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(71) Applicant : **MITA INDUSTRIAL CO. LTD.**
2-28, 1-chome, Tamatsukuri Chuo-ku
Osaka-shi Osaka 540 (JP)

(72) Inventor : **Fujihara, Kensuke, Room 105,**
Sumiyoshipakumanshon
10-19, Sumiyoshi 2-chome, Sumiyoshi-ku
Osaka-shi, Osaka 558 (JP)
Inventor : **Tanaka, Hideyuki**
Room 404, Sanpierunakano, 3-23,
Nakanonishi
Itami-shi, Hyogo 664 (JP)
Inventor : **Takemura, Yoshinobu**
717-1, Hirose, Koryo-cho
Kitakatsuragi-Gun, Nara 635 (JP)

(74) Representative : **W.P. Thompson & Co.**
Coopers Building, Church Street
Liverpool L1 3AB (GB)

(54) Apparatus for, and method of correcting a potential sensor.

(57) In the potential sensor correcting apparatus of the present invention, two reference bias voltages are applied to a photoreceptor drum (1) by a low reference bias unit (21) and a high reference bias unit (22), and the values measured by a potential sensor (4) are stored in a memory (23a) of a control unit (23). Based on the measured values stored in the memory (23a), there is determined a first straight line (Y_1) which represents the relationship between the detected voltages and outputs of the potential sensor (4). Then, there is obtained a second straight line (Y_2) which has the same inclination as that of the first straight line (Y_1) and which passes through the origin. Based on the second straight line (Y_2) thus obtained, the output of the potential sensor (4) is corrected. Thus, the output of the potential sensor (4) can be accurately corrected without any influence exerted by residual charge.

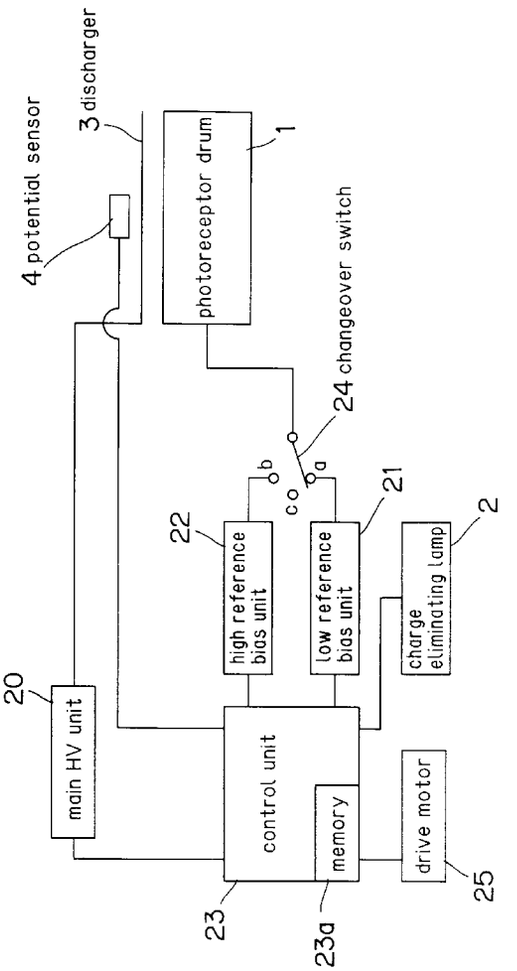
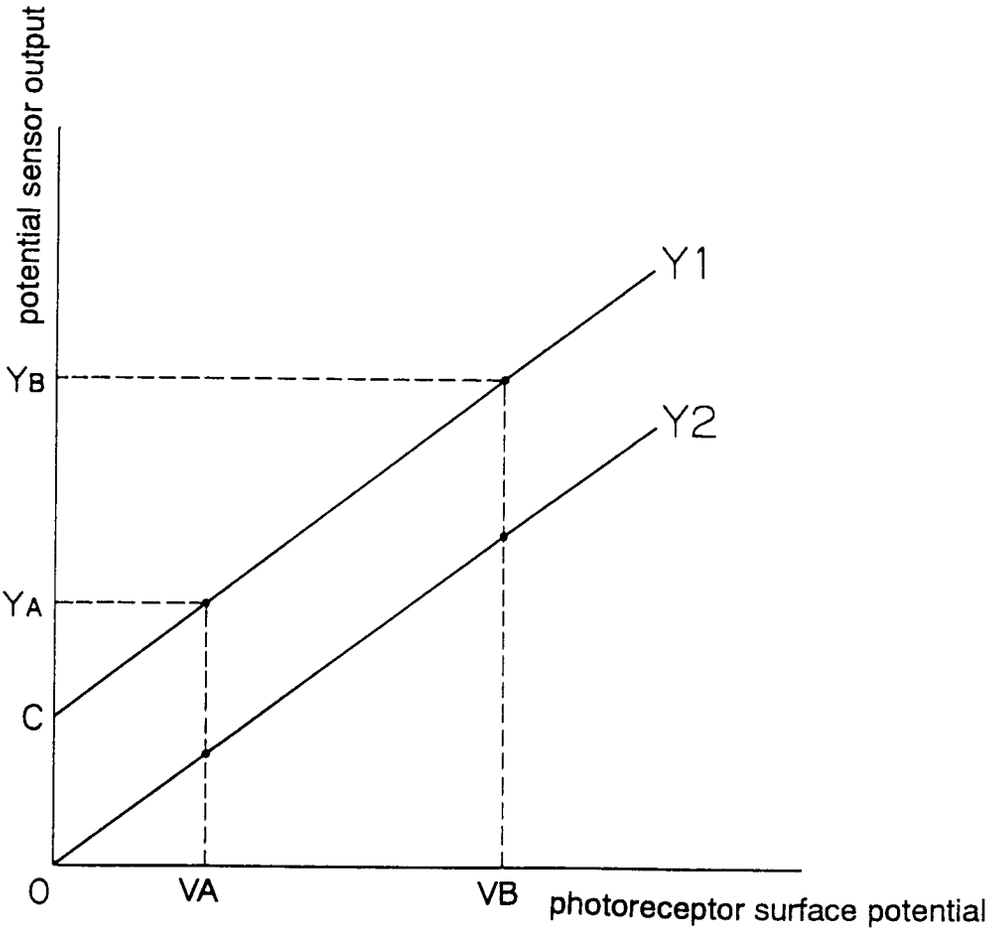


Fig. 2

EP 0 545 639 A2

Fig. 3



VA : low reference bias (200V)

VB : high reference bias (600V)

The present invention relates to apparatus for and method of correcting the output of a potential sensor for detecting the electric charge potential of a photoreceptor.

As an image forming apparatus having a photoreceptor, there is generally known an electrophotographic copying apparatus, a laser printer, an electrophotographic facsimile or the like.

For example, a laser printer has a photoreceptor in the form of a drum (hereinafter referred to a photoreceptor drum). Such a photoreceptor drum is generally made of an aluminium tube and provided at the surface thereof with a photosensitive semiconductor layer. The laser printer is arranged such that, during image formation, the photosensitive semiconductor layer on the surface of the photoreceptor drum is electrically charged to have a uniform potential by corona discharge of a charger, and the photosensitive semiconductor layer thus charged is then exposed to laser light to eliminate the electric charge in the light-exposed area thereof, where an electrostatic latent image will be formed.

However, it often occurs that the electric charges are not evenly distributed in the photosensitive semiconductor layer (residual electric charge). It is therefore required to adjust such an uneven distribution.

As a method of checking the residual electric charge, there has been proposed a method by which a potential sensor for measuring the surface potential of a photoreceptor drum, measures the surface potential of the photoreceptor drum with the electric charge on the surface thereof eliminated by a charge eliminator, and the measurement result is fed back to the charge eliminator to maintain the surface potential of the photoreceptor drum to a fixed value (See Japanese Patent Laid-Open Publication No. 142492(A)/1991).

When there is disposed a potential sensor for measuring the surface potential of a photoreceptor drum, the output of the potential sensor is required to be corrected for the following two reasons.

(1) The sensitivity varies depending on the potential sensor.

(2) When a potential sensor is disposed opposite to the surface of a photoreceptor drum, the distance between the drum surface and the potential sensor varies slightly dependent on the product. Due to such a difference in distance, potential sensors supply different outputs even though the sensors have detected the same potential.

In correcting the output of a potential sensor, it is considered convenient that a predetermined high voltage is applied directly to the photoreceptor drum, the output of the potential sensor at that time is read out, and a correction value is determined based on the output of the potential sensor supplied at the time when the high voltage is applied to the photoreceptor drum.

There is conventionally known an image forming apparatus arranged such that, to correct the output of a potential sensor, a connector connected to a developing bias circuit is exchanged with a connector connected to a photoreceptor drum, a predetermined high voltage is applied from a high voltage generating circuit to the photoreceptor drum, and the output of the potential sensor at that time is read out to correct the output of the potential sensor.

However, the correcting method above-mentioned uses a high voltage and can therefore be applied only at the time of production of the image forming apparatus or at a time of maintenance carried out by a professional service engineer.

On the other hand, when the image forming apparatus is driven, it often occurs that the potential sensor is contaminated by toner or the like during its use and this may gradually deteriorate the sensor sensitivity. In such a case, too, the sensor output is required to be corrected; otherwise, a good image cannot be obtained.

In this connection, the applicant of the present invention has already proposed an image forming apparatus which incorporates a potential sensor for detecting the surface potential of a photoreceptor drum, a high voltage generating circuit and a switching circuit, and which is arranged such that, when the switching circuit is operated to apply a high voltage to the photoreceptor drum, the surface potential of the photoreceptor drum is measured by the potential sensor, and provision is made such that the potential sensor for measuring the surface potential of the photoreceptor drum supplies an output always equal to a proper corrected value, thereby to electrically charge the photoreceptor drum with a desired potential at all times (US Patent No. 4,939,542).

According to the technology above-mentioned, however, when the output of the potential sensor is corrected with residual charge remaining on the photoreceptor drum immediately after image formation or the like, this causes the potential of the residual charge to be added to the corrected value. This fails to accurately correct the output of the potential sensor.

It is an object of the present invention to provide a potential sensor correcting apparatus capable of accurately correcting the output of a potential sensor with no influence exerted by a residual potential.

According to the present invention, a plurality of different reference bias voltages are applied to a photoreceptor, the surface potentials of the photoreceptor are detected, and there is determined a first straight line which represents the relationship between the detected voltages and output characteristics of the potential sensor, based on the outputs of the potential sensor supplied at the time when the reference bias voltages are applied to the photoreceptor. Then, there is obtained a second straight line having

the same inclination as that of the first straight line and passing through the origin. Based on the second straight line thus obtained, the output of the potential sensor is corrected.

According to the present invention, the output of the potential sensor is corrected based on the second straight line having the same inclination as that of the first straight line and passing through the origin, so that the output of the potential sensor can be accurately corrected without any influence exerted by a residual potential.

The invention is described further hereinafter, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a schematic view illustrating the arrangement of an image forming unit in an image forming apparatus;

Figure 2 is a block diagram illustrating the electric correction of a potential sensor correcting apparatus in accordance with one embodiment of the present invention;

Figure 3 is a graph illustrating a calculating method used for correcting the output of a potential sensor; and

Figure 4 is a flow chart of the operation of the potential sensor correcting apparatus of the present invention.

With reference to Fig. 1, the following description will discuss the arrangement of an image forming unit of an image forming apparatus (e.g., a laser printer) having the potential sensor correcting apparatus according to an embodiment of the present invention. Fig. 1 is a schematic view illustrating the arrangement of an image forming unit of an image forming apparatus.

In Fig. 1, there are disposed, around a photoreceptor drum 1, charge eliminating lamps 2, a main corona discharger 3, a potential sensor 4, a developing device 6, a transferring corona discharger 7, a separating corona discharger 8 and a cleaner 9 in this order along the rotation direction of the photoreceptor drum 1.

In the photoreceptor drum 1, an exposure position Ex is set between the main corona discharger 3 and the potential sensor 4, and light from an optical system 10 is adapted to be irradiated to the exposure position Ex. The optical system 10 has a camera element (hereinafter referred to as CCD) 11 for converting document image information into an electric signal, a laser scan unit (hereinafter referred to as LSU) 12 for irradiating laser light to the photoreceptor drum 1 based on an output signal from the CCD 11, so that the photoreceptor drum 1 is exposed to the laser light, and a polygon mirror 13 for reflecting and guiding the laser light from the LSU 12 to the exposure position Ex of the photoreceptor drum 1.

The following description will discuss the operation of the image forming apparatus having the arrangement above-mentioned.

The photoreceptor drum 1 is rotated at a constant speed in the direction of the arrow in Fig.1 and residual charge at the surface of the photoreceptor drum 1 is removed by the charge eliminating lamps 2, and the surface of the photoreceptor drum 1 is then electrically charged to a fixed potential by the main corona discharger 3. Through the Polygon mirror 13, laser light of the LSU 12 irradiated based on the output signal of the CCD 11, is applied to the exposure position Ex of the photoreceptor drum 1. Such light exposure eliminates the electric charge at the area which has been exposed to the light, and an electrostatic latent image is then formed on the surface of the photoreceptor drum 1.

Then, the developing device 6 supplies toner to the surface of the photoreceptor drum 1, so that the electrostatic latent image is developed by the toner. The toner is supplied to the surface of the photoreceptor drum 1 by a developing roller (not shown) incorporated in the developing device 6. Preferably, a developing bias voltage having the same potential as that at the surface of the photoreceptor drum 1 is applied to the developing roller in order to prevent excessive toner from sticking to the surface of the photoreceptor drum 1.

In association with the operations above-mentioned, a paper sheet is fed by a paper feeding unit (not shown) and the toner image on the surface of the photoreceptor drum 1 is transferred to the paper sheet. The paper sheet to which the toner image has been transferred, is separated from the surface of the photoreceptor drum 1 by the separating corona discharger 8 and then sent to a fixing unit (not shown), where the transferred image is fixed.

Thereafter, residual toner on the surface of the photoreceptor drum 1 is removed by the cleaner 9 and residual charge at the surface of the photoreceptor 1 is removed by the charge eliminating lamps 2.

In a series of the image forming operations above-mentioned, if the surface potential of photoreceptor drum 1 is not equal to a desired preset potential when the surface of the photoreceptor drum 1 is electrically charged to a fixed potential by the main corona discharger 3, this exerts a bad influence on the subsequent exposure and development, so that the image to be transferred to the paper sheet will become unclear.

It is therefore required to control the output of the main corona discharger 3 such that the electric charge potential at the surface of the photoreceptor drum 1 is always maintained at a fixed potential level.

In this connection, this embodiment is arranged as follows. At the initial stage of the image forming operation, two reference bias voltages are applied to the photoreceptor drum 1, and the surface potentials of the photoreceptor drum 1 are measured by the potential sensor 4. The measured values are fed back to a

potential sensor correcting apparatus, to be discussed later, which is adapted to control the main corona discharger 3. The potential sensor correcting apparatus is adapted to correct the output of the potential sensor 4 such that the values measured by the potential sensor 4 always present an accurate relationship with respect to the surface potentials of the photoreceptor drum 1.

The following description will discuss the potential sensor correcting apparatus with reference to a block diagram (Fig. 2) of the electric correction thereof.

As shown in Fig. 2, the correcting apparatus has a main high voltage unit 20 for supplying a high voltage to the main corona discharger 3 to carry out corona discharge to the surface of the photoreceptor drum 1, causing the photosensitive semiconductor layer at the surface of the photoreceptor drum 1 to be electrically charged; a low reference bias unit 21 for applying a low reference bias voltage VA (for example, 200V) directly to the photoreceptor drum 1; a high reference bias unit 22 for applying a high reference bias voltage VB (for example, 600V) directly to the photoreceptor drum 1; and a control unit 23 for controlling the drives of the units 20, 21, 22. It is known that, when the reference bias voltage VA or VB is applied directly to the photoreceptor drum 1 with no residual charge remaining thereon, the surface of the photoreceptor drum 1 is generally electrically charged at the potential VA or VB.

The control unit 23 has a memory 23a adapted to store values Y_A and Y_B measured by the potential sensor 4 at the time when the two reference bias voltages VA and VB are applied to the photoreceptor drum 1. As shown in Fig. 3, from the values Y_A and Y_B which have been measured by the potential sensor 4 at the time of application of the two reference bias voltages VA, VB, and which have been stored in the memory 23a, the control unit 23 determines a first straight line Y1 which represents the relationship between the detected voltages and outputs of the potential sensor 4, on the assumption that the same residual potential C remains on the surface of the photoreceptor drum 1 when the two reference bias voltages VA, VB are applied. Further, the control unit 23 has both a calculating function for obtaining a second straight line Y2 which has the same inclination as that of the first straight line Y1 thus determined and which passes through the origin, and a correcting function for correcting the output of the potential sensor 4 based on the second straight line Y2.

A changeover switch 24 controls the energization between the photoreceptor drum 1 and each of the low and high reference bias units 21, 22. More specifically, at the time of correction, when the changeover switch 24 is connected to a contact a, the low reference bias unit 21 is electrically connected to the photoreceptor drum 1, and when the changeover switch 24 is connected to a contact b, the high reference bias unit 22 is electrically connected to the photoreceptor drum 1. Normally, the changeover switch 24 is connected to a contact c to prevent the two bias voltages VA, VB from being applied to the photoreceptor drum 1.

Connected to the control unit 23 are a drive motor 25 for driving the photoreceptor drum 1 and other image forming mechanisms, and the charge eliminating lamps 2.

The following description will discuss the operation of the potential sensor 4 correcting apparatus, with reference to the operation flow chart in Fig. 4.

When the main switch is turned on to start the image forming apparatus, the control unit 23 turns on the charge eliminating lamps 2 at Step 1 to eliminate the electric charge of the photoreceptor drum 1 such that the surface potential thereof drops to a certain extent to prevent the potential from being changed in a moment due to dark-attenuation or the like.

Upon completion of charge elimination, the changeover switch 24 is thrown to the side of the contact a (See Fig. 2) of the low reference bias unit 21 at Step 2, thereby to connect the low reference bias unit 21 to the photoreceptor drum 1, so that the low reference bias voltage VA (for example, 200V) is applied to the photoreceptor drum 1. At Step 3, there is read out the output Y_A of the potential sensor 4 with the low reference bias voltage VA applied to the photoreceptor drum 1. At Step 4, the value Y_A is stored in the memory 23a of the control unit 23.

At Step 5, the changeover switch 24 is thrown to the side of the contact b (See Fig. 2) of the high reference bias unit 22 to connect the high reference bias unit 22 to the photoreceptor drum 1, so that the high reference bias voltage VB (for example, 600V) is applied to the photoreceptor drum 1. At Step 6, there is read out the output Y_B of the potential sensor 4 with the high reference bias voltage VB applied to the photoreceptor drum 1. At Step 7, the value Y_B is stored in the memory 23a of the control unit 23.

Upon completion of the application of the two reference bias voltages VA, VB, the first straight line Y1 representing the relationship between the detected voltages and output characteristics of the potential sensor 4 is determined, as shown in Fig. 3, based on the measured values Y_A and Y_B of the potential sensor 4 stored in the memory 23a. Then, there is obtained the second straight line Y2 which has the same inclination as that of the first straight line Y1 thus determined and which passes through the origin. More specifically, even though the electric charge of the photoreceptor drum 1 has been eliminated at Step 1, it is difficult to perfectly eliminate the residual charge of the photoreceptor drum 1, and any amount of residual charge still remains. Accordingly, attention is placed on a method of correcting the output of the potential sensor 4 in recognition of the presence of the

residual charge.

In other words, it is assumed that, when the two reference bias voltages VA, VB are applied, the same residual potential C remains on the surface of the photoreceptor drum 1 as shown below:

$$Y_A = mVA + C \quad (1)$$

$$Y_B = mVB + C \quad (2)$$

From the equations (1), (2), there is determined the following first straight line Y1 passing through the coordinates (VA, Y_A) and the coordinates (VB, Y_B).

$$Y1 = (Y_A - Y_B)X/(VA - VB) + C \quad (3)$$

$$(m = (Y_A - Y_B)/(VA - VB))$$

Then, there is obtained the following second straight line Y2 having the same inclination with that in the equation (3) and passing through the origin.

$$Y2 = (Y_A - Y_B)X/(VA - VB) \quad (4)$$

At Step 9, the second straight line Y2 represented by the equation (4) is stored, as the correction characteristics of the potential sensor 4, in the memory 23a.

Thereafter, a normal image forming processing is carried out. More specifically, the main high voltage unit 20 is driven at Step 10 so that the surface of the photoreceptor drum 1 is electrically charged with a high voltage by the main corona discharger 3. The main corona discharger 3 is driven by a high voltage required for the desired potential which is 800V for example. At Step 11, the potential of actual electric charge at the surface of the photoreceptor drum 1 is measured by the potential sensor 4. It is now supposed that the output of the potential sensor 4 at this time is Y_X. At Step 12, the surface potential of the photoreceptor drum 1 which corresponds to the measured value Y_X of the potential sensor 4, is calculated by applying the value Y_X to the correction characteristics stored at Step 9, i.e., to the equation (4). It is then judged whether or not the surface potential thus calculated (for example, 780V) is in a predetermined error range with respect to the desired potential of 800V.

When it is judged at Step 12 that the surface potential calculated by applying the measured value Y_X of the potential sensor 4 to the correction characteristics in the equation (4), is in the predetermined error range with respect to the desired potential, the LSU 12 irradiates laser light to the exposure position Ex of the photoreceptor drum 1 at Step 13, thereby to expose the photoreceptor drum 1 to light. At Step 14, the exposure potential of the photoreceptor drum 1 is measured by the potential sensor 4. Likewise at Step 12, it is judged at Step 15 whether or not the surface potential calculated by applying the value thus measured to the correction characteristics stored at Step 9, is in a predetermined error range with respect to the desired exposure potential.

When it is judged at Step 15 that the surface potential calculated by applying the measured value of the potential sensor 4 to the correction characteristics in the equation (4), is in the predetermined error range with respect to the desired exposure potential, the sequence is returned.

When it is judged at Step 12 that the calculated surface potential deviates from the predetermined error range with respect to the desired potential, the control voltage of the main corona discharger 3 is changed at Step 16, based on the judging result at Step 12, and the sequence is returned back to Step 10, where the photoreceptor drum 1 will be again electrically charged with a high voltage. When it is judged at Step 15 that the calculated surface potential deviates from the predetermined error range with respect to the desired exposure potential, the laser output of the LSU 12 is changed at Step 17, based on the judging result at Step 15, and the sequence is returned back to Step 13 where the photoreceptor drum 1 will be again exposed to light.

Steps 1 to 9 of correcting the potential sensor 4, may be carried out at the time when the image forming apparatus is started. Further, a potential sensor correcting switch may be disposed and a professional service engineer or the like may carry out the correction by operating such a potential sensor correcting switch at the time of maintenance of the image forming apparatus. In short, by correcting the potential sensor 4 at predetermined time intervals, a proper electric charge can be measured at all times, enabling a clear image to be formed.

As discussed in the foregoing, according to the correcting apparatus of the embodiment above-mentioned, the electric charge at the surface of the photoreceptor drum 1 is first eliminated such that the surface potential thereof drops to a certain extent to prevent the potential from being greatly changed due to dark-attenuation or the like, and the output of the potential sensor 4 is then corrected. As shown in Fig. 3, the first straight line Y1 representing the relationship between the detected voltages and outputs of the potential sensor 4 is determined on the assumption that the same residual potential C still remains on the surface of the photoreceptor drum 1 when the two reference bias voltages VA, VB are applied thereto, and there is obtained the second straight line Y2 which has the same inclination as that of the first straight line Y1 thus determined and which passes through the origin. Based on the second straight line Y2, the output of the potential sensor 4 is corrected. Accordingly, even though the output of the potential sensor 4 is corrected with residual charge still remaining on the surface of the photoreceptor drum 1 immediately after the completion of image formation or the like, the output of the potential sensor 4 can be corrected without any influence exerted by the residual potential.

The present invention should not be limited to the embodiment above-mentioned, but may be of course modified and changed without departing from the

scope of the invention.

In the embodiment above-mentioned, two reference bias voltages are applied to the photoreceptor drum 1 and the surface potentials of the photoreceptor drum 1 are measured by the potential sensor 4. However, three or more reference bias voltages VA, VB, VC, VD.... may be applied and surface potentials YA, YB, YC, YD.... of the photoreceptor drum 1 may be measured, so that the first straight line Y1 may be determined with the use of a least squares method. Then, there may be obtained the second straight line Y2 which has the same inclination as that of the first straight line Y1 thus determined and which passes through the origin.

In the embodiment above-mentioned, the description has been made of a laser printer taken as an example, but similar effects may be produced when the correcting apparatus of the present invention is applied to other image forming apparatus such as an electrophotographic copying apparatus, an electrophotographic facsimile or the like.

Claims

1. A potential sensor correcting apparatus for correcting the output of a potential sensor (4) adapted to detect the electric charge potential of a of a photoreceptor (1), characterised by:

   reference bias applying means (21, 22) for applying reference bias voltages to said photoreceptor (1);

   calculating means (23) for determining a first straight line (Y1) representing the relationship between the detected voltages and output characteristics of said potential sensor (4), based on the outputs of said potential sensor (4) supplied at the time when a plurality of different reference bias voltages are applied by said reference bias applying means (21, 22), and for obtaining a second straight line (Y2) which has the same inclination as that of said first straight line (Y1) thus determined and which passes through the origin; and

   correcting means (23) for correcting the output of said potential sensor (4) based on said second straight line (Y2) obtained by said calculating means (23).

2. A potential sensor correcting apparatus according to Claim 1, wherein the reference bias applying means includes low reference bias applying means (21) for applying a low reference bias voltage to the photoreceptor (1), and high reference bias applying means (22) for applying a high reference bias voltage to said photoreceptor (1).

3. A method of correcting the output of a potential sensor (4) adapted to detect the electric charge potential of a photoreceptor (1), characterised by the steps of:

   applying a plurality of different reference bias voltages to said photoreceptor (1);

   detecting the surface potentials of said photoreceptor (1);

   determining a first straight line (Y1) representing the relationship between the detected voltages and output characteristics of said potential sensor (4), based on the outputs of said potential sensor (4) supplied at the time when said reference bias voltages are applied;

   obtaining a second straight line (Y2) which has the same inclination as that of said first straight line (Y1) thus determined and which passes through the origin; and

   correcting the output of said potential sensor (4) based on said second straight line (Y2).

4. A potential sensor correcting method according to Claim 3, wherein the number of the plurality of different reference bias voltages to be applied to the photoreceptor (1) is two.

Fig. 1

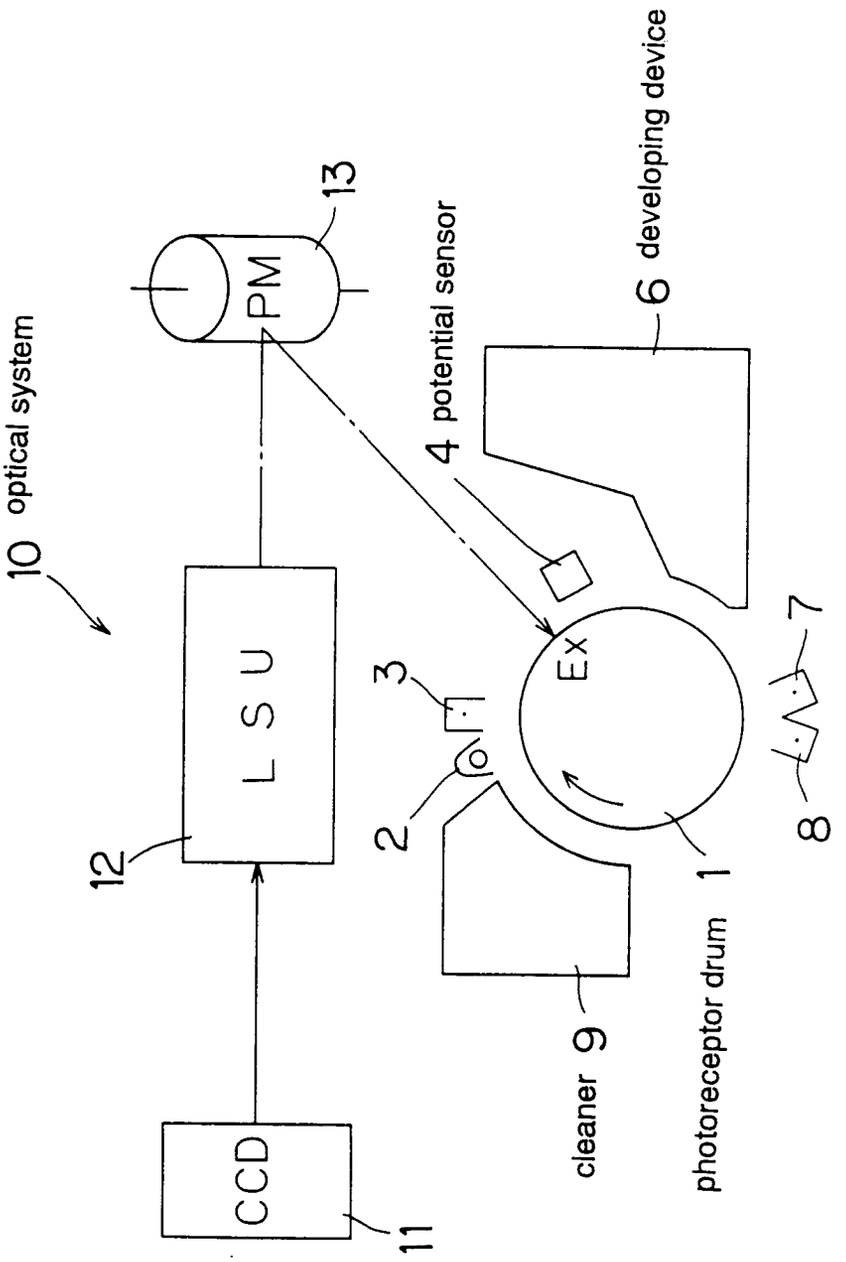

10 optical system
12
L S U
11
CCD
13
PM
4 potential sensor
6 developing device
3
2
Ex
1
8
7
cleaner 9
photoreceptor drum

Fig. 2

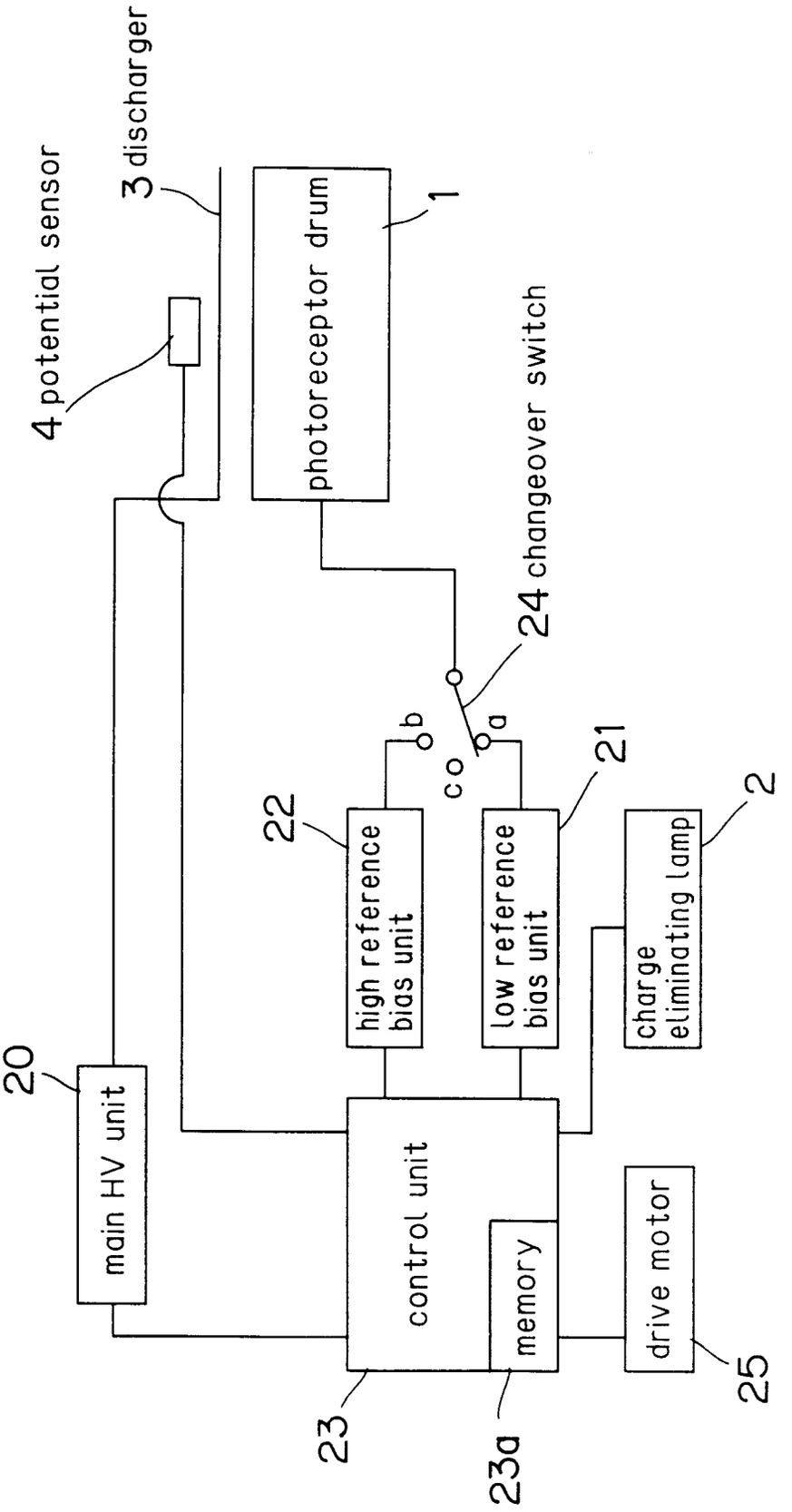
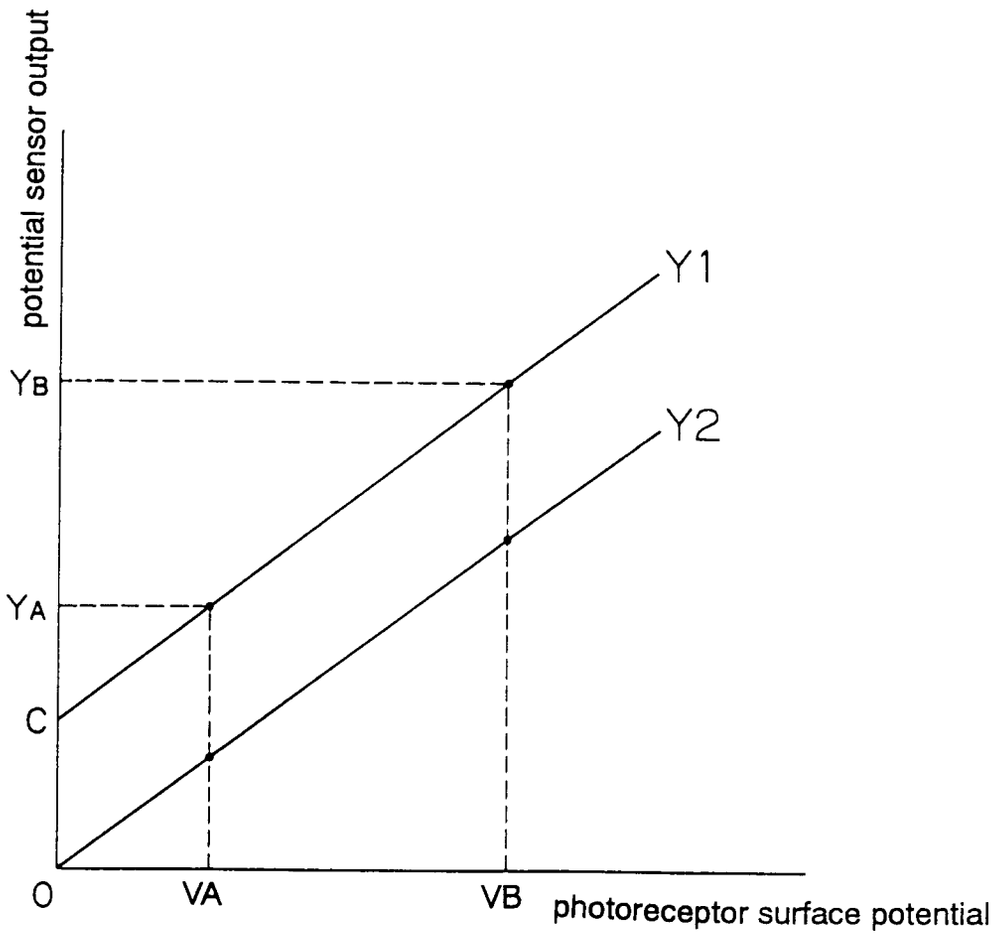

4 potential sensor
3 discharger
photoreceptor drum
1
24 changeover switch
b
a
c o
22
21
2
high reference bias unit
low reference bias unit
charge eliminating lamp
20
main HV unit
control unit
memory
drive motor
23
23a
25

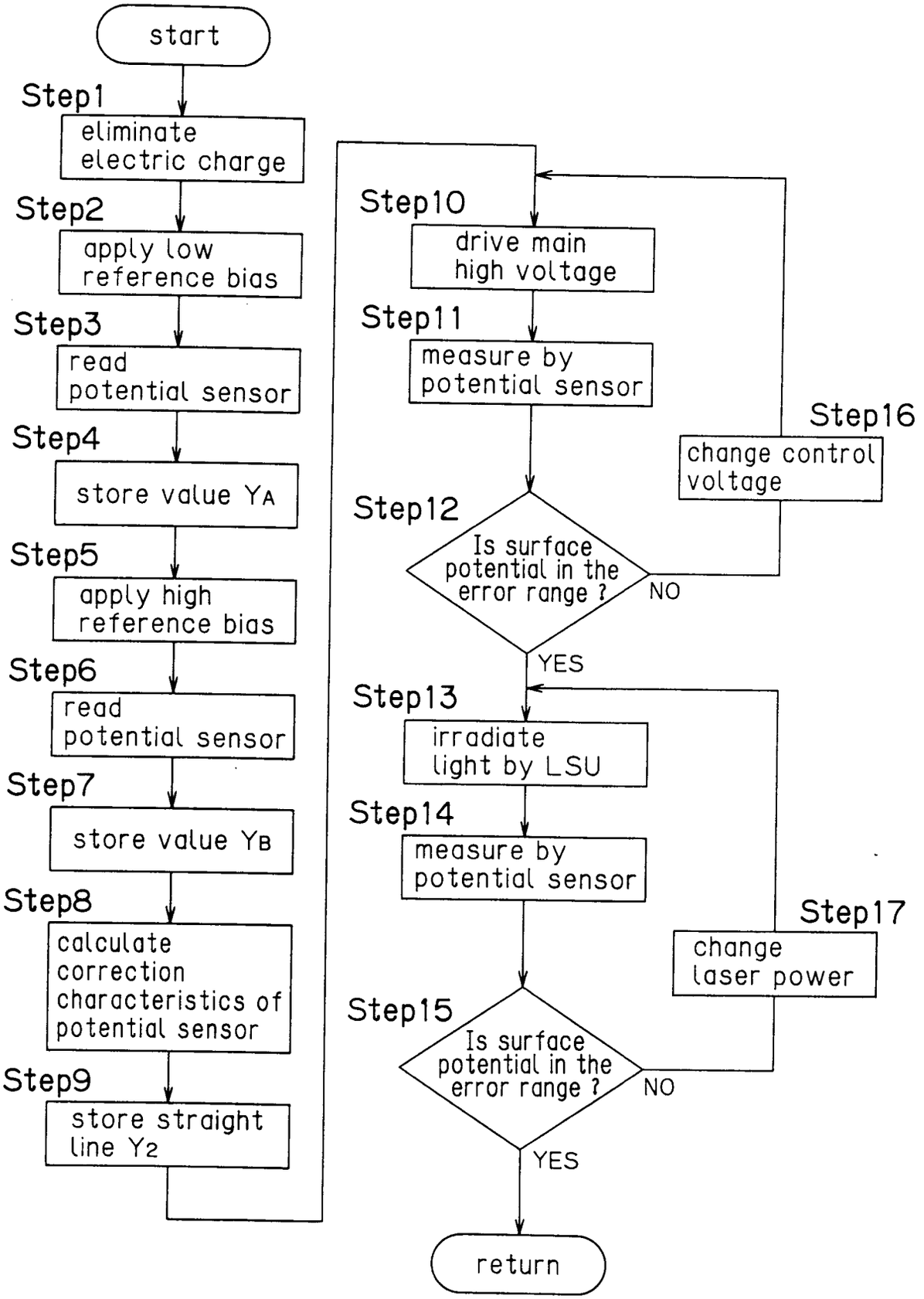
Fig. 3



VA : low reference bias (200V)

VB : high reference bias (600V)

Fig. 4


start
Step1
eliminate electric charge
Step2
apply low reference bias
Step3
read potential sensor
Step4
store value YA
Step5
apply high reference bias
Step6
read potential sensor
Step7
store value YB
Step8
calculate correction characteristics of potential sensor
Step9
store straight line Y2
Step10
drive main high voltage
Step11
measure by potential sensor
Step12
Is surface potential in the error range ?
NO
YES
Step16
change control voltage
Step13
irradiate light by LSU
Step14
measure by potential sensor
Step15
Is surface potential in the error range ?
NO
YES
Step17
change laser power
return