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(54) **IMAGE FORMING APPARATUS THAT CONTROLS CHARGING BIAS APPLIED TO CHARGER**

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G03G 15/06 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/065*** (2013.01); ***G03G 15/0266*** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/1675; G03G 21/14
See application file for complete search history.

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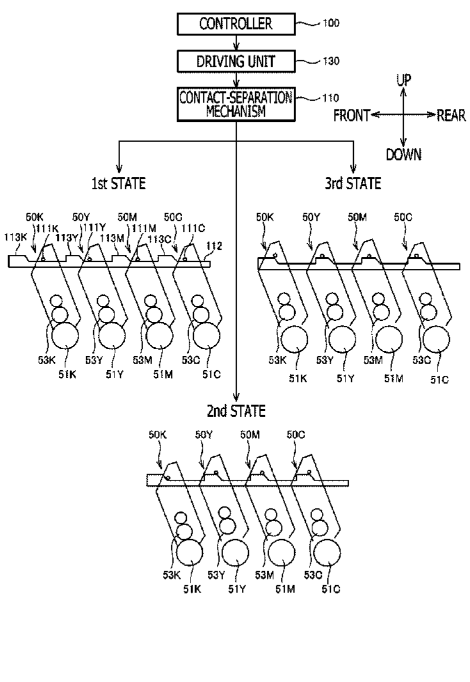
(57) **ABSTRACT**

An image forming apparatus includes a controller configured to apply a charging bias to a charger during image formation on a photoconductive body, an absolute value of the charging bias being a first absolute value. The controller applies a development bias to a development roller during the image formation, places the development roller in a development position during the image formation, after the image formation, reduces the absolute value of the charging bias to a second absolute value less than the first absolute value, after reducing the absolute value of the charging bias, separates the development roller away from the photoconductive body and places the development roller in a non-development position, and after placing the development roller in the non-development position, stops applying the development bias to the development roller.

19 Claims, 10 Drawing Sheets



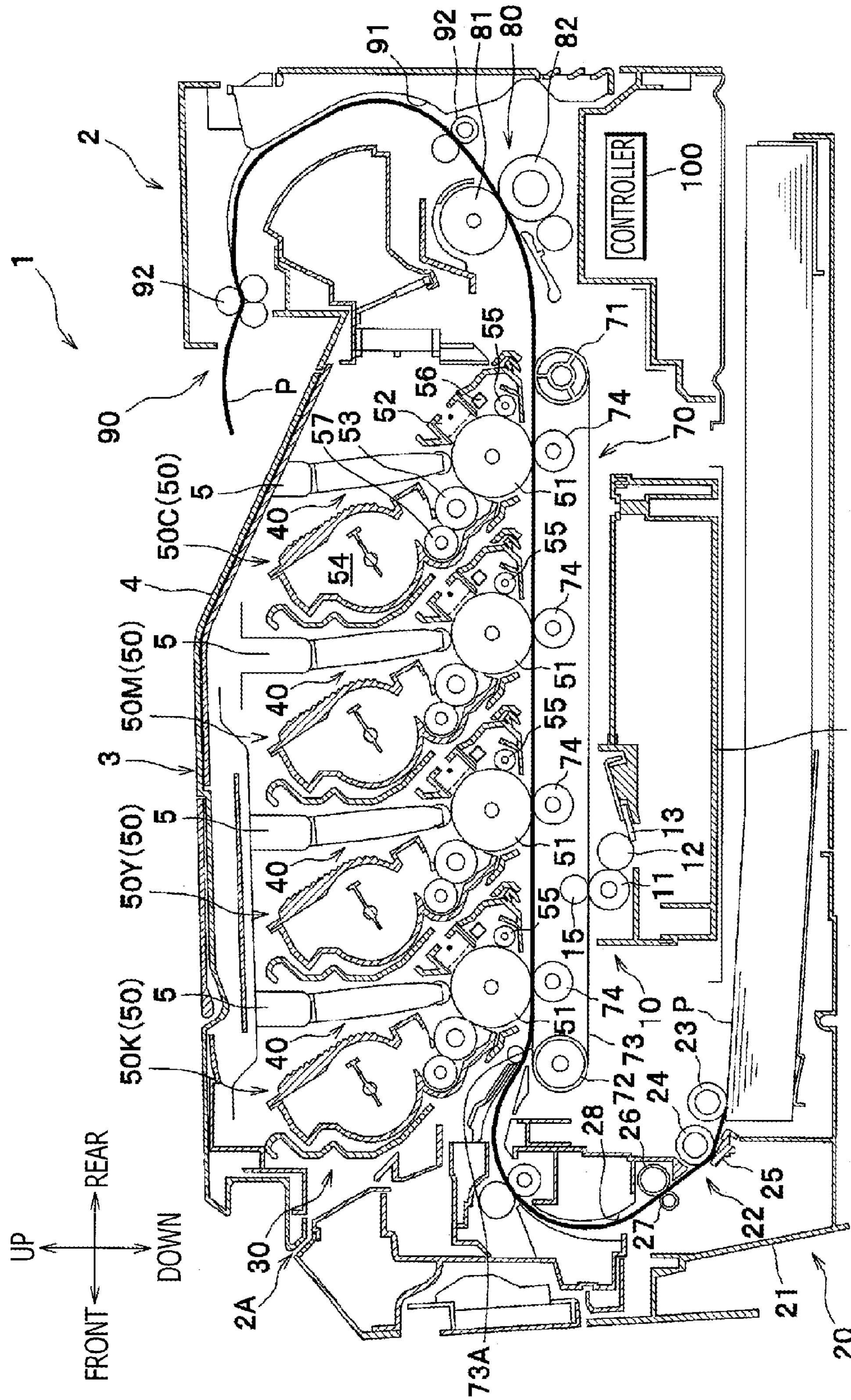

CONTROLLER
100
UP
DOWN
FRONT
REAR
1
2
2A
3
4
5
10
14
20
21
22
30
40
50K(50)
50Y(50)
50M(50)
50C(50)
51
54
70
71
73A
74
80
81
82
90
91
92
P

FIG. 1

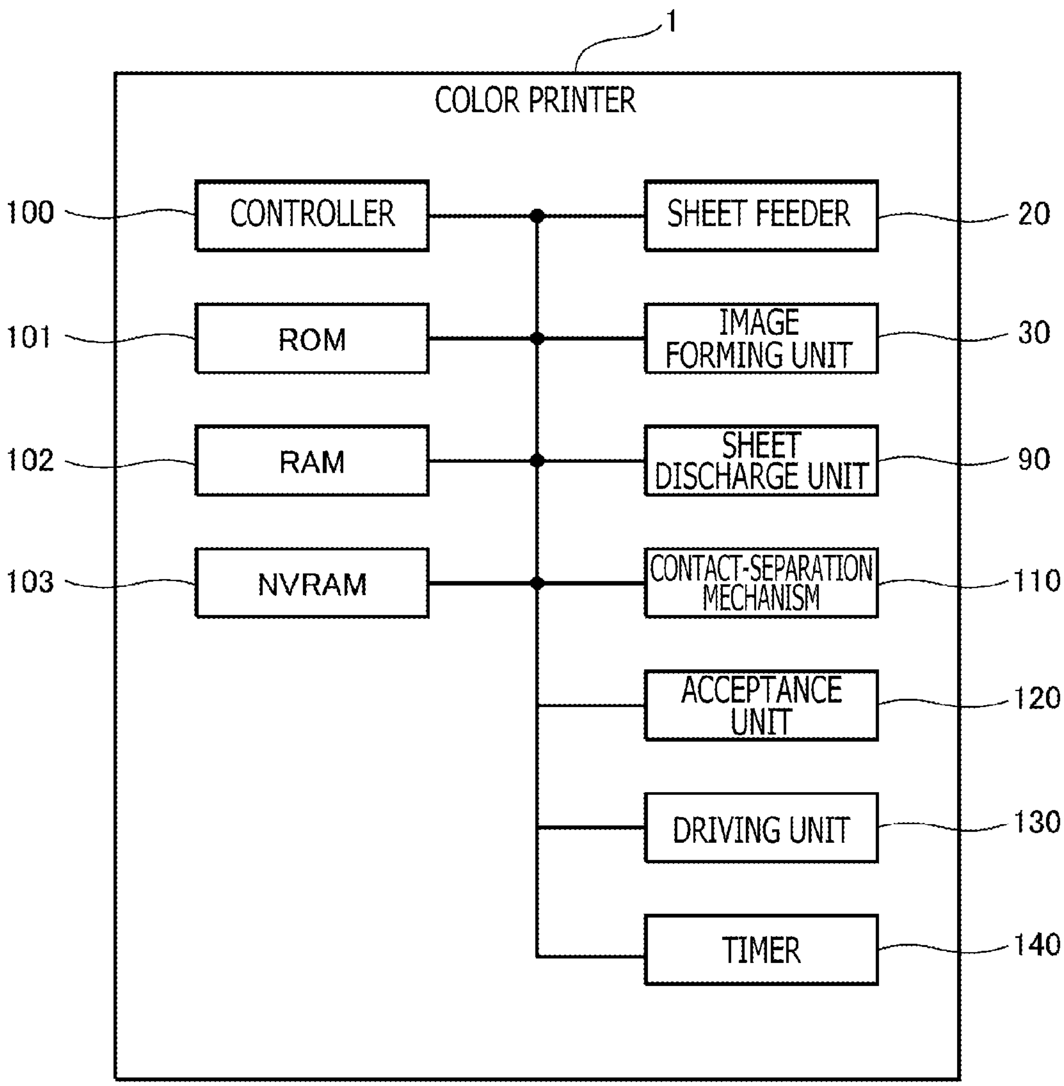

1
COLOR PRINTER
100
CONTROLLER
101
ROM
102
RAM
103
NVRAM
SHEET FEEDER
20
IMAGE FORMING UNIT
30
SHEET DISCHARGE UNIT
90
CONTACT-SEPARATION MECHANISM
110
ACCEPTANCE UNIT
120
DRIVING UNIT
130
TIMER
140

FIG. 2

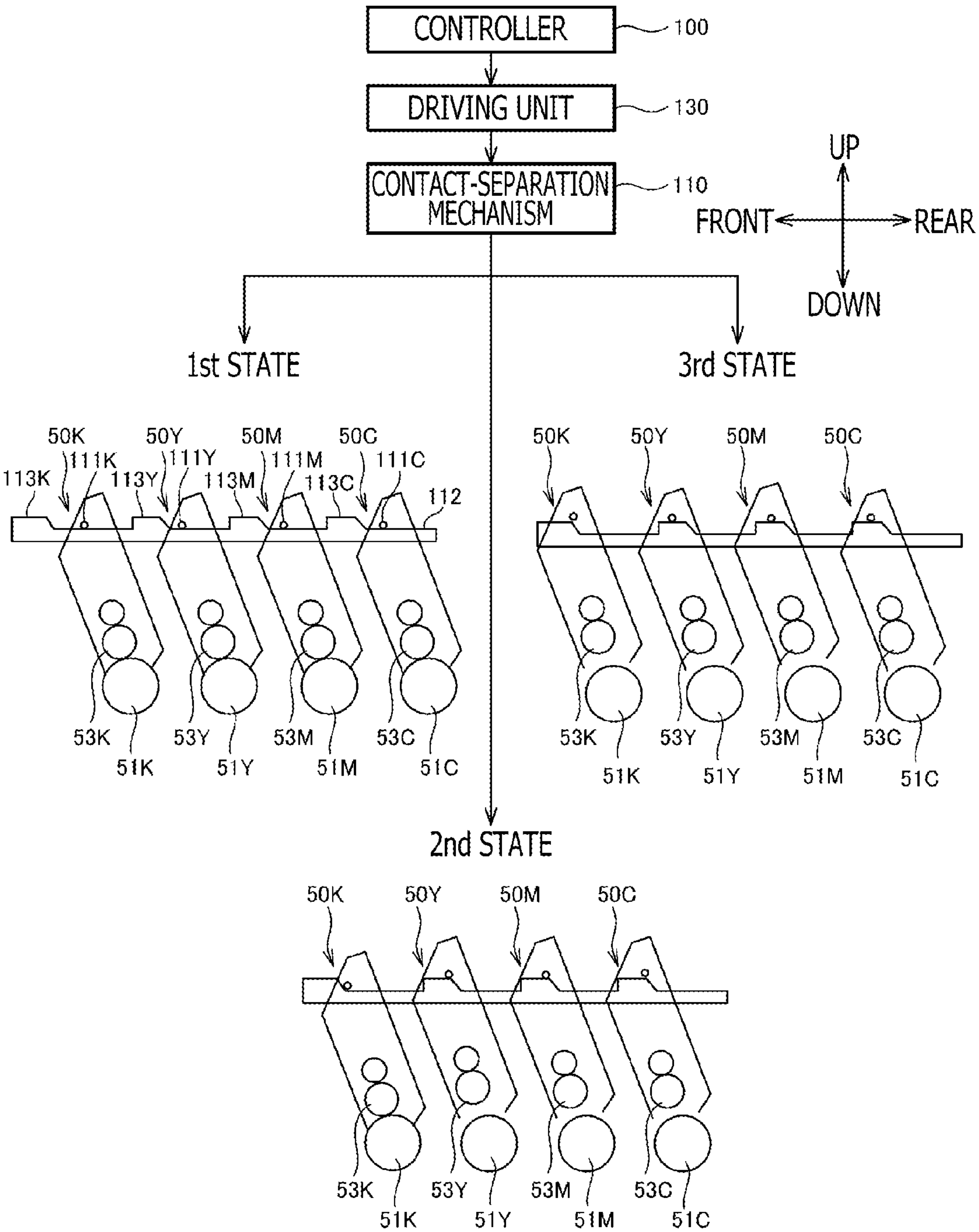

CONTROLLER
100
DRIVING UNIT
130
CONTACT-SEPARATION MECHANISM
110
UP
FRONT
REAR
DOWN
1st STATE
3rd STATE
2nd STATE
50K
50Y
50M
50C
111K
111Y
111M
111C
113K
113Y
113M
113C
112
53K
53Y
53M
53C
51K
51Y
51M
51C

FIG. 3

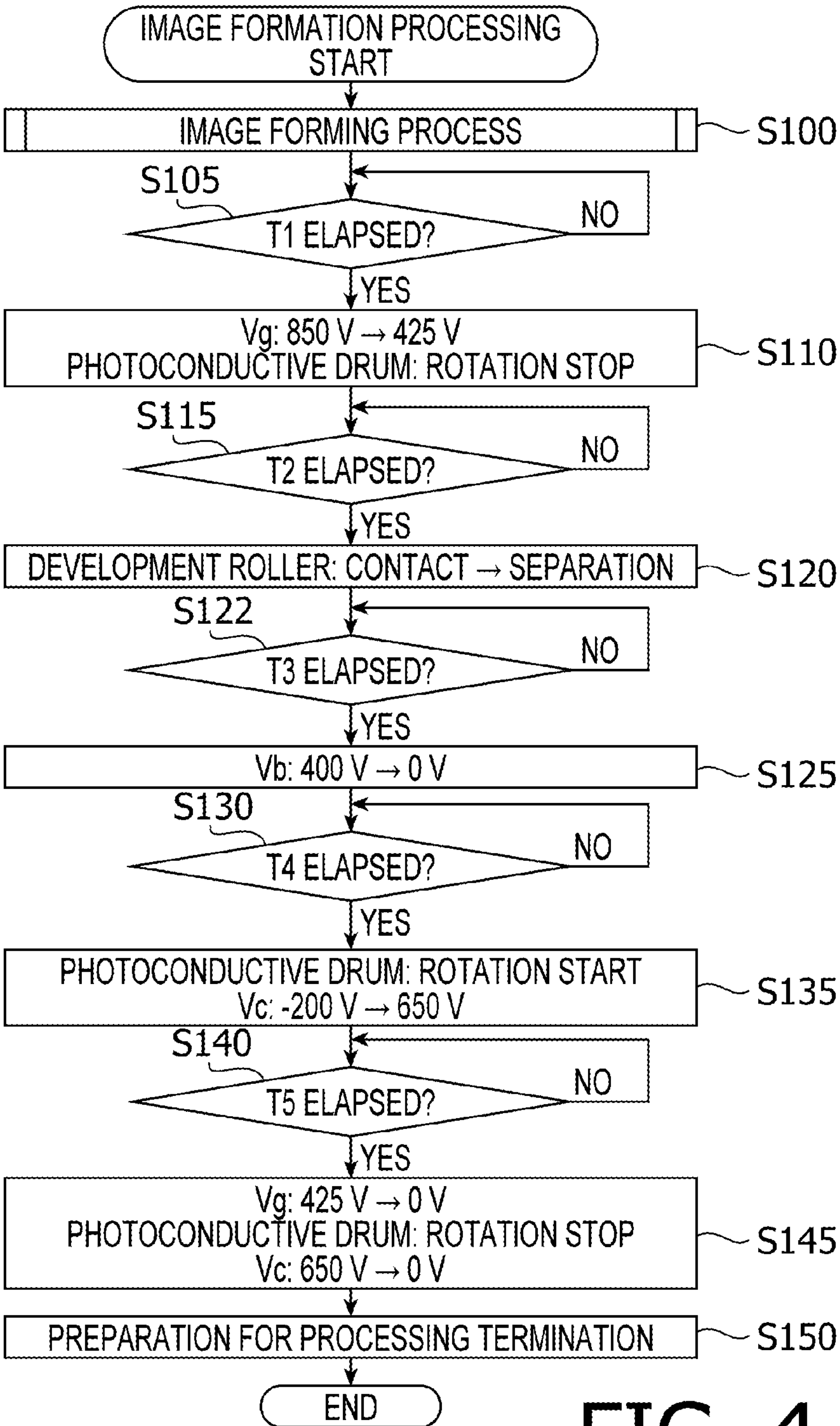


IMAGE FORMATION PROCESSING START
IMAGE FORMING PROCESS
S100
S105
T1 ELAPSED?
NO
YES
Vg: 850 V → 425 V
PHOTOCONDUCTIVE DRUM: ROTATION STOP
S110
S115
T2 ELAPSED?
NO
YES
DEVELOPMENT ROLLER: CONTACT → SEPARATION
S120
S122
T3 ELAPSED?
NO
YES
Vb: 400 V → 0 V
S125
S130
T4 ELAPSED?
NO
YES
PHOTOCONDUCTIVE DRUM: ROTATION START
Vc: -200 V → 650 V
S135
S140
T5 ELAPSED?
NO
YES
Vg: 425 V → 0 V
PHOTOCONDUCTIVE DRUM: ROTATION STOP
Vc: 650 V → 0 V
S145
PREPARATION FOR PROCESSING TERMINATION
S150
END

FIG. 4

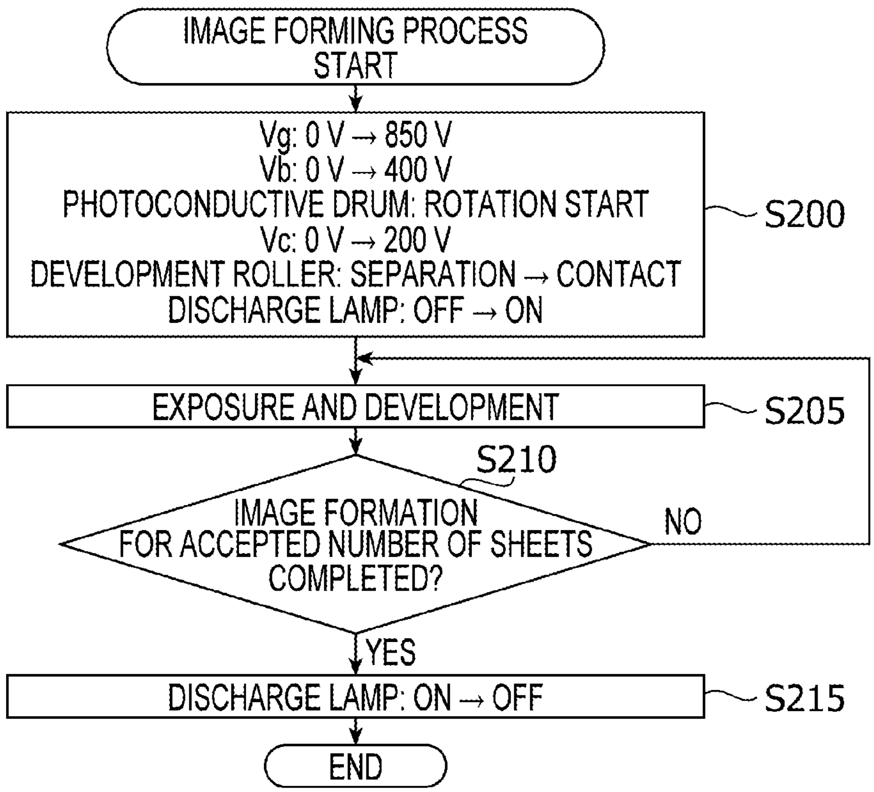
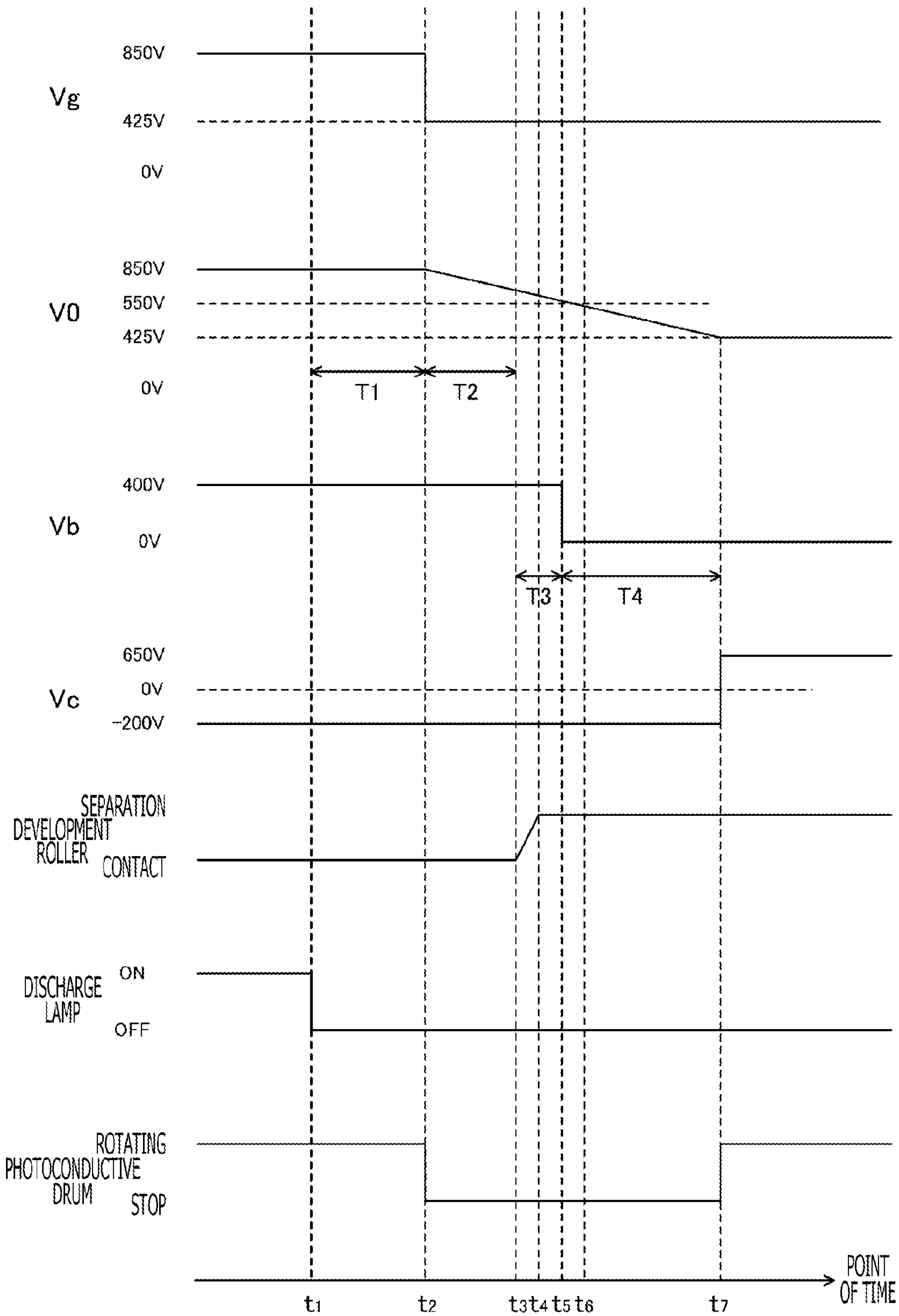


IMAGE FORMING PROCESS
START
Vg: 0 V → 850 V
Vb: 0 V → 400 V
PHOTOCONDUCTIVE DRUM: ROTATION START
Vc: 0 V → 200 V
DEVELOPMENT ROLLER: SEPARATION → CONTACT
DISCHARGE LAMP: OFF → ON
S200
EXPOSURE AND DEVELOPMENT
S205
S210
IMAGE FORMATION
FOR ACCEPTED NUMBER OF SHEETS
COMPLETED?
NO
YES
DISCHARGE LAMP: ON → OFF
S215
END

FIG. 5



850V
Vg
425V
0V
850V
550V
V0
425V
0V
T1
T2
400V
Vb
0V
T3
T4
650V
0V
Vc
-200V
SEPARATION
DEVELOPMENT ROLLER
CONTACT
DISCHARGE LAMP
ON
OFF
ROTATING
PHOTOCONDUCTIVE DRUM
STOP
t1 t2 t3 t4 t5 t6 t7
POINT OF TIME

FIG. 6

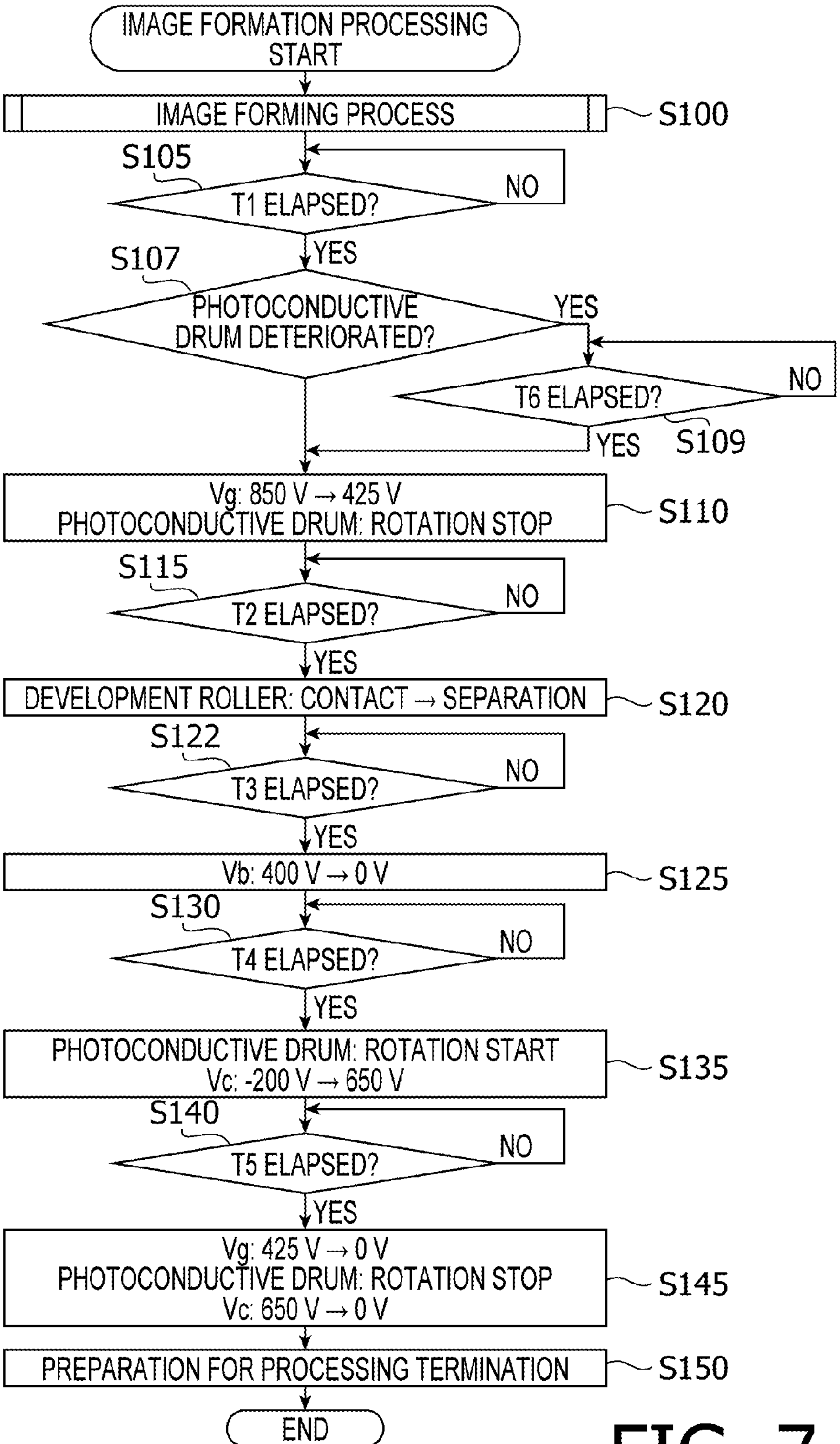
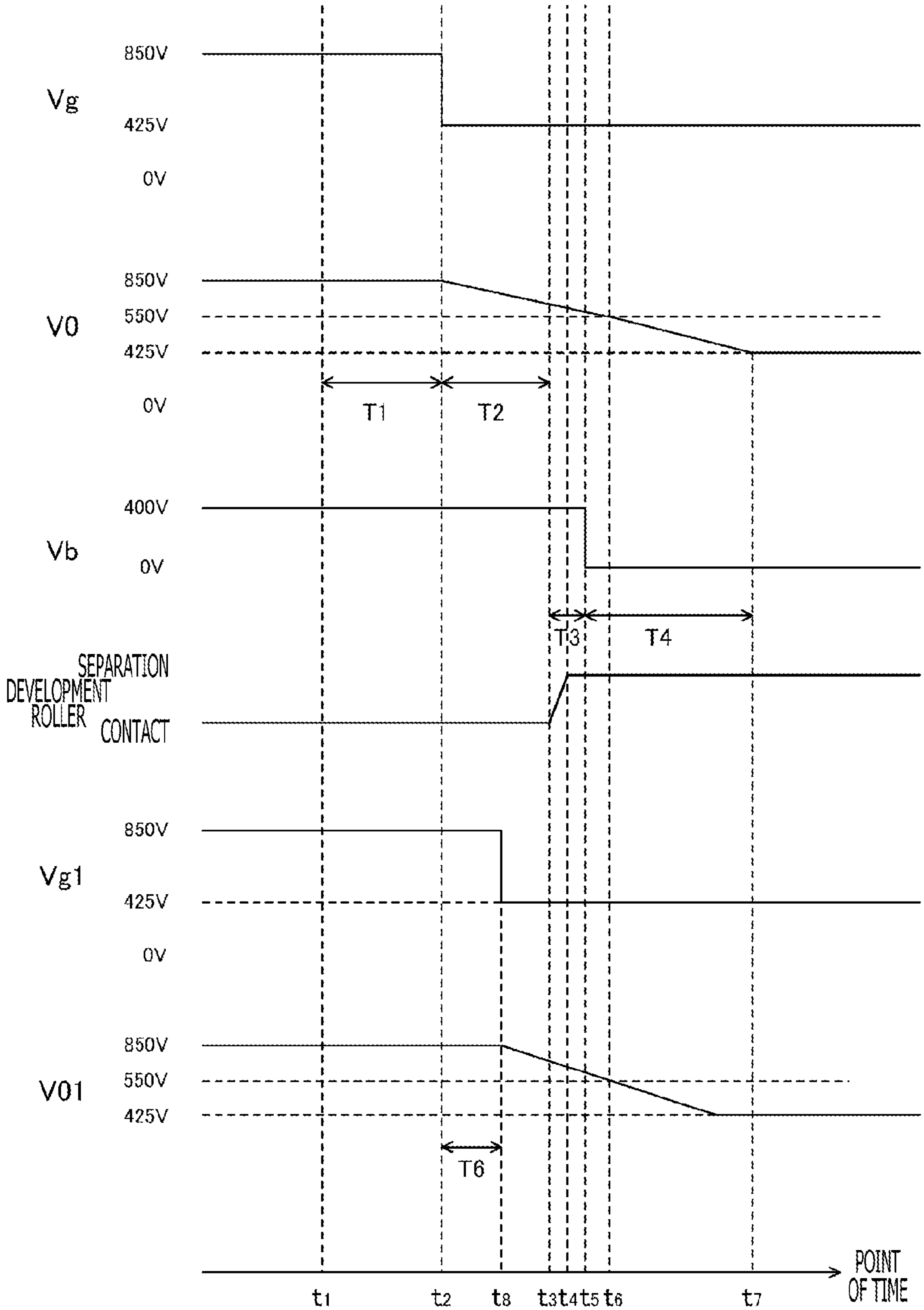


IMAGE FORMATION PROCESSING START
IMAGE FORMING PROCESS
S100
S105
T1 ELAPSED?
NO
YES
S107
PHOTOCONDUCTIVE DRUM DETERIORATED?
YES
T6 ELAPSED?
NO
YES
S109
Vg: 850 V → 425 V
PHOTOCONDUCTIVE DRUM: ROTATION STOP
S110
S115
T2 ELAPSED?
NO
YES
DEVELOPMENT ROLLER: CONTACT → SEPARATION
S120
S122
T3 ELAPSED?
NO
YES
Vb: 400 V → 0 V
S125
S130
T4 ELAPSED?
NO
YES
PHOTOCONDUCTIVE DRUM: ROTATION START
Vc: -200 V → 650 V
S135
S140
T5 ELAPSED?
NO
YES
Vg: 425 V → 0 V
PHOTOCONDUCTIVE DRUM: ROTATION STOP
Vc: 650 V → 0 V
S145
PREPARATION FOR PROCESSING TERMINATION
S150
END

FIG. 7



Vg
850V
425V
0V
V0
850V
550V
425V
0V
T1
T2
Vb
400V
0V
T3
T4
SEPARATION
DEVELOPMENT
ROLLER
CONTACT
Vg1
850V
425V
0V
V01
850V
550V
425V
T6
t1
t2
t8
t3
t4
t5
t6
t7
POINT
OF TIME

FIG. 8

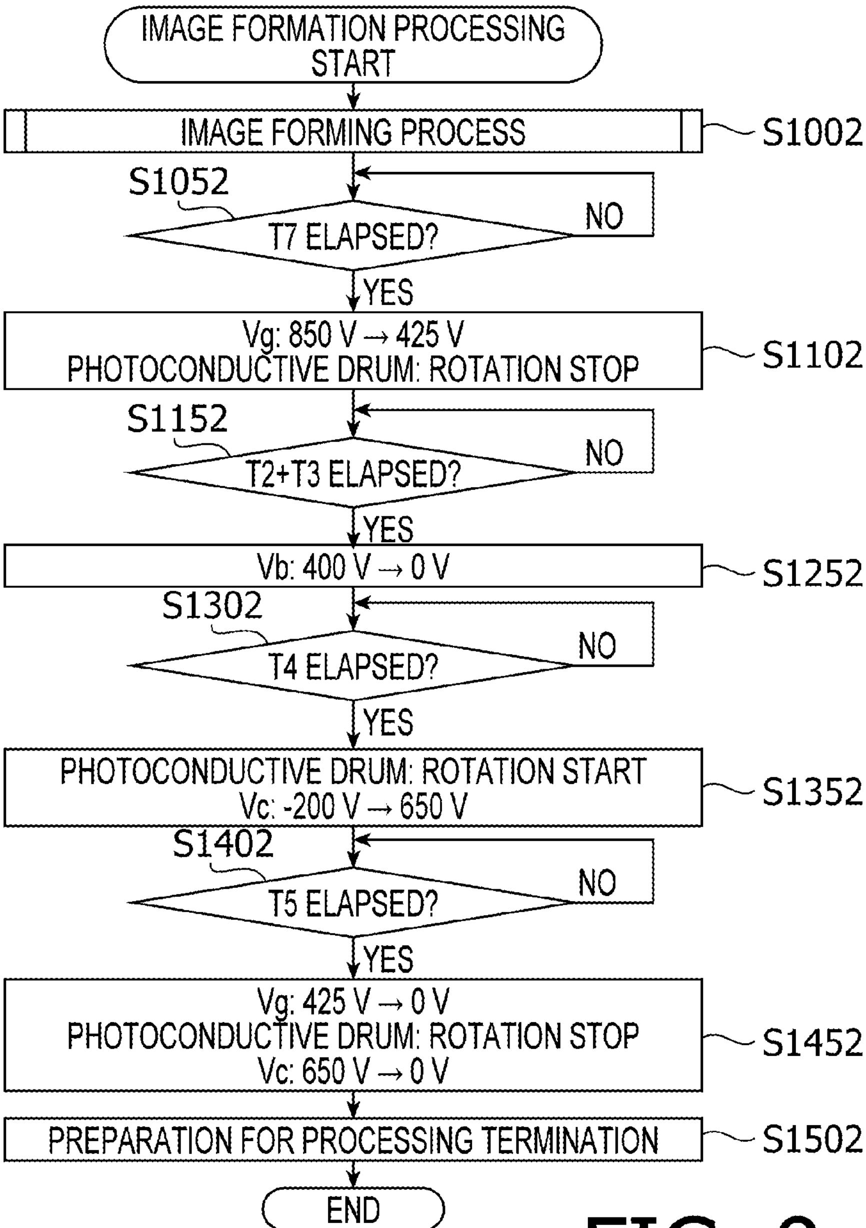


IMAGE FORMATION PROCESSING START
IMAGE FORMING PROCESS
S1002
S1052
T7 ELAPSED?
NO
YES
Vg: 850 V → 425 V
PHOTOCONDUCTIVE DRUM: ROTATION STOP
S1102
S1152
T2+T3 ELAPSED?
NO
YES
Vb: 400 V → 0 V
S1252
S1302
T4 ELAPSED?
NO
YES
PHOTOCONDUCTIVE DRUM: ROTATION START
Vc: -200 V → 650 V
S1352
S1402
T5 ELAPSED?
NO
YES
Vg: 425 V → 0 V
PHOTOCONDUCTIVE DRUM: ROTATION STOP
Vc: 650 V → 0 V
S1452
PREPARATION FOR PROCESSING TERMINATION
S1502
END

FIG. 9

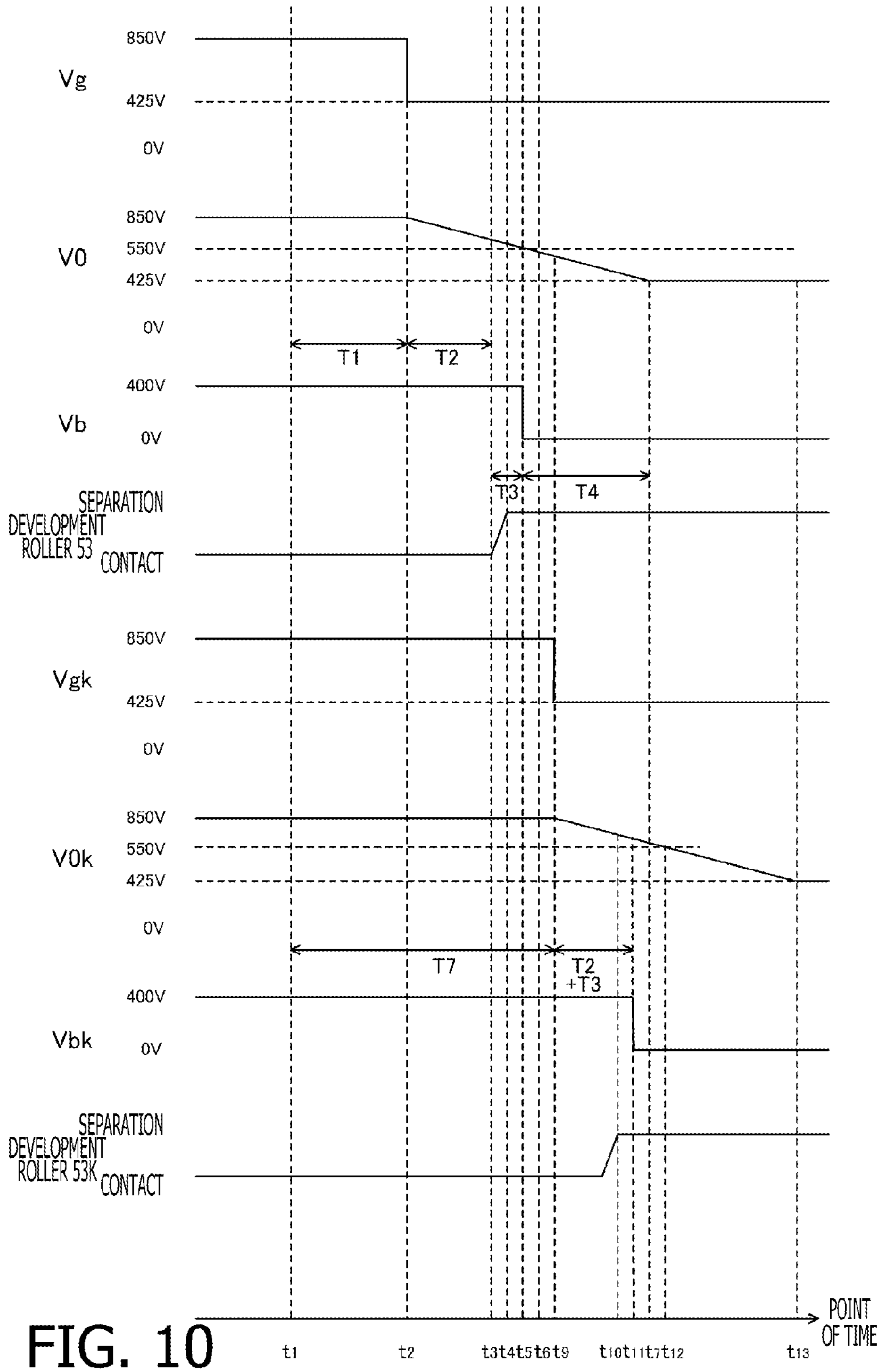

850V
Vg
425V
0V
850V
V0
550V
425V
0V
T1
T2
400V
Vb
0V
T3
T4
SEPARATION
DEVELOPMENT
ROLLER 53
CONTACT
850V
Vgk
425V
0V
850V
V0k
550V
425V
0V
T7
T2
+T3
400V
Vbk
0V
SEPARATION
DEVELOPMENT
ROLLER 53K
CONTACT
t1
t2
t3t4t5t6t9
t10t11t7t12
t13
POINT
OF TIME

FIG. 10

IMAGE FORMING APPARATUS THAT CONTROLS CHARGING BIAS APPLIED TO CHARGER

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority under 35 U.S.C. §119 from Japanese Patent Applications No. 2014-165721 filed on Aug. 18, 2014 and No. 2015-116309 filed on Jun. 9, 2015. The entire subject matters of the applications are incorporated herein by reference.

BACKGROUND

1. Technical Field

The following description relates to one or more techniques to control a charging bias to be applied to a charger of an image forming apparatus.

2. Related Art

So far, a technique to suppress deterioration of a photoconductive body has been known. In the known technique, the photoconductive body is prevented from being deteriorated, by reducing an amount of discharge current applied to a charger for charging the photoconductive body after image formation on the photoconductive body.

SUMMARY

However, when the amount of discharge current applied to the charging member is reduced, and additionally, application of a development bias to a development roller is stopped, so-called "fog" might be caused according to a difference between a surface potential of the photoconductive body and an electric charge amount of toner on the development roller. It is noted that the "fog" is a situation where toner on the development roller is transferred onto an unexposed portion on the photoconductive body.

Aspects of the present disclosure are advantageous to provide one or more improved techniques, for an image forming apparatus, which make it possible to prevent deterioration of a photoconductive body and occurrence of "fog."

According to aspects of the present disclosure, an image forming apparatus is provided, which includes an image forming unit including a photoconductive body, a charger configured to charge the photoconductive body, and a development roller, and a controller configured to apply a charging bias to the charger during image formation on the photoconductive body, an absolute value of the charging bias being a first absolute value, apply a development bias to the development roller during the image formation on the photoconductive body, place the development roller in a development position during the image formation on the photoconductive body, after the image formation on the photoconductive body, reduce the absolute value of the charging bias to a second absolute value less than the first absolute value, after reducing the absolute value of the charging bias, separate the development roller away from the photoconductive body and place the development roller in a non-development position, the non-development position being farther from the photoconductive body than the development position, and after placing the development roller in the non-development position, stop applying the development bias to the development roller.

According to aspects of the present disclosure, further provided is a method adapted to be implemented on a processor coupled with an image forming apparatus, the image forming apparatus including an image forming unit including a photoconductive body, a charger, and a development roller, the method including applying a charging bias to the charger during image formation on the photoconductive body, an absolute value of the charging bias being a first absolute value, applying a development bias to the development roller during the image formation on the photoconductive body, placing the development roller in a development position during the image formation on the photoconductive body, after the image formation on the photoconductive body, reducing the absolute value of the charging bias to a second absolute value less than the first absolute value, after reducing the absolute value of the charging bias, separating the development roller away from the photoconductive body and placing the development roller in a non-development position, the non-development position being farther from the photoconductive body than the development position, and after placing the development roller in the non-development position, stopping applying the development bias to the development roller.

According to aspects of the present disclosure, further provided is a non-transitory computer-readable medium storing computer-readable instructions that are executable by a processor coupled with an image forming apparatus, the image forming apparatus including an image forming unit including a photoconductive body, a charger, and a development roller, the instructions being configured to, when executed by the processor, cause the processor to apply a charging bias to the charger during image formation on the photoconductive body, an absolute value of the charging bias being a first absolute value, apply a development bias to the development roller during the image formation on the photoconductive body, place the development roller in a development position during the image formation on the photoconductive body, after the image formation on the photoconductive body, reduce the absolute value of the charging bias to a second absolute value less than the first absolute value, after reducing the absolute value of the charging bias, separate the development roller away from the photoconductive body and place the development roller in a non-development position, the non-development position being farther from the photoconductive body than the development position, and after placing the development roller in the non-development position, stop applying the development bias to the development roller.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

FIG. **1** is a cross-sectional side view showing a color printer in an illustrative embodiment according to one or more aspects of the present disclosure.

FIG. **2** is a block diagram schematically showing an electrical configuration of the color printer in the illustrative embodiment according to one or more aspects of the present disclosure.

FIG. **3** illustrates a mechanism for separating development rollers away from photoconductive drums in the illustrative embodiment according to one or more aspects of the present disclosure.

FIG. **4** is a flowchart showing a procedure of image formation processing to be executed by the color printer in the illustrative embodiment according to one or more aspects of the present disclosure.

FIG. **5** is a flowchart showing a procedure of an image forming process to be executed in the image formation processing in the illustrative embodiment according to one or more aspects of the present disclosure.

FIG. **6** is a timing chart showing timings to control elements of the color printer during a period of time between when the image forming process is completed and when cleaning control is performed, in the illustrative embodiment according to one or more aspects of the present disclosure.

FIG. **7** is a flowchart (different from FIG. **4**) showing a procedure of image formation processing to be executed by the color printer in the illustrative embodiment according to one or more aspects of the present disclosure.

FIG. **8** is a timing chart (different from FIG. **6**) showing timings to control elements of the color printer during the period of time between when the image forming process is completed and when the cleaning control is performed, in the illustrative embodiment according to one or more aspects of the present disclosure.

FIG. **9** is a flowchart (different from FIGS. **4** and **7**) showing a procedure of image formation processing to be executed by the color printer in the illustrative embodiment according to one or more aspects of the present disclosure.

FIG. **10** is a timing chart (different from FIGS. **6** and **8**) showing timings to control elements of the color printer during the period of time between when the image forming process is completed and when the cleaning control is performed, in the illustrative embodiment according to one or more aspects of the present disclosure.

DETAILED DESCRIPTION

It is noted that various connections are set forth between elements in the following description. It is noted that these connections in general and, unless specified otherwise, may be direct or indirect and that this specification is not intended to be limiting in this respect. Aspects of the present disclosure may be implemented on circuits such as application specific integrated circuits or in computer software as programs storable on computer-readable media including but not limited to RAMs, ROMs, flash memories, EEPROMs, CD-media, DVD-media, temporary storage, hard disk drives, floppy drives, permanent storage, and the like.

Hereinafter, an illustrative embodiment according to aspects of the present disclosure will be described with reference to the accompanying drawings. In the following description, each side of an apparatus (i.e., a color printer **1**) will be defined as follows. In FIG. **1**, a left-hand side and a right-hand side of the figure will be defined as a front side and a rear side of the apparatus, respectively. Further, a vertical direction of the figure will be defined as a vertical direction of the apparatus.

As shown in FIG. **1**, the color printer **1** includes, inside a main body **2** thereof, a sheet feeder **20**, an image forming unit **30**, a sheet discharge unit **90**, and a controller **100**. The sheet feeder **20** is configured to feed sheets P. The image forming unit **30** is configured to form images on the sheets P fed from the sheet feeder **20**. The sheet discharge unit **90** is configured to discharge the sheets P with the images formed thereon.

At an upper portion of the main body **2**, an opening **2**A is formed. The opening **2**A is open and closed responsive to rotation of an upper cover **3** that is rotatably supported by the main body **2**. A discharge tray **4** is disposed on an upper surface of the upper cover **3**. The discharge tray **4** is configured to receive the sheets P discharged out of the main body **2**. Further, on a lower surface of the upper cover **3**, a plurality of LED attachment members **5** are disposed. Each LED attachment member **5** is configured to support a corresponding one of LED units **40**.

The sheet feeder **20** includes a feed tray **21** and a sheet feeding mechanism **22**. The feed tray **21** is disposed at a lower portion inside the main body **2**. The feed tray **21** is detachably attached to the main body **2**. The sheet feeding mechanism **22** is configured to convey the sheets P from the feed tray **21** to the image forming unit **30**. The sheet feeding mechanism **22** is disposed in front of the feed tray **21**. The sheet feeding mechanism **22** includes a pickup roller **23**, a separation roller **24**, and a separation pad **25**.

In the sheet feeder **20**, the sheets P in the feed tray **21** are conveyed upward after separated on a sheet-by-sheet basis. Then, the sheets P pass between a paper dust removing roller **26** and a pinch roller **27**. In this process, paper dust is removed from the sheets P. Thereafter, the sheets P are conveyed along a conveyance path **28** and turned around rearward. Thus, the sheets P are supplied to the image forming unit **30**.

The image forming unit **30** includes four LED units **40**, four process cartridges **50**, a transfer unit **70**, a cleaning unit **10**, and a fuser unit **80**.

Each LED unit **40** is swingably attached to a corresponding one of the LED attachment members **5**. Each LED unit **40** includes an LED array having a plurality of LEDs arranged. Each LED unit **40** is configured to expose a corresponding one of below-mentioned photoconductive drums **51** by emitting light toward the photoconductive drum **51**.

The process cartridges **50** are arranged along a front-to-rear direction, between the upper cover **3** and the sheet feeder **20**. Each process cartridge **50** includes a photoconductive drum **51**, a charger **52**, a development roller **53**, a toner container **54** configured to store toner, a cleaning roller **55**, and a discharge lamp **56**.

The process cartridges **50** include a process cartridge **50**K storing black toner, a process cartridge **50**Y storing yellow toner, a process cartridge **50**M storing magenta toner, and a process cartridge **50**C storing cyan toner. The process cartridges **50**K, **50**Y, **50**M, and **50**C are arranged in this order from an upstream end in a conveyance direction of the sheets P. It is noted that the conveyance direction is a moving direction of a below-mentioned belt surface, i.e., a direction rearward from the front. In the present disclosure, a particular element (e.g., a photoconductive drum **51**, a development roller **53**, and a cleaning roller **55**) corresponding to a particular color of toner is identified by a reference character provided thereto, which is a corresponding one of reference characters "K," "Y," "M," and "C" representing black, yellow, magenta, and cyan, respectively.

As described above, each of the four process cartridges **50** includes a corresponding photoconductive drum **51**. As the plurality of process cartridges **50** are arranged in line along the front-to-rear direction, the plurality of photoconductive drums **51** are arranged in line along the front-to-rear direction.

As described above, each of the four process cartridges **50** includes a corresponding charger **52**. The plurality of chargers **52** are provided corresponding to the plurality of photoconductive drums **51**, respectively. As will be described in detail below, each charger **52** is configured to, when a charging bias Vg is applied thereto, charge the corresponding photoconductive drum **51**. In the illustrative embodiment, the charger **52** is a scorotron charger having a charging wire and a grid. The charging bias Vg is applied to the grid. A surface potential of the photoconductive drum **51** corresponds to a potential of the grid. Namely, the charging bias Vg is for controlling the surface potential of the photoconductive drum **51**.

As will be described in detail below, each development roller **53** is configured to contact a corresponding one of the photoconductive drums **51** and supply toner to an electrostatic latent image on the corresponding photoconductive drum **51**. In the illustrative embodiment, when toner is supplied from the development roller **53** to the photoconductive drum **51**, the toner is positively charged by friction between the development roller **53** and a supply roller **57**.

Each cleaning roller **55** is disposed adjacent to a corresponding one of the photoconductive drums **51**. Each cleaning roller **55** is configured to, when a cleaning bias Vc is applied thereto, temporarily hold (retrieve) at least a part of toner adhering onto the photoconductive drum **51**. In the illustrative embodiment, in order to allow the cleaning roller **55** to temporarily hold at least a part of the toner adhering onto the photoconductive drum **51**, the cleaning bias Vc needs to have a negative polarity opposite to the polarity of the toner. Thereby, the toner is more easily transferred from the positively charged photoconductive drum **51** to the cleaning roller **55**.

For instance, each discharge lamp **56** includes a light source such as an LED. Each discharge lamp **56** is configured to, when turned on, emit light toward the corresponding photoconductive drum **51** and remove electric charges on the photoconductive drum **51**. The discharge lamp **56** is disposed downstream of the transfer unit **70** in a rotational direction of the photoconductive drum **51**. Therefore, the discharge lamp **56** removes electric charges that remain on the photoconductive drum **51** after a transferring operation to transfer a toner image on the photoconductive drum **51** onto a sheet P. Thus, the discharge lamp **56** has a function to prevent electric charges remaining on the photoconductive drum **51** from having an influence on a next electrostatic latent image or appearing on an image finally formed on a sheet P.

The transfer unit **70** is disposed between the sheet feeder **20** and each process cartridge **50**. The transfer unit **70** includes a driving roller **71**, a driven roller **73**, and a transfer roller **74**.

The driving roller **71** and the driven roller **72** are spaced apart from each other in the front-to-rear direction. An endless conveyance belt **73** is wound around the driving roller **71** and the driven roller **72**. The conveyance belt **73** has a belt surface **73**A that is an outer surface opposed to and in contact with the plurality of photoconductive drums **51**. The conveyance belt **73** is configured to be turned by the driving roller **71** such that the belt surface **73**A moves along an arrangement direction (i.e., the front-to-rear direction) of the photoconductive drums **51**. Further, there are four transfer rollers **74** disposed inside a region surrounded by the conveyance belt **73**. Each transfer roller **74** is opposed to a corresponding one of the photoconductive drums **51** across the conveyance belt **73**. In other words, the conveyance belt **73** is pinched between each transfer roller **74** and the corresponding photoconductive drum **51**. In the transferring operation, each transfer roller **74** is supplied with a transfer bias under constant current control.

The cleaning unit **10** is configured to slide in contact with the conveyance belt **73** and retrieve toner adhering onto the conveyance belt **73**. The cleaning unit **10** is disposed below the conveyance belt **73**. Specifically, the cleaning unit **10** includes a sliding contact roller **11**, a retrieval roller **12**, a blade **13**, and a waste toner container **14**.

The sliding contact roller **11** is disposed to contact an outer circumferential surface of the conveyance belt **73**. When a retrieval bias is applied between the sliding contact roller **11** and a backup roller **15**, the sliding contact roller **11** retrieves substance (e.g., toner) adhering onto the conveyance belt **73**. The backup roller **15** is disposed to contact an inner circumferential surface of the conveyance belt **73** and face the sliding contact roller **11** across the conveyance belt **73**.

The retrieval roller **12** is disposed to contact the sliding contact roller **11**. The retrieval roller **12** is configured to retrieve substance (e.g., toner) adhering onto the sliding contact roller **11**. Substance adhering onto the retrieval roller **12** is scraped by the blade **13** disposed to slide in contact with the retrieval roller **12**, and is put into the waste toner container **14**.

According to the cleaning roller **55**, the transfer unit **70**, and the cleaning unit **10**, it is possible to perform cleaning control to retrieve, into the waste toner container **14**, the toner temporarily held by the cleaning roller **55**. In a specific procedure, firstly, when a positive cleaning bias Vc higher than the charging bias Vg is applied to the cleaning roller **55**, the toner on the cleaning roller **55** is again transferred onto the photoconductive drum **51**. Subsequently, for instance, when a negative transfer bias is applied to the transfer unit **70**, the toner on the photoconductive drum **51** is transferred onto the conveyance belt **73**. Then, as described above, the toner on the conveyance belt **73** is retrieved into the waste toner container **14** by the cleaning unit **10**.

The fuser unit **80** is disposed behind the plurality of process cartridges **50** and the transfer unit **70**. The fuser unit **80** includes a heating roller **81** and a pressing roller **82**. The pressing roller **82** is disposed to face the heating roller **81** and configured to press the heating roller **81**.

In the image forming unit **30** configured as above, firstly, when the charging bias Vg is applied to each charger **52**, the surface of each photoconductive drum **51** is evenly and positively charged. Thereafter, the surface of each photoconductive drum **51** is exposed by each LED unit **40**. Thereby, an electric potential of an exposed portion of the surface of each photoconductive drum **51** becomes lower, and an electrostatic latent image based on image data is formed on each photoconductive drum **51**. After that, when positively-charged toner is supplied from each development roller **53** to the electrostatic latent image on each photoconductive drum **51**, a toner image is carried on each photoconductive drum **51**.

A sheet P fed onto the conveyance belt **73** passes between each photoconductive drum **51** and a corresponding one of the transfer rollers **74** disposed inside the region surrounded by the conveyance belt **73**. Thereby, the toner image formed on each photoconductive drum **51** is transferred onto the sheet P. Then, when the sheet P passes between the heating roller **81** and the pressing roller **82**, the toner transferred onto the sheet P is thermally fixed.

The sheet discharge unit **90** includes a discharge path **91** and a plurality of pairs of conveyance rollers **92**. The discharge path **91** is formed to extend upward from an exit of the fuser unit **80** and be turned around frontward. The sheet P with the toner image transferred and thermally fixed thereon is conveyed along the discharge path **91** by the conveyance rollers **92**, discharged out of the main body **2**, and put on the discharge tray **4**.

Next, an electrical configuration of the color printer **1** will be described. As shown in FIG. **2**, the color printer **1** includes the controller **100**, a ROM **101**, a RAM **102**, and an NVRAM (which is an abbreviation form of "Non-volatile

RAM") **103**. Further, the color printer **1** includes the sheet feeder **20**, the image forming unit **30**, the sheet discharge unit **90**, a contact-separation mechanism **110**, an acceptance unit **120**, a driving unit **130**, and a timer **140**. The aforementioned elements included in the color printer **1** are electrically connected with the controller **100**.

The ROM **101** stores control programs, setting values, and initial values to control the color printer **1**. The RAM **102** is used as a work area into which the control programs are loaded, or as a storage area for temporarily storing data. The controller **100** controls each of elements included in the color printer **1** while storing processing results into the RAM **102** or the NVRAM **103**, in accordance with the control programs loaded from the ROM **101**.

When controlled by the controller **100**, the sheet feeder **20**, the image forming unit **30**, and the sheet discharge unit **90** perform image forming on the sheets P in the aforementioned manner. In particular, the chargers **52**, the development rollers **53**, and the cleaning rollers **55** are supplied with the charging bias Vg, a development bias Vb, and the cleaning bias Vc, respectively. In addition, the discharge lamp **56** is turned on and off under control by the controller **100**.

Further, as shown in FIG. **3**, when the contact-separation mechanism **110** is controlled by the controller **100**, each development roller **53** is positioned close to or spaced apart from the corresponding photoconductive drum **51**. The operations will be described in detail below.

As shown in FIG. **3**, projections **111**K, **111**Y, **111**M, and **111**C are provided at upper portions of the process cartridges **50**K, **50**Y, **50**M, and **50**C, respectively. Each projection **111** is disposed substantially in the same position relative to a corresponding one of the process cartridges **50**. The contact-separation mechanism **110** includes a translation cam **112**. In a side view as shown in FIG. **3**, the translation cam **112** extends in the front-to-rear direction across each of the process cartridges **50**K, **50**Y, **50**M, and **50**C. The translation cam **112** includes pushing-up portions **113**K, **113**Y, **113**M, and **113**C, which correspond to the projections **111**K, **111**Y, **111**M, and **111**C, respectively. In the illustrative embodiment, when each pushing-up portion **113** is positioned in front of a corresponding one of the projections **111**, each development roller **53** is in a first state to contact the corresponding photoconductive drum **51**. From this state, when the translation cam **112** is driven and moved rearward by the driving unit **130**, each projection **111** is pushed up by the corresponding pushing-up portion **113**, and each development roller **53** is also lifted up. Namely, each development roller **53** is brought into a state separated upward from the corresponding photoconductive drum **51**.

Than the pushing-up portions **113**Y, **113**M, and **113**C are positioned ahead of the projections **111**Y, **111**M, and **111**C, respectively, the pushing-up portion **113**K is positioned further ahead of the corresponding projection **111**K. Namely, when the translation cam **112** is driven and moved rearward by the driving unit **130**, firstly, the development rollers **53**Y, **53**M, and **53**C are separated away from the photoconductive drums **51**Y, **51**M, and **51**C, respectively. Subsequently, the development roller **53**K is separated away from the photoconductive drum **51**K.

By the contact-separation mechanism **110**, the first state (e.g., for color printing) is changed to a third state (e.g., for cleaning control) via a second state (e.g., for monochrome printing). It is noted that the first state is a state where all the development rollers **53** K, **53**Y, **53**M, and **53**C are in contact with the photoconductive drums **51**K, **51**Y, **51**M, and **51**C, respectively. In addition, the second state is a state where the development roller **53**K for black (i.e., for monochrome) is only in contact with the photoconductive drum **51**K, and the development rollers **53**Y, **53**M, and **53**C for the other three colors are separated away from the photoconductive drums **51**Y, **51**M, and **51**C, respectively. Further, the third state is a state where all the development rollers **53** K, **53**Y, **53**M, and **53**C are separated away from the photoconductive drums **51**K, **51**Y, **51**M, and **51**C, respectively.

The acceptance unit **120** is configured to accept an image forming instruction to instruct the color printer **1** to perform image formation. For instance, the acceptance unit **120** includes hardware that communicates with devices connected with the color printer **1** via a LAN cable and/or a USB cable. Further, the acceptance unit **120** includes a liquid crystal display (hereinafter, which may be referred to as an "LCD" in an abbreviation form) and various operable members such as a start key, a stop key, and a numeric keypad. The acceptance unit **120** is configured to show various kinds of displays to a user and accept an entry of a user instruction.

The driving unit **130** is configured to, when controlled by the controller **100**, transmit a driving force to the sheet feeder **20**, the image forming unit **30**, the sheet discharge unit **90**, and the contact-separation mechanism **110**. In particular, each photoconductive drum **51** is controlled to rotate or stop its rotation depending on whether the driving force from the driving unit **130** is transmitted thereto.

The timer **140** is configured to measure a time and transmit a signal corresponding to the measured time to the controller **100**.

Subsequently, image formation processing by the color printer **1** will be described in detail with reference to FIGS. **4** and **5**. The image formation processing includes an image forming process and cleaning control to be performed after the image forming process. It is noted that in the following description, numerical values such as bias voltage values are merely examples, and the present disclosure are not to be limited to the values.

For instance, when the acceptance unit **120** has accepted an image forming job, and the controller **100** determines that an image forming instruction to execute the image formation processing has been accepted, the image formation processing shown in FIGS. **4** and **5** is executed for each process cartridge **50**. At the beginning of the image formation processing, neither the charging bias Vg, the development bias Vb, nor the cleaning bias Vc is applied, and each development roller **53** is spaced apart from the corresponding photoconductive drum **51**. Further, the photoconductive drums **51** do not rotate. The discharge lamps **56** are turned off. Hereinafter, an explanation will be provided of the image formation processing for the process cartridge **50**C as an example. The same image formation processing applies to the process cartridges **50**M and **50**Y. Nonetheless, the image formation processing for the process cartridge **50**K will be described later with reference to a different flowchart.

In the image formation processing, the controller **100** firstly performs an image forming process (S**100**).

More specifically, firstly, the controller **100** applies the charging bias Vg, the development bias Vb, and the cleaning bias Vc for image formation, and starts rotating the photoconductive drum **51** (S**200**). It is noted that when controlling the photoconductive drum **51** to start and stop its rotation, the controller **100** controls the conveyance belt **73** to start and stop its revolution. In the illustrative embodiment, the charging bias Vg for image formation is 850 V. Further, the development bias Vb for image formation is 400 V. These are voltage values that make feasible image formation on the sheets P. Namely, in the illustrative embodiment, an absolute bias difference between the charging bias Vg and the development bias Vb is 450 V. For instance, when a predetermined bias difference is 150 V, the absolute bias difference is larger than the predetermined bias difference. The predetermined bias difference is a bias difference, between the charging bias Vg and the development bias Vb, at which it is anticipated that so-called "fog" would begin to be observed. It is noted that the "fog" is a situation where toner is transferred onto an unexposed portion other than an exposed portion on the photoconductive drum **51**. Nonetheless, the predetermined bias difference is not limited to 150 V. For instance, the predetermined bias difference may be any value less than 150 V at which the fog would generally begin to be observed. In particular, the predetermined bias difference may be any value within a range from 100 V to 150 V.

Further, in S**200**, the controller **100** applies −200 V as the cleaning bias Vc for image formation. Toner is positively charged, e.g., via the development roller **53**. Therefore, "−200 V" is a voltage value that makes it possible to electrostatically attract the toner on the photoconductive drum **51**. Moreover, in S**200**, the controller **100** brings the development roller **53** into contact with the photoconductive drum **51**. In addition, the controller **100** starts rotating the driving roller **71**, the transfer rollers **74**, and the sliding contact roller **11**. Further, the controller **100** turns on the discharge lamp **56**. Furthermore, the controller **100** begins to apply other biases required for image formation.

Subsequently, based on the accepted image forming instruction, the controller **100** performs exposure and development to form a toner image on the photoconductive drum **51** (S**205**). Further, in S**205**, the controller **100** transfers the toner image formed on the photoconductive drum **51** onto a sheet P, and conveys the sheet P to the sheet discharge unit **90**. Then, after S**205**, the controller **100** determines whether image formation on the photoconductive drum **51** has been completed for the number of image-formed sheets indicated by the accepted image forming instruction (S**210**). When determining that image formation on the photoconductive drum **51** has not been completed for the number of image-formed sheets indicated by the accepted image forming instruction (S**210**: No), the controller **100** continuously performs image formation (S**205**).

Meanwhile, when determining that image formation on the photoconductive drum **51** has been completed for the number of image-formed sheets indicated by the accepted image forming instruction (S**210**: Yes), the controller **100** turns off the discharge lamp **56** (S**215**). Then, the controller **100** terminates the image forming process.

Next, the controller **100** determines whether a time T**1** has elapsed after the image forming process in S**100** (S**105**). The time T**1** is a period of time between the end of the image forming process and when the controller **100** begins to reduce the charging bias Vg. The controller **100** repeatedly makes the determination in S**105** until determining that the time T**1** has elapsed after the image forming process (S**105**: No).

When determining that the time T**1** has elapsed after the image forming process (S**105**: Yes), the controller **100** reduces the charging bias Vg to be applied to the charger **52** (S**110**). Further, in S**110**, the controller **100** stops the rotation of the photoconductive drum **51**. In the illustrative embodiment, the charging bias Vg is reduced from 850 V to 425 V that is half as high as the initial value 850 V. Through S**110**, the absolute difference between the development bias Vb and the charging bias Vg becomes 25 V.

Subsequently, the controller **100** determines whether a time T**2** has elapsed since the time T**1** elapsed (S**115**). The time T**2** is a period of time between when the charging bias Vg is reduced in S**110** and when the controller **100** begins to separate the development roller **53** away from the photoconductive drum **51** (i.e., when the controller **100** begins to operate the contact-separation mechanism **110**. The time T**2** is set such that after the development roller **53** is completely separated away from the photoconductive drum **51**, a potential difference between a surface potential V**0** of the photoconductive drum **51** and a potential of a surface of the development roller **53** becomes equal to or less than a predetermined potential difference. The controller **100** repeatedly makes the determination in S**115** until determining that the time T**2** has elapsed since the time T**1** elapsed (S**115**: No). In the illustrative embodiment, the surface potential V**0** of the photoconductive drum **51** is converged to the same value as the charging bias Vg. In particular, when the charging bias Vg is reduced, the surface potential V**0** of the photoconductive drum **51** is gradually attenuated and becomes the reduced value of the charging bias Vg. Further, the potential of the surface of the development roller **53** is identical to the development bias Vb. Thereby, in the illustrative embodiment, the time T**2** is shorter than a period of time until the potential difference between the surface potential V**0** of the photoconductive drum **51** and the potential of the surface of the development roller **53** becomes equal to or less than the predetermined potential difference (e.g., 150 V).

When determining that the time T**2** has elapsed since the time T**1** elapsed (S**115**: Yes), the controller **100** controls the contact-separation mechanism **110** to separate the development roller **53** away from the photoconductive drum **51** (S**120**). After S**120**, the controller **100** determines whether a time T**3** has elapsed since the time T**3** elapsed (S**122**). The time T**3** is longer than a period of time between when the contact-separation mechanism **110** begins to be operated and when the development roller **53** is completely separated away from the photoconductive drum **51**. The controller **100** repeatedly makes the determination in S**122** until determining that the time T**3** has elapsed since the time T**3** elapsed (S**122**: No). When determining that the time T**3** has elapsed since the time T**3** elapsed (S**122**: Yes), the controller **100** stops applying the development bias Vb to the development roller **53** (S**125**). In other words, the controller **100** changes the development bias Vb from 400 V to 0 V.

Subsequently, the controller **100** determines whether a time T**4** has elapsed after stopping the application of the development bias Vb in S**125** (S**130**). The time T**4** is a period of time until, in response to the reduction of the charging bias Vg in S**110**, the surface potential of the photoconductive drum **51** attenuates and stabilizes. In other words, in the illustrative embodiment, the T**4** is a period of time until the surface potential of the photoconductive drum **51** attenuates to 425 V. The controller **100** repeatedly makes the determination in S**130** until determining that the time T**4** has elapsed (S**130**: No).

When determining that the time T**4** has elapsed after stopping the application of the development bias Vb in S**125** (S**130**: Yes), the controller **100** applies, to the cleaning roller **55**, the cleaning bias Vc that is a positive bias having an absolute value larger than the charging bias Vg (S**135**). Further, in S**135**, the controller **100** starts rotating the photoconductive drum **51**. In the illustrative embodiment, the cleaning bias Vc is changed from −200 V to 650 V. Through this operation, toner carried on the cleaning roller **55** and charged with the same polarity as the cleaning roller

55 is transferred onto the photoconductive drum 51 that has a lower potential than the cleaning roller 55. Further, the photoconductive drum 51 is rotating, and the conveyance belt 73 is revolving. In this situation, when proper biases are applied as needed to the transfer roller 74 and the cleaning unit 10, the toner on the cleaning roller 55 is retrieved into the waste toner container 14. Thus, in the illustrative embodiment, the toner on the cleaning roller 55 is transferred onto the photoconductive drum 51, by applying to the cleaning roller 55 the cleaning bias Vc that has the same polarity as the toner and the charging bias Vg and has a larger absolute value than the charging bias Vg (S135), later than S120 in which the development roller 53 is separated away from the photoconductive drum 51.

After S135, the controller 100 determines whether a time T5 has elapsed (S140). The time T5 is a period of time required to retrieve the toner on the cleaning roller 55 into the waste toner container 14. The controller 100 repeatedly makes the determination in S140 until determining that the time T5 has elapsed (S140: No).

When determining that the time T5 has elapsed (S140: Yes), the controller 100 determines that the toner on the cleaning roller 55 has substantially completely been retrieved into the waste toner container 14, and stops the application of the charging bias Vg to the charger 52, the rotation of the photoconductive drum 51, and the application of the cleaning bias Vc to the cleaning roller 55 (S145). In other words, the controller 100 changes the charging bias Vg from 425 V to 0 V, and changes the cleaning bias Vc from 650 V to 0 V. Further, the controller 100 stops application of biases to other elements (S150). Thereafter, the controller 100 terminates the image formation processing.

<Explanation of Timing Chart>

Subsequently, referring to FIG. 6, a detailed explanation will be provided of timing to make a transition from the image forming process to the cleaning control.

As shown in FIG. 6, during the image forming process, the charging bias Vg, the development bias Vb, and the cleaning bias Vc are 850 V, 400 V, and −200 V, respectively. Further, in this state, the development roller 53 is in contact with the photoconductive drum 51, the discharge lamp 56 is turned on, and a surface potential V0 of a contact portion of the photoconductive drum 51 with the development roller 53 is 850 V. In this state, firstly, the image forming process is completed (t=t1). At the point of time t1, the discharge lamp 56 is turned off. Thereafter, the controller 100 reduces the charging bias Vg from 850 V to 425 V, and stops the rotation of the photoconductive drum 51 (t=t2). From the point of time t2 at which the charging bias Vg is reduced, the surface potential V0 of the photoconductive drum 51 is attenuated. It is noted that the value of the development bias Vb is constant during a period of time between the point of time t1 and the point of time t3. The point of time t1 is a moment at which the image forming process is completed. The point of time t3 is a moment at which the contact-separation mechanism 110 begins to be operated (controlled) to separate the development roller 53 away from the photoconductive drum 51.

After the point of time t2, at the point of time t3, the contact-separation mechanism 110 begins to be operated (controlled) to separate the development roller 53 away from the photoconductive drum 51. After t3, at the point of time t4, the operation of the contact-separation mechanism 110 is completed, and the development roller 53 is placed in a non-development position relative to the photoconductive drum 51. Further, after t4, at the point of time t5, the application of the development bias Vb is stopped. At the point of time t6 later than t4, the surface potential V0 of the photoconductive drum 51 is continuously attenuated and reduced to 550 V. Namely, the point of time t6 is a moment at which the potential difference between the surface potential V0 of the photoconductive drum 51 and the potential (400 V) of the surface of the development roller 53 at the point of time t4 becomes 150 V.

After the development roller 53 has been separated away from the photoconductive drum 51, the surface potential V0 of the photoconductive drum 51 is continuously attenuated and reduced to 550 V, at which the potential difference between the surface potential V0 of the photoconductive drum 51 and the potential (400 V) of the surface of the development roller 53 at the point of time t4 becomes 150 V (t=t6). When the potential difference between the surface potential V0 of the photoconductive drum 51 and the potential of the surface of the development roller 53 is about 150 V, and the development roller 53 is in contact with the photoconductive drum 51, the “fog” might be caused that is a situation where toner on the development roller 53 is transferred onto an unexposed portion (other than an exposed portion) on the photoconductive drum 51. However, in the illustrative embodiment, before the surface potential V0 of the photoconductive drum 51 is reduced to 550 V, the development roller 53 is separated away from the photoconductive drum 51. Thus, it is possible to prevent occurrence of the “fog.”

After reduced to 550 V at the point of time t4, the surface potential V0 of the photoconductive drum 51 is further continuously attenuated and reduced to 425 V that is identical to the charging bias Vg (t=t7). The surface potential V0 of the photoconductive drum 51 is 550 V when the potential difference becomes 150 V between the surface potential V0 of the photoconductive drum 51 and the potential (400 V) of the surface of the development roller 53 that is a potential value to be maintained when the movement of the development roller 53 to the non-development position is not completed. At the point of time t7, the cleaning bias Vc is controlled and changed from −200 V to 650 V. Additionally, at the point of time t7, the photoconductive drum 51 begins to be rotated. Further, at the point of time t7, the aforementioned cleaning control is performed, and the image formation processing is terminated.

According to the illustrative embodiment, firstly, the charging bias Vg is reduced (t=t2, S110). Thereby, it is possible to prevent deterioration of the photoconductive drum 51. Further, the development roller 53 is separated away from the photoconductive drum 51 (t=t4, S120), and thereafter the application of the development bias Vb is stopped (t=t5, S125). Therefore, it is possible to prevent the potential difference between the surface potential V0 of the photoconductive drum 51 (that is gradually attenuated in response to the reduction of the charging bias Vg) and the potential of the surface of the development roller 53 from increasing at a development position. Thus, it is possible to avoid occurrence of the “fog.”

Further, by execution of S135 at the point of time t7, it is possible to transfer, onto the photoconductive drum 51, the tonner electrostatically attracted onto the development roller 53.

Further, the charging bias Vg in the aforementioned toner transferring from the development roller 53 onto the photoconductive drum 51 is 425 V resulting from the reduction of the charging bias Vg in S110. Therefore, there is no need to adjust the charging bias Vg so as to transfer onto the photoconductive drum 51 the tonner electrostatically attracted onto the development roller 53.

Further, in S110 at the point of time t2, the rotation of the photoconductive drum 51 is stopped. Therefore, it is possible to prevent deterioration of the photoconductive drum 51.

Further, the discharge lamp 56 is turned off (t=t1, S215) after completion of the image forming process (t=t1, S210: Yes) and before the reduction of the charging bias Vg (t=t2, S110). Therefore, it becomes more likely that the surface potential of the photoconductive drum 51 is gradually attenuated. Thereby, it is more certainly possible to set earlier the point of time t2 at which the charging bias Vg is reduced in S110. Thus, it is possible to more effectively prevent deterioration of the photoconductive drum 51. In addition, it is possible to prevent the discharge lamp 56 from being unnecessarily turned on.

Further, the development roller 53 is in contact with the photoconductive drum 51 until the point of time t3 at which S120 is executed. There is a possibility that the "fog" might be caused not only when the development roller 53 is in proximity to the photoconductive drum 51 but also when the development roller 53 is in physical contact with the photoconductive drum 51. In this case, since the development roller 53 is separated away from the photoconductive drum 51, it is possible to avoid the physical contact therebetween. Thus, it is possible to more certainly prevent occurrence of the "fog."

Subsequently, a detailed explanation will be provided of another example of image formation processing to be executed by the color printer 1, with reference to FIG. 7 showing a flowchart different from FIG. 4.

In the flowchart shown in FIG. 7, S107 is added between S105 and S110 of the flowchart shown in FIG. 4. It is noted that in S105, the controller 100 determines whether the time T1 has elapsed after the image forming process in S100. Further, in S110, the controller 100 reduces the charging bias Vg to be applied to the charger 52.

In S107, the controller 100 determines whether the photoconductive drum 51 is deteriorated, by determining whether an accumulated number of sheets image-formed during a period of time between when the photoconductive drum 51 was new and the present is equal to or more than a predetermined number of sheets. It is noted that the accumulated number of image-formed sheets is stored in the NVRAM 103, and is reset each time the photoconductive drum 51 is replaced with a new one. In addition, the accumulated number of image-formed sheets is incremented each time image formation is performed.

When determining that the accumulated number of image-formed sheets is less than the predetermined number of sheets (S107: No), the controller 100 determines that the photoconductive drum 51 is not deteriorated, and goes to S110.

Meanwhile, when determining that the accumulated number of image-formed sheets is equal to or more than the predetermined number of sheets (S107: Yes), the controller 100 determines that the photoconductive drum 51 is deteriorated, and goes to S109. In S109, the controller 100 determines whether a time T6 has elapsed since the time T1 elapsed. The time T6 is a period of time for which the controller 100 is to wait so as to delay a point of time to reduce the charging bias Vg in consideration that the surface potential V0 of the photoconductive drum 51 might be promptly attenuated due to the deterioration of the photoconductive drum 51. The controller 100 repeatedly makes the determination in S109 until determining that the time T6 has elapsed since the time T1 elapsed (S109: No).

When determining that the time T6 has elapsed since the time T1 elapsed (S109: Yes), the controller 100 goes to S110 to reduce the charging bias Vg.

Subsequently, referring to FIG. 8, a detailed explanation will be provided of timing to make a transition from the image forming process to the cleaning control in the flowchart shown in FIG. 7.

Hereinafter, in this example, a "charging bias Vg" and a "surface potential V0" will represent a charging bias to be applied to the charger 52 and a surface potential of the photoconductive drum 51 when it is determined that the photoconductive drum 51 is not deteriorated, respectively. Meanwhile, a "charging bias Vg1" and a "surface potential V01" will represent a charging bias to be applied to the charger 52 and a surface potential of the photoconductive drum 51 when it is determined that the photoconductive drum 51 is deteriorated, respectively.

The controller 100 reduces the charging bias Vg at the point of time t2. Meanwhile, the controller 100 reduces the charging bias Vg1 at a point of time t8 later than the point of time t2. This is because as shown in FIG. 8, the surface potential V01 of the photoconductive drum 51 is attenuated more promptly than the surface potential V0. Namely, when determining in S107 that the photoconductive drum 51 is deteriorated, the controller 100 shortens a period of time between a point of time (t8) at which the charging bias Vg1 is reduced and a point of time (t3) at which the development roller 53 begins to be separated away from the photoconductive drum 51.

Thereafter, regardless of whether the photoconductive drum 51 is deteriorated, the contact-separation mechanism 110 begins to be operated (controlled) to separate the development roller 53 away from the photoconductive drum 51 at the point of time t3. After that, for instance, the surface potential V01 of the photoconductive drum 51 is attenuated to 550 V at the point of time t6, which is the same point of time as when the surface potential V0 of the photoconductive drum 51 is attenuated to 550 V.

According to the illustrative embodiment, the controller 100 reduces the charging bias Vg1 and separates the development roller 53 away from the photoconductive drum 51 at respective proper timings, in consideration of that the surface potential V01 of the photoconductive drum 51 is promptly attenuated due to the deterioration of the photoconductive drum 51. Thereby, it is possible to more effectively prevent the photoconductive drum 51 from being further deteriorated, and to prevent the "fog."

In particular, the point of time to reduce the charging bias Vg1 is set to the point of time t8 that is later than the point of time t2 at which the charging bias Vg is reduced when it is determined that the photoconductive drum 51 is not deteriorated. Namely, the period of time between the completion of the image forming process and the point of time (t8) at which the charging bias Vg1 is reduced is set longer than the period of time between the completion of the image forming process and the point of time (t2) at which the charging bias Vg is reduced. Thereby, without having to change the timing (t3, S120) to begin to separate the development roller 53 away from the photoconductive drum 51, it is possible to shorten the period of time between when the charging bias Vg1 is reduced and when the development roller 53 begins to be separated away from the photoconductive drum 51.

Subsequently, a detailed explanation will be provided of another example of image formation processing to be executed by the color printer 1, with reference to FIG. 9 showing a flowchart different from FIGS. 4 and 7.

The image formation processing shown in FIG. **9** is executed for the process cartridge **50**K. For the process cartridges **50**Y, **50**M, and **50**C other than the process cartridge **50**K, the image formation processing shown in FIG. **4** is executed in parallel. In the flowchart shown in FIG. **9**, S**1052** is a step corresponding to S**105** in FIG. **4**. Nonetheless, in S**1052**, the controller **100** determines whether a time T**7**, instead of the time T**1** in S**105**, has elapsed after an image forming process. Moreover, the flowchart shown in FIG. **9** does not include a step corresponding to S**120** in FIG. **4** to separate the development roller **53** away from the photoconductive drum **51**.

After the image forming process has been completed in S**1002** for each of the photoconductive drums **51** corresponding to the process cartridges **50**C, **50**M, **50**Y, and **50**K, in S**1052**, the controller **100** determines whether the time T**7** has elapsed after the image forming process. The time T**7** is a period of time for which the controller **100** is to wait so as to delay a point of time to reduce the charging bias Vg in consideration of that as described above, among all the development rollers **53**K, **53**Y, **53**M, and **53**C, only the development roller **53**K begins to be separated away from the corresponding photoconductive drum **51**K later than the other development rollers **53**Y, **53**M, and **53**C. Namely, the time T**7** is longer than the time T**1**. The controller **100** repeatedly makes the determination in S**1052** until determining that the time T**7** has elapsed after the image forming process (S**1052**: No).

When determining that the time T**7** has elapsed after the image forming process (S**1052**: Yes), the controller **100** goes to S**1102** and reduces a charging bias Vgk to be applied to the charger **52**K in the same manner as executed in S**110**.

After S**1102**, when determining that a sum of the times T**2** and T**3** has elapsed after a lapse of the time T**7** (S**1152**: Yes), the controller **100** reduces the development bias Vb (S**1252**). Since the image formation processing shown in FIG. **4** is performed in parallel, when the sum of the times T**2** and T**3** has elapsed after a lapse of the time T**7** (S**1152**: Yes), the development roller **53**K is placed in the non-development position.

Subsequently, referring to FIG. **10**, a detailed explanation will be provided of timing to make a transition from the image forming process to the cleaning control.

Hereinafter, a surface potential V**0** will represent a surface potential of each of the photoconductive drums **51**Y, **51**M, and **51**C other than the photoconductive drum **51**K. Further, a surface potential V**0***k* will represent a surface potential of the photoconductive drum **51**K.

The charging bias Vgk is reduced at a point of time t**9**. It is noted that the point of time t**9** is a moment after a lapse of the time T**7** from the point of time t**1** at which the image forming process is completed. Further, as described above, the time T**7** is a period of time longer than the time T**1**. This is because, as shown in FIG. **10**, a point of time (t**10**) at which the development roller **53**K is completely moved to the non-development position is later than a point of time (t**4**) at which the other development rollers **53**Y, **53**M, and **53**C are completely moved to the respective non-development positions.

Thereafter, the development bias Vbk is reduced at a point of time t**11** that is a moment after a lapse of the sum of the times T**2** and T**3** from the point of time t**9**. The surface potential V**0***k* of the photoconductive drum **51***k* is attenuated to 550 V at a point of time t**12**, and further attenuated to 425 V at a point of time t**13**.

According to the illustrative embodiment, each charging bias Vg is reduced at the points of time (t**2** and t**9**), which is a timing determined depending on the length of the period of time (t**1** to t**7**, and t**1** to t**13**) during which the surface potential of the corresponding photoconductive drum **51** is allowed to be attenuated, before the corresponding development roller **53** is separated away from the photoconductive drum **51**. Thereby, it is possible to prevent deterioration of the photoconductive drums **51** and avoid occurrence of the "fog."

Hereinabove, the illustrative embodiment according to aspects of the present disclosure has been described. The present disclosure can be practiced by employing conventional materials, methodology and equipment. Accordingly, the details of such materials, equipment and methodology are not set forth herein in detail. In the previous descriptions, numerous specific details are set forth, such as specific materials, structures, chemicals, processes, etc., in order to provide a thorough understanding of the present disclosure. However, it should be recognized that the present disclosure can be practiced without reapportioning to the details specifically set forth. In other instances, well known processing structures have not been described in detail, in order not to unnecessarily obscure the present disclosure.

Only an exemplary illustrative embodiment of the present disclosure and but a few examples of their versatility are shown and described in the present disclosure. It is to be understood that the present disclosure is capable of use in various other combinations and environments and is capable of changes or modifications within the scope of the inventive concept as expressed herein. For instance, according to aspects of the present disclosure, the following modifications are possible.

MODIFICATION

In the aforementioned illustrative embodiment, the controller **100** performs all of the control operations. Nonetheless, the control operations may be performed by a plurality of controllers. Further, the processes and operations disclosed in the illustrative embodiment may be achieved by various aspects such as a storage medium storing computer-executable instructions to perform the processes and operations and methods for performing the processes and operations.

In the aforementioned illustrative embodiment, aspects of the present disclosure are applied to the color printer **1**. Nonetheless, aspects of the present disclosure may be applied to other image forming apparatuses such as copy machines and multi-function peripherals.

In the aforementioned illustrative embodiment, the color printer **1** is an image forming apparatus configured to perform an exposure operation in an LED array method. Nonetheless, the color printer **1** may be an image forming apparatus configured to perform an exposure operation in a laser scanning method.

In the aforementioned illustrative embodiment, the color printer **1** is configured to positively charge toner and perform the image forming process and the cleaning control. Nonetheless, the color printer **1** may be configured to negatively charge toner. In this case, the polarity of each bias may be inverted.

In the aforementioned illustrative embodiment, during the image forming process in S**100**, the development rollers **53** are placed in contact with the corresponding photoconductive drums **51**, respectively. Nonetheless, the development rollers **53** may not necessarily be placed in contact with the photoconductive drums **51**. The development rollers **53** may be placed in proximity to the photoconductive drums **51**. In this case, after the image forming process, the development rollers **53** may be separated farther away from the photoconductive drums **51** than during the image forming process.

According to the aforementioned illustrative embodiment, in the operation, to be started with the cleaning bias Vc set to 650 V in S**135**, of transferring the toner on the cleaning roller **55** onto the photoconductive drum **51**, the charging bias Vg is 425 V to which the charging bias Vg is reduced from 850 V in S**110**. However, the value of the charging bias Vg reduced in S**110** may not necessarily be identical to the value of the charging bias Vg in the operation of transferring the toner on the cleaning roller **55** onto the photoconductive drum **51**. For instance, instead, the charging bias Vg may be adjusted to an appropriate value (e.g., 425 V) after the development roller **53** is separated away from the photoconductive drum **51** in S**120**. Nonetheless, when the value of the charging bias Vg reduced in S**110** is identical to the value of the charging bias Vg in the operation of transferring the toner on the cleaning roller **55** onto the photoconductive drum **51**, it provides such an advantageous effect that there is no need to later adjust the charging bias Vg to an appropriate value (e.g., 425 V) for the operation of transferring the toner on the cleaning roller **55** onto the photoconductive drum **51**.

In the aforementioned illustrative embodiment, the color printer **1** includes the discharge lamps **56** configured to emit light toward the photoconductive drums **51** and remove electric charges on the photoconductive drums **51**. Nonetheless, instead, the electric charges on the photoconductive drums **51** may be removed by other methods such as supplying electric charges onto the photoconductive drums **51**.

In the aforementioned illustrative embodiment, the image forming process for each process cartridge **50** is completed at the same point of time t**1**. Further, the development rollers **53**Y, **53**M, and **53**C are completely moved to their respective non-development positions at the point of time t**4**, while the development roller **53**K is completely moved to its non-development position at the point of time t**10** later than t**4**. In these situations, the charging biases Vg to be applied to the chargers **52**Y, **52**M, and **52**C are reduced to be equal to or less than 550 V at the point of time t**2**. Further, the charging bias Vg to be applied to the charger **52**K is reduced to be equal to or less than 550 V at the point of time t**9** later than t**2**. Thereby, each development roller **53** is separated away from the corresponding photoconductive drum **51** before the surface potential of the photoconductive drum **51** becomes equal to or less than 550 V. Nonetheless, for example, the following modification is possible. Suppose, for instance, that the image forming processes for the process cartridges **50** are completed at different timings depending on whether each individual process cartridge **50** is positioned upstream or downstream of the sheet P in the conveyance direction, and that each development roller **53** is separated away from the corresponding photoconductive drum **51** at the same point of time. In such situations, by reducing the charging biases Vg for the chargers **52**K, **52**Y, **52**M, and **52**C to be equal to or less than 550 V at different timings, each development roller **53** may be separated away from the corresponding photoconductive drum **51** before the surface potential of the photoconductive drum **51** becomes equal to or less than 550 V.

In the aforementioned illustrative embodiment, the value of the development bias Vb is constant during the period of time between the point of time t**1** at which the image forming process is completed and the point of time t**5** at which the application of the development bias Vb is stopped. Nonetheless, for instance, at the point of time t**2** at which the charging bias Vg is reduced, the development bias Vb may be reduced to a predetermined value or may be gradually reduced.

In the aforementioned illustrative embodiment, the controller **100** reduces the charging bias Vg (S**110**), and thereafter begins to control the contact-separation mechanism **110** to separate the development roller **53** away from the photoconductive drum **51** (S**120**). Nonetheless, as long as the development roller **53** is completely moved to the non-development position after the reduction of the charging bias Vg, the controller **100** may begin to control the contact-separation mechanism **110** to separate the development roller **53** away from the photoconductive drum **51** before reducing the charging bias Vg.

In the aforementioned illustrative embodiment, the controller **100** reduces the charging bias Vg (S**110**) and completes the movement of the development roller **53** to the non-development position (S**122**: Yes), and thereafter stops the rotation of the photoconductive drum **51** (S**145**). Nonetheless, for instance, the controller **100** may stop the rotation of the photoconductive drum **51** after reducing the charging bias Vg (S**110**) and before completing the movement of the development roller **53** to the non-development position.

In the aforementioned illustrative embodiment, the controller **100** stops applying the development bias Vb to the development roller **53** in S**125** before executing S**135** and S**145**. Nonetheless, the controller **100** may stop applying the development bias Vb to the development roller **53** after executing S**135** or S**145**.

In the aforementioned illustrative embodiment, a scorotron charger is employed as the charger **52**. Nonetheless, a corotron charger or a contact electrifying type charger may be employed. In this case, the charging bias Vg may represent a bias for controlling the surface potential of the photoconductive drum **51**.

In the aforementioned illustrative embodiment, the surface potential of the photoconductive drum **51** converges to the same value as the charging bias Vg. Nonetheless, the surface potential of the photoconductive drum **51** may converge to a value different from the charging bias Vg. Further, the potential of the surface of the development roller **53** may not be the same as the value of the development bias Vb. In this case, in the same manner as the predetermined bias, the predetermined potential difference may be a potential difference at which it is anticipated that the "fog" would begin to be observed, and may be any value that satisfies the requirement. It is noted that the "fog" is a situation where toner is transferred onto the unexposed portion (other than the exposed portion) on the photoconductive drum **51**. Further, as described above, when each bias to be applied to the corresponding element is not the same as the potential of the surface of the element, the predetermined potential difference and the predetermined bias may not necessarily be identical to each other.

In the aforementioned illustrative embodiment, in S**110**, the charging bias Vg is reduced to the value more than 0 V. Nonetheless, the charging bias Vg may be reduced to 0 V. Thereby, it would be possible to prevent deterioration of the photoconductive drum **51** more effectively than when the charging bias Vg is reduced to the value more than 0 V.

In the aforementioned illustrative embodiment, the degree of deterioration of the photoconductive drum **51** is evaluated in two levels. Then, when it is determined that the degree of deterioration of the photoconductive drum **51** is large (S**107**: Yes), the point of time to reduce the charging bias Vg is set later (i.e., the period of time between when the image forming process for the photoconductive drum **51** is completed and when the charging bias Vg is reduced is set longer). Nonetheless, for instance, the degree of deterioration of the photoconductive drum **51** may be evaluated in a plurality of levels. In this case, as the degree of deterioration of the photoconductive drum **51** is larger, the point of time to reduce the charging bias Vg may be set later. Further, when it is determined that the photoconductive drum **51** is deteriorated, the point of time to reduce the charging bias Vg may not necessarily be set later. In this case, instead, the point of time to begin to separate the development roller **53** away from the photoconductive drum **51** may be set earlier. Namely, the period of time between when the image forming process for the photoconductive drum **51** is completed and when the development roller **53** begins to be separated away from the photoconductive drum **51** may be set shorter. Thereby, the period of time between the point of time to reduce the charging bias Vg and the point of time to start separating the development roller **53** away from the photoconductive drum **51** may be shortened. Alternatively, both the point of time to reduce the charging bias Vg and the point of time to start separating the development roller **53** away from the photoconductive drum **51** may be changed. Thereby, the period of time between the point of time to reduce the charging bias Vg and the point of time to start separating the development roller **53** away from the photoconductive drum **51** may be shortened.

In the aforementioned illustrative embodiment, the rotation of the photoconductive drum **51** is stopped before the development roller **53** begins to be separated away from the photoconductive drum **51**. Nonetheless, the rotation of the photoconductive drum **51** may not necessarily be stopped before the development roller **53** begins to be separated away from the photoconductive drum **51**. If the photoconductive drum **51** is rotating when the development roller **53** begins to be separated away from the photoconductive drum **51**, it would provide such an advantageous effect that it is less likely that there arises a necessity for beginning to rotate the photoconductive drum **51**.

What is claimed is:

1. An image forming apparatus comprising:
an image forming unit comprising:
a photoconductive body;
a charger configured to charge the photoconductive body; and
a development roller; and
a controller configured to:
apply a charging bias to the charger during image formation on the photoconductive body, an absolute value of the charging bias being a first absolute value;
apply a development bias to the development roller during the image formation on the photoconductive body;
place the development roller in a development position during the image formation on the photoconductive body;
after the image formation on the photoconductive body, reduce the absolute value of the charging bias to a second absolute value less than the first absolute value and greater than the development bias;
after reducing the absolute value of the charging bias, separate the development roller away from the photoconductive body and place the development roller in a non-development position, the non-development position being farther from the photoconductive body than the development position;
after placing the development roller in the non-development position, stop applying the development bias to the development roller; and
as an accumulated number of sheets image-formed by the photoconductive body increases, set shorter a period of time between when reducing the absolute value of the charging bias and when beginning to separate the development roller away from the photoconductive body.

2. The image forming apparatus according to claim **1**,
wherein the image forming unit comprises a plurality of image forming process units, the plurality of image forming process units comprising a first image forming process unit and a second image forming unit, each image forming process unit comprising the photoconductive body, the charger, and the development roller, and
wherein the controller is further configured to:
place the development roller of the first image forming process unit in the non-development position after a lapse of a first period of time from completion of the image formation on the photoconductive bodies of all of the plurality of image forming process units;
place the development roller of the second image forming process unit in the non-development position after a lapse of a second period of time from the completion of the image formation on the photoconductive bodies of all of the plurality of image forming process units, the second period of time being longer than the first period of time;
reduce the absolute value of the charging bias applied to the charger of the first image forming process unit after a lapse of a third period of time from the completion of the image formation on the photoconductive bodies of all of the plurality of image forming process units; and
reduce the absolute value of the charging bias applied to the charger of the second image forming process unit after a lapse of a fourth period of time from the completion of the image formation on the photoconductive bodies of all of the plurality of image forming process units, the third period of time being set shorter than the fourth period of time.

3. The image forming apparatus according to claim **1**, wherein the controller is further configured to stop rotation of the photoconductive body after reducing the absolute value of the charging bias and before separating the development roller away from the photoconductive body and placing the development roller in the non-development position.

4. The image forming apparatus according to claim **1**, further comprising a discharger configured to discharge a surface of the photoconductive body,
wherein the controller is further configured to:
control the discharger to discharge the surface of the photoconductive body during the image formation on the photoconductive body; and
turn off the discharger before reducing the absolute value of the charging bias.

5. An image forming apparatus comprising:
an image forming unit comprising:
a photoconductive body;
a charger configured to charge the photoconductive body;
a development roller; and
a plurality of image forming process units, the plurality of image forming process units comprising a first

image forming process unit and a second image forming unit, each image forming process unit comprising the photoconductive body, the charger, and the development roller; and

a controller configured to:

apply a charging bias to the charger during image formation on the photoconductive body, an absolute value of the charging bias being a first absolute value;

apply a development bias to the development roller during the image formation on the photoconductive body;

place the development roller in a development position during the image formation on the photoconductive body;

after the image formation on the photoconductive body, reduce the absolute value of the charging bias to a second absolute value less than the first absolute value;

after reducing the absolute value of the charging bias, separate the development roller away from the photoconductive body and place the development roller in a non-development position, the non-development position being farther from the photoconductive body than the development position;

after placing the development roller in the non-development position, stop applying the development bias to the development roller;

place the development roller of the first image forming process unit in the non-development position after a lapse of a first period of time from completion of the image formation on the photoconductive bodies of all of the plurality of image forming process units;

place the development roller of the second image forming process unit in the non-development position after a lapse of a second period of time from the completion of the image formation on the photoconductive bodies of all of the plurality of image forming process units, the second period of time being longer than the first period of time;

reduce the absolute value of the charging bias applied to the charger of the first image forming process unit after a lapse of a third period of time from the completion of the image formation on the photoconductive bodies of all of the plurality of image forming process units; and

reduce the absolute value of the charging bias applied to the charger of the second image forming process unit after a lapse of a fourth period of time from the completion of the image formation on the photoconductive bodies of all of the plurality of image forming process units, the third period of time being set shorter than the fourth period of time.

6. The image forming apparatus according to claim **5**, wherein the controller is further configured to, as an accumulated number of sheets image-formed by the photoconductive body increases, set shorter a period of time between when reducing the absolute value of the charging bias and when beginning to separate the development roller away from the photoconductive body.

7. The image forming apparatus according to claim **6**, wherein the controller is further configured to, as the accumulated number of sheets image-formed by the photoconductive body increases, set shorter the period of time between when reducing the absolute value of the charging bias and when beginning to separate the development roller away from the photoconductive body, by setting longer a period of time between when completing the image formation on the photoconductive body and when reducing the absolute value of the charging bias.

8. The image forming apparatus according to claim **5**, wherein the controller is further configured to rotate the photoconductive body when separating the development roller away from the photoconductive body and placing the development roller in the non-development position.

9. The image forming apparatus according to claim **5**, wherein the controller is further configured to stop rotation of the photoconductive body after reducing the absolute value of the charging bias and before separating the development roller away from the photoconductive body and placing the development roller in the non-development position.

10. The image forming apparatus according to claim **5**, wherein the controller is further configured to apply to the development roller the development bias that is constant during a period of time between when completing the image formation on the photoconductive body and when stopping applying the development bias to the development roller.

11. The image forming apparatus according to claim **5**, wherein the second absolute value of the charging bias is zero.

12. The image forming apparatus according to claim **5**, further comprising a discharger configured to discharge a surface of the photoconductive body,

wherein the controller is further configured to:

control the discharger to discharge the surface of the photoconductive body during the image formation on the photoconductive body; and

turn off the discharger before reducing the absolute value of the charging bias.

13. The image forming apparatus according to claim **5**, wherein when the development roller is placed in the development position, the development roller is in contact with a surface of the photoconductive body.

14. The image forming apparatus according to claim **5**, further comprising a memory storing controller-executable instructions,

wherein the controller is further configured to, when executing the controller-executable instructions stored in the memory, perform:

applying the charging bias to the charger during image formation on the photoconductive body;

applying the development bias to the development roller during the image formation on the photoconductive body;

placing the development roller in the development position during the image formation on the photoconductive body;

after the image formation on the photoconductive body, reducing the absolute value of the charging bias;

after reducing the absolute value of the charging bias, separating the development roller away from the photoconductive body and placing the development roller in the non-development position; and

after placing the development roller in the non-development position, stopping applying the development bias to the development roller.

15. An image forming apparatus comprising:

an image forming unit comprising:

a photoconductive body;

a charger configured to charge the photoconductive body; and

a development roller;

an attracting roller configured to contact the photoconductive body; and

a controller configured to:

apply a charging bias to the charger during image formation on the photoconductive body, an absolute value of the charging bias being a first absolute value;

apply a development bias to the development roller during the image formation on the photoconductive body;

place the development roller in a development position during the image formation on the photoconductive body;

after the image formation on the photoconductive body, reduce the absolute value of the charging bias to a second absolute value less than the first absolute value;

after reducing the absolute value of the charging bias, separate the development roller away from the photoconductive body and place the development roller in a non-development position, the non-development position being farther from the photoconductive body than the development position;

after placing the development roller in the non-development position, stop applying the development bias to the development roller;

before placing the development roller in the non-development position, apply to the attracting roller a before-separation bias to cause the attracting roller to electrostatically attract toner on the photoconductive body; and

after placing the development roller in the non-development position, control the attracting roller and the charger to electrostatically transfer the toner on the attracting roller onto the photoconductive body, by:

applying to the attracting roller an after-separation bias having a same polarity as the toner electrostatically transferred onto the attracting roller; and

applying to the charger the charging bias having a same polarity as the after-separation bias and a third absolute value, the third absolute value being less than an absolute value of the after-separation bias; and

after the image formation on the photoconductive body, reduce the absolute value of the charging bias to the second absolute value that is identical to the third absolute value.

16. The image forming apparatus according to claim **15**, wherein the controller is further configured to, as an accumulated number of sheets image-formed by the photoconductive body increases, set shorter a period of time between when reducing the absolute value of the charging bias and when beginning to separate the development roller away from the photoconductive body.

17. The image forming apparatus according to claim **15**, wherein the image forming unit comprises a plurality of image forming process units, the plurality of image forming process units comprising a first image forming process unit and a second image forming unit, each image forming process unit comprising the photoconductive body, the charger, and the development roller, and

wherein the controller is further configured to:

place the development roller of the first image forming process unit in the non-development position after a lapse of a first period of time from completion of the image formation on the photoconductive bodies of all of the plurality of image forming process units;

place the development roller of the second image forming process unit in the non-development position after a lapse of a second period of time from the completion of the image formation on the photoconductive bodies of all of the plurality of image forming process units, the second period of time being longer than the first period of time;

reduce the absolute value of the charging bias applied to the charger of the first image forming process unit after a lapse of a third period of time from the completion of the image formation on the photoconductive bodies of all of the plurality of image forming process units; and

reduce the absolute value of the charging bias applied to the charger of the second image forming process unit after a lapse of a fourth period of time from the completion of the image formation on the photoconductive bodies of all of the plurality of image forming process units, the third period of time being set shorter than the fourth period of time.

18. The image forming apparatus according to claim **15**, wherein the controller is further configured to stop rotation of the photoconductive body after reducing the absolute value of the charging bias and before separating the development roller away from the photoconductive body and placing the development roller in the non-development position.

19. The image forming apparatus according to claim **15**, further comprising a discharger configured to discharge a surface of the photoconductive body,

wherein the controller is further configured to:

control the discharger to discharge the surface of the photoconductive body during the image formation on the photoconductive body; and

turn off the discharger before reducing the absolute value of the charging bias.

* * * * *