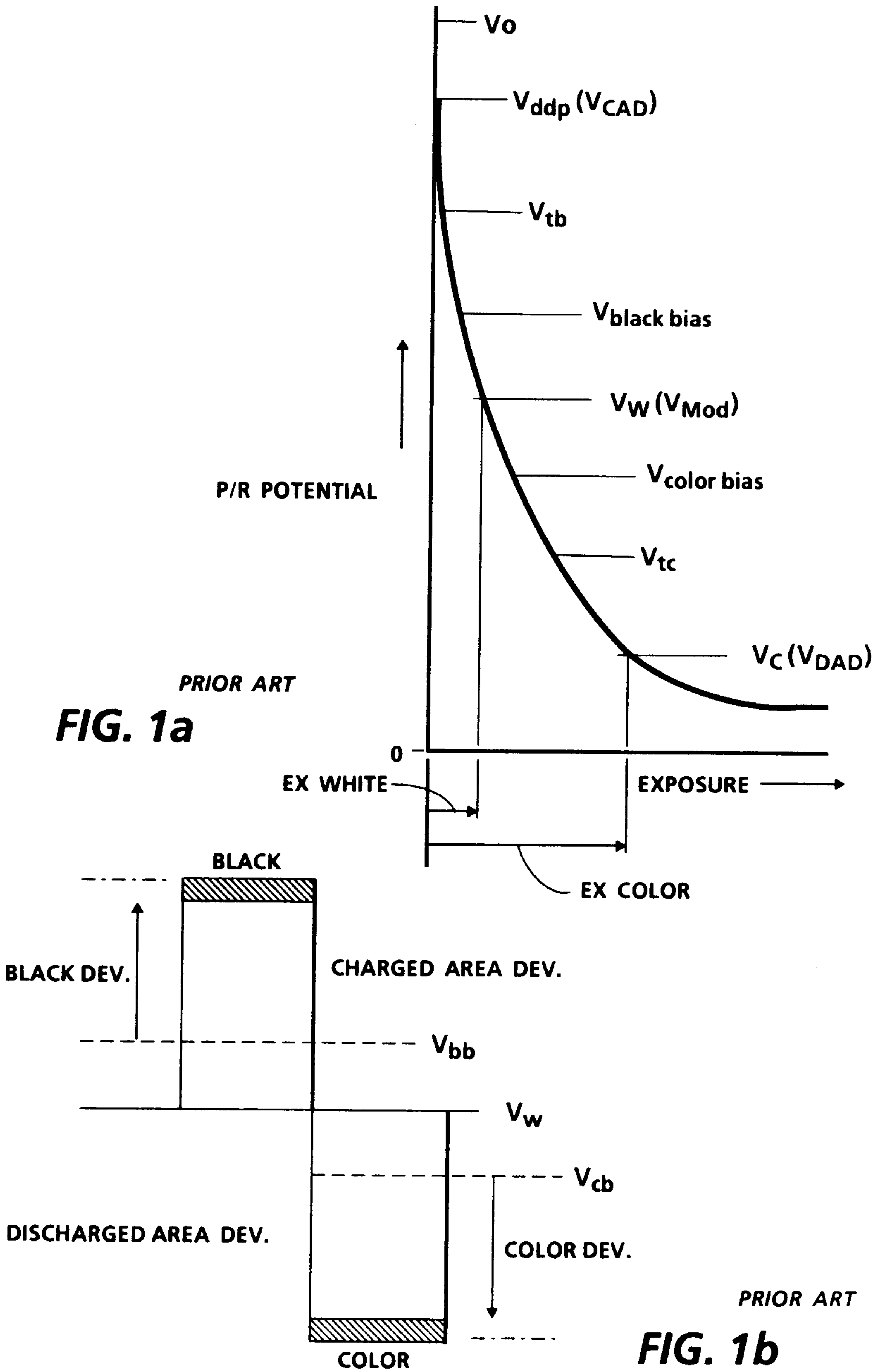
means for adjusting the electrical bias voltages applied to said developer structures by an amount equal to the voltage difference between said reference voltage applied to said uncharged charge retentive surface and the voltage sensed by the said other sensor .

7. Apparatus according to claim 6, wherein said means for applying a reference voltage to the charge retentive surface is operable to apply said electrical bias voltages to the charge retentive surface.

8. Apparatus according to claim 6 or claim 7, wherein said sensor means and adjusting means are operable during a cycle up period following a normal cycle down of said imaging apparatus.

9. Apparatus according to any one of claims 6 to 8, wherein said other sensor means is located in a position which is less sensitive to contamination than the location occupied by the said one sensor means.

10. Apparatus according to any one of claims 6 to 9, wherein said sensor means comprise electrostatic voltmeters.



PRIOR ART

FIG. 1a

PRIOR ART

FIG. 1b

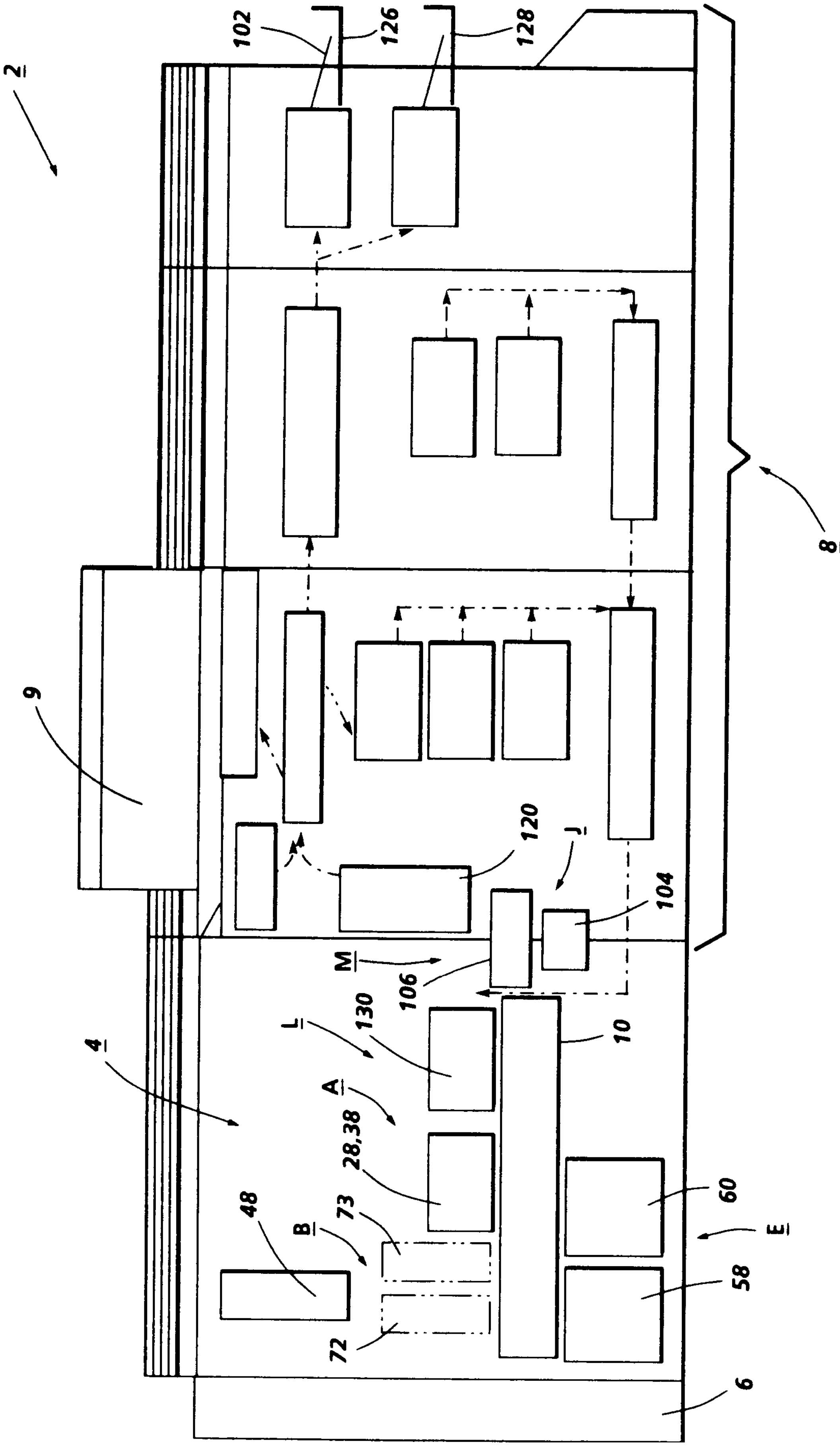


FIG. 2

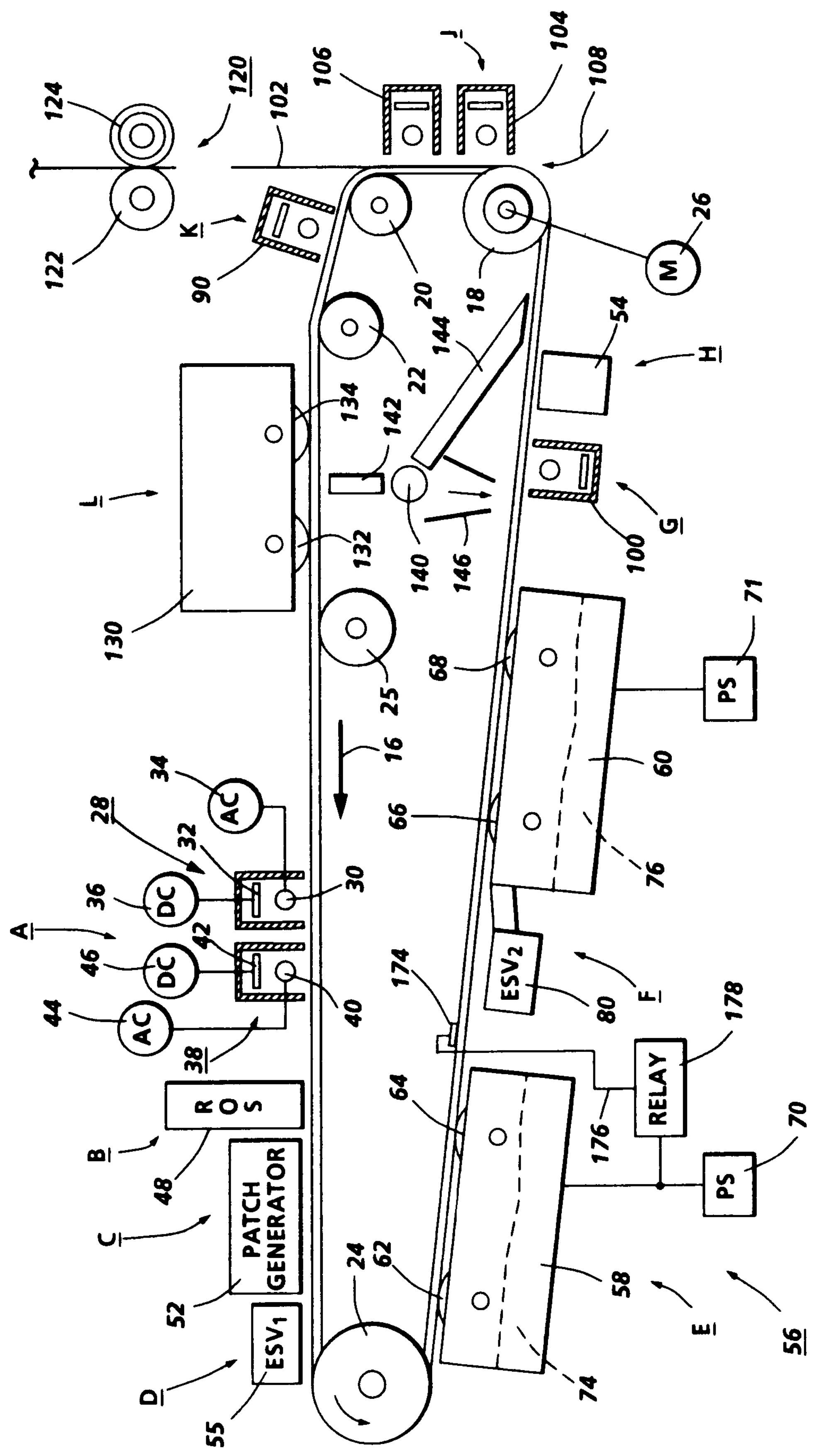


FIG. 3

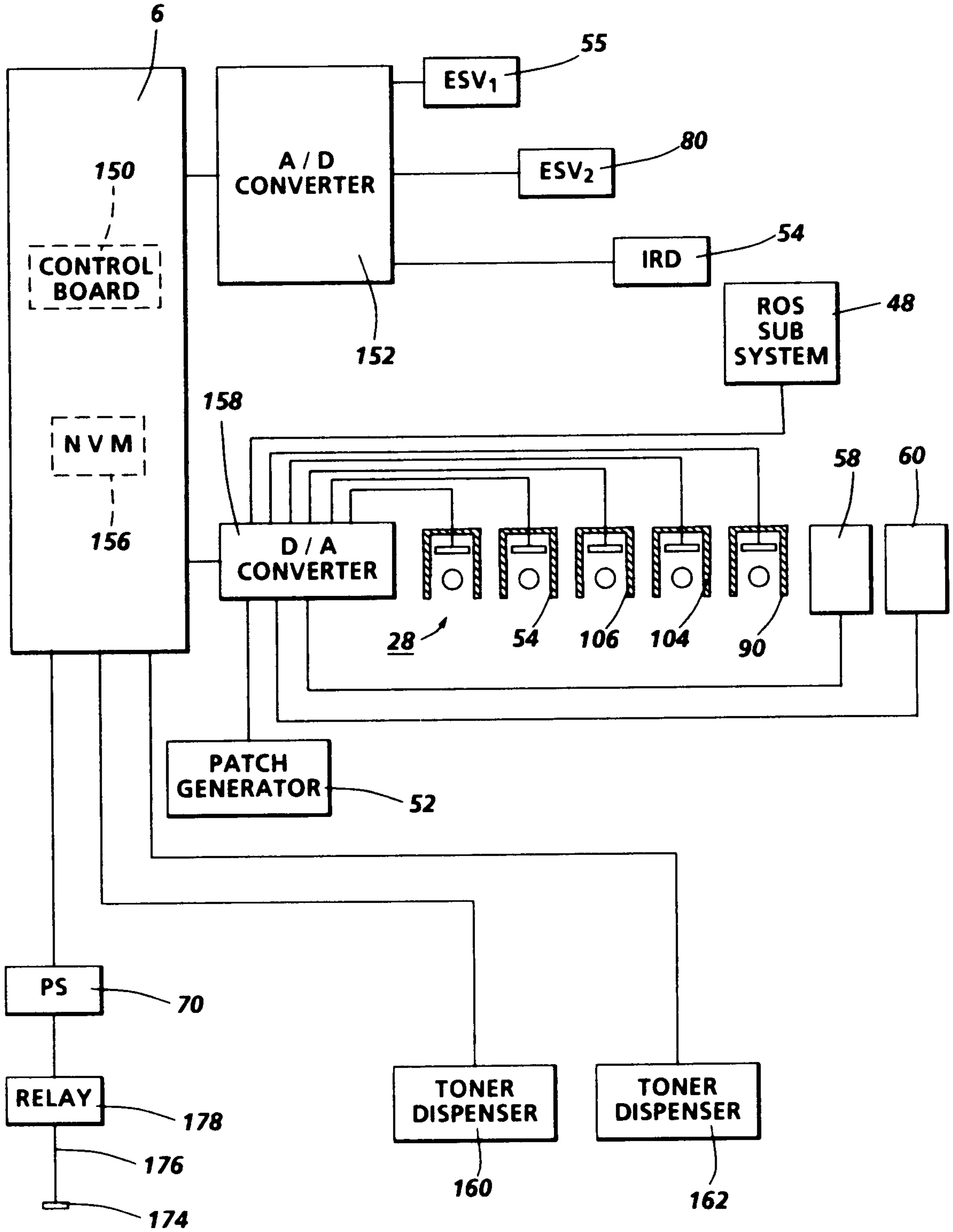

6
150
CONTROL BOARD
NVM
156
A / D CONVERTER
152
ESV1
55
ESV2
80
IRD
54
ROS SUB SYSTEM
48
158
D / A CONVERTER
58
60
28
54
106
104
90
PATCH GENERATOR
52
PS
70
RELAY
178
176
174
TONER DISPENSER
160
TONER DISPENSER
162

FIG. 4