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(54) **IMAGE FORMING APPARATUS ENSURING CALIBRATION OF TRANSFER UNIT**

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(57) **ABSTRACT**

An image forming apparatus includes: a transfer unit, a reflectance sensor, a time-series data acquiring unit, and a transfer-unit rotation-time calculating unit. The time-series data acquiring unit is configured to acquire time-series data with respect to the image carrier background-portion reflectance, measured by the reflectance sensor, as reference data over a time period twice longer than a time period that by design the image carrier requires for one cycle, and as advance/delay data over a time period twice longer than a time period longer or shorter in multiples of a predetermined time interval than the by-design time period. The transfer-unit rotation-time calculating unit is configured to calculate a one-cycle-time calculation value that is the time actually required for one cycle of the image carrier, based on the reference data and the advance/delay data acquired by the time-series data acquiring unit.
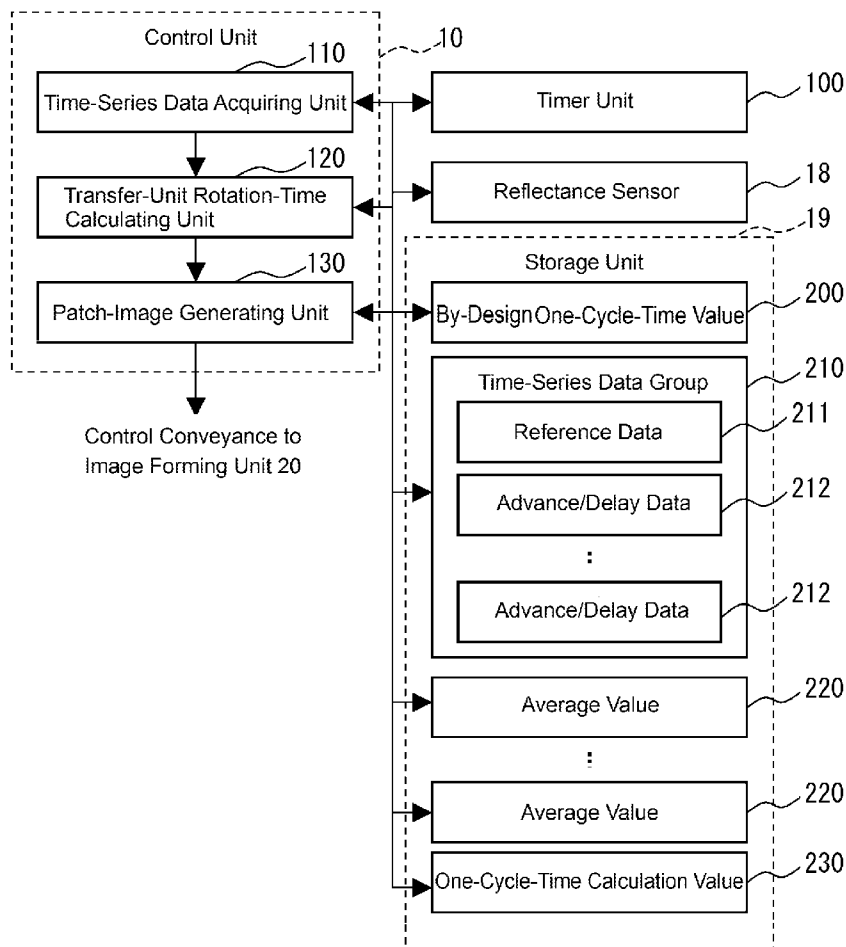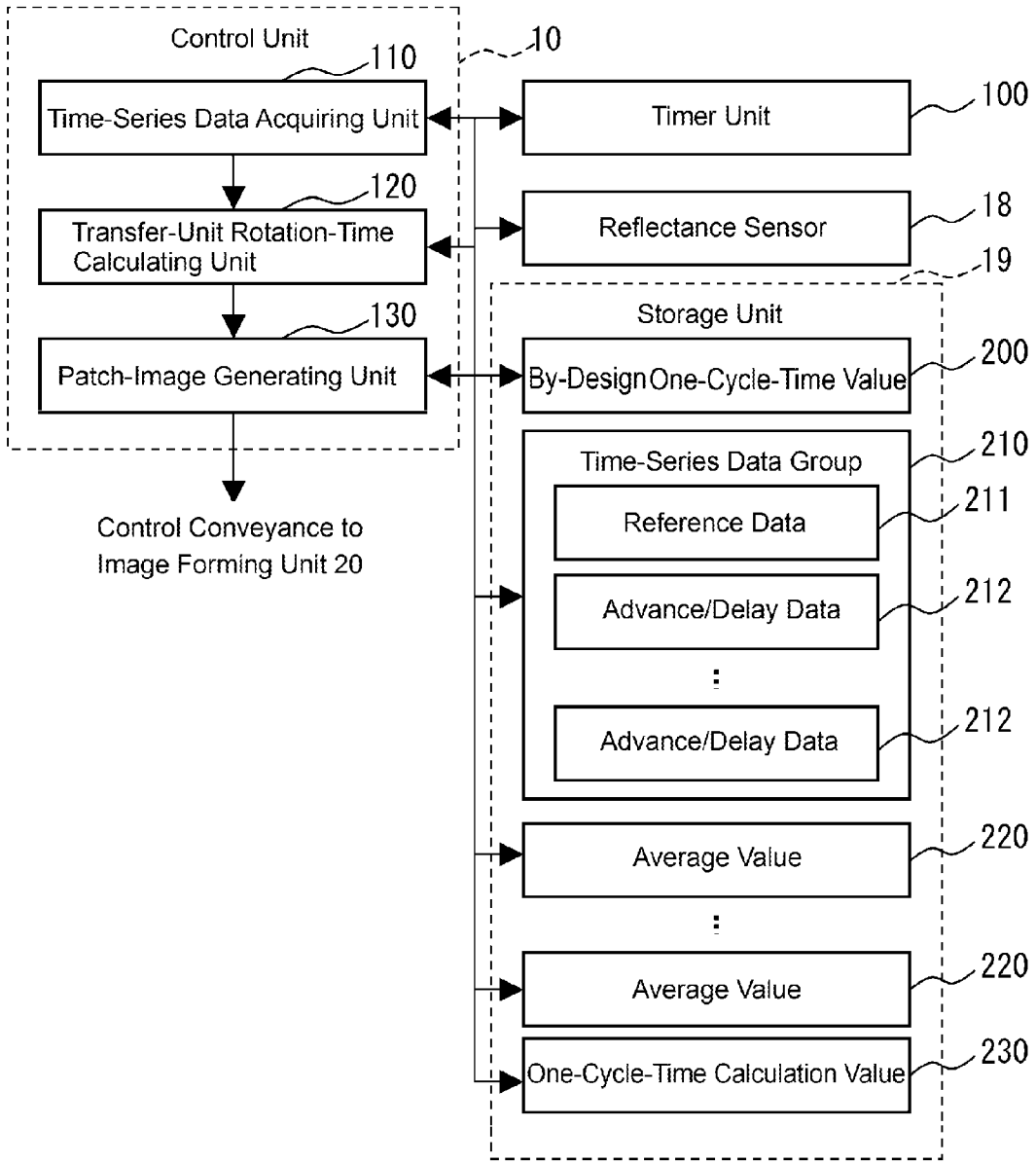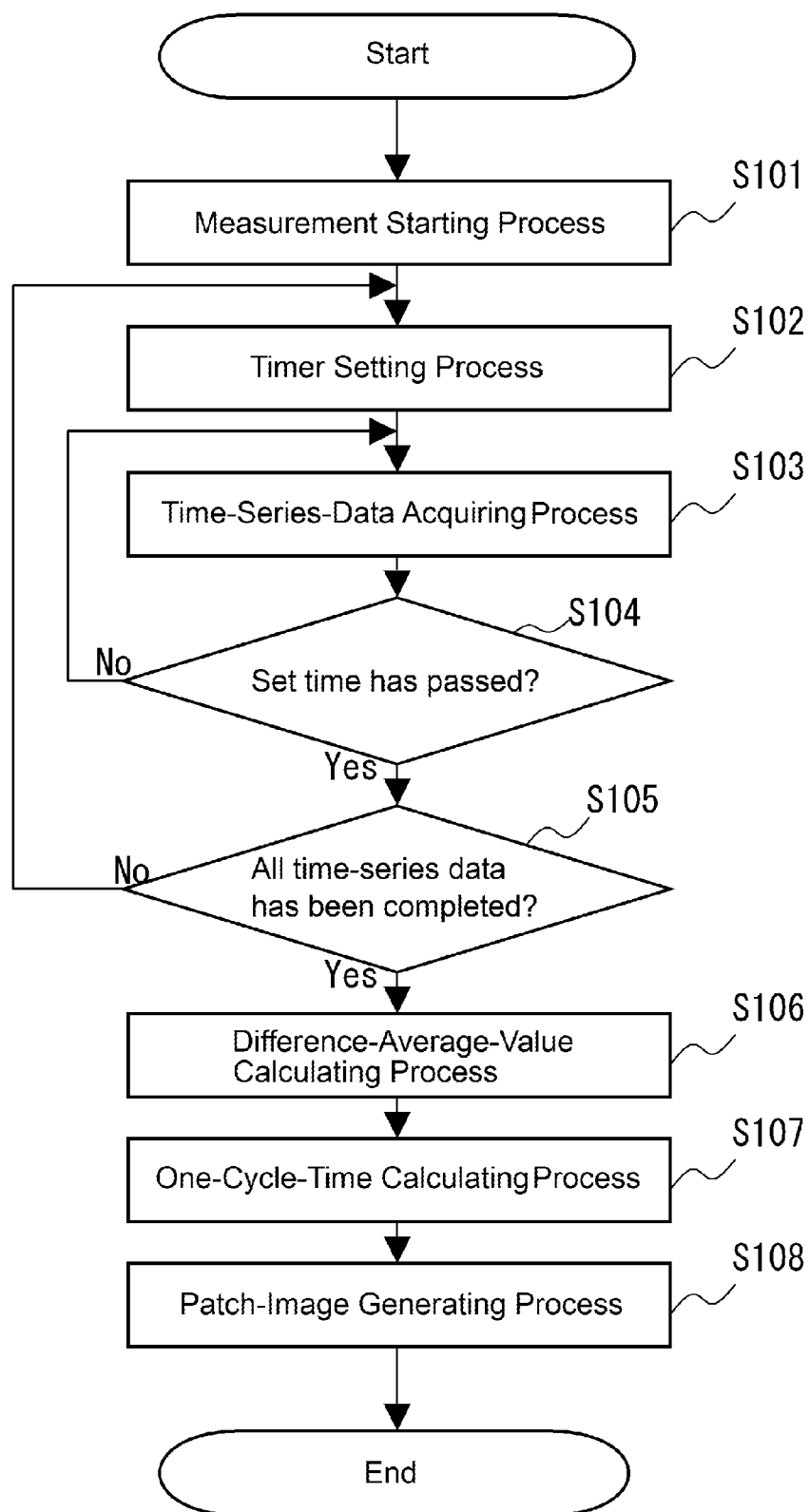
FIG. 1

Control Unit

110 Time-Series Data Acquiring Unit

120 Transfer-Unit Rotation-Time Calculating Unit

130 Patch-Image Generating Unit

Control Conveyance to Image Forming Unit 20

10

100 Timer Unit

18 Reflectance Sensor

19

Storage Unit

200 By-Design One-Cycle-Time Value

Time-Series Data Group **210**

211 Reference Data

212 Advance/Delay Data

⋮

212 Advance/Delay Data

220 Average Value

⋮

220 Average Value

230 One-Cycle-Time Calculation Value

FIG. 2

Start

Measurement Starting Process — S101

Timer Setting Process — S102

Time-Series-Data Acquiring Process — S103

Set time has passed? — S104
No
Yes

All time-series data has been completed? — S105
No
Yes

Difference-Average-Value Calculating Process — S106

One-Cycle-Time Calculating Process — S107

Patch-Image Generating Process — S108

End

FIG. 3C

Data A - Data B

0 : 0 — (−70) = 70
1 : 100 — 30 = 70
2 : 200 — 130 = 70
3 : 270 — 200 = 70
......

FIG. 3B

Data A

0	0
1	100
2	200
3	270
	...

Data B

0	−70
1	30
2	130
3	200
	...

FIG. 3A

Half of Timer Set Time

Data A

Data B

Sampling Points

0 1 2 3

FIG. 4A

Reflectance

Half of Timer Set Time

Half of Timer Set Time

Data A

Data B

Half of Timer Set Time

Half of Timer Set Time

Data A

Data B

FIG. 4B

Half of Timer Set Time

Half of Timer Set Time

Reflectance

Data A

Data B

Half of Timer Set Time

Half of Timer Set Time

Data A
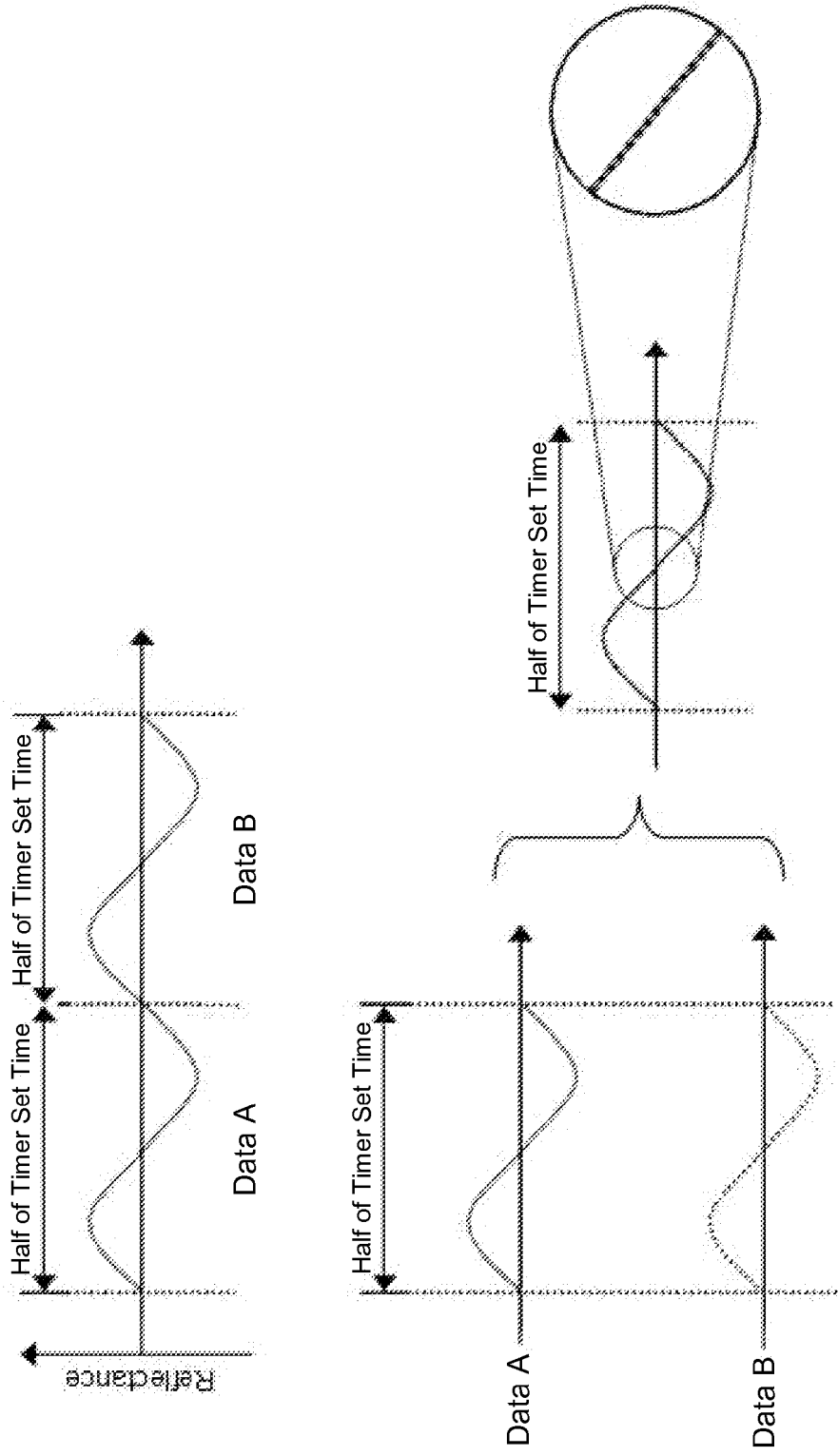
Data B
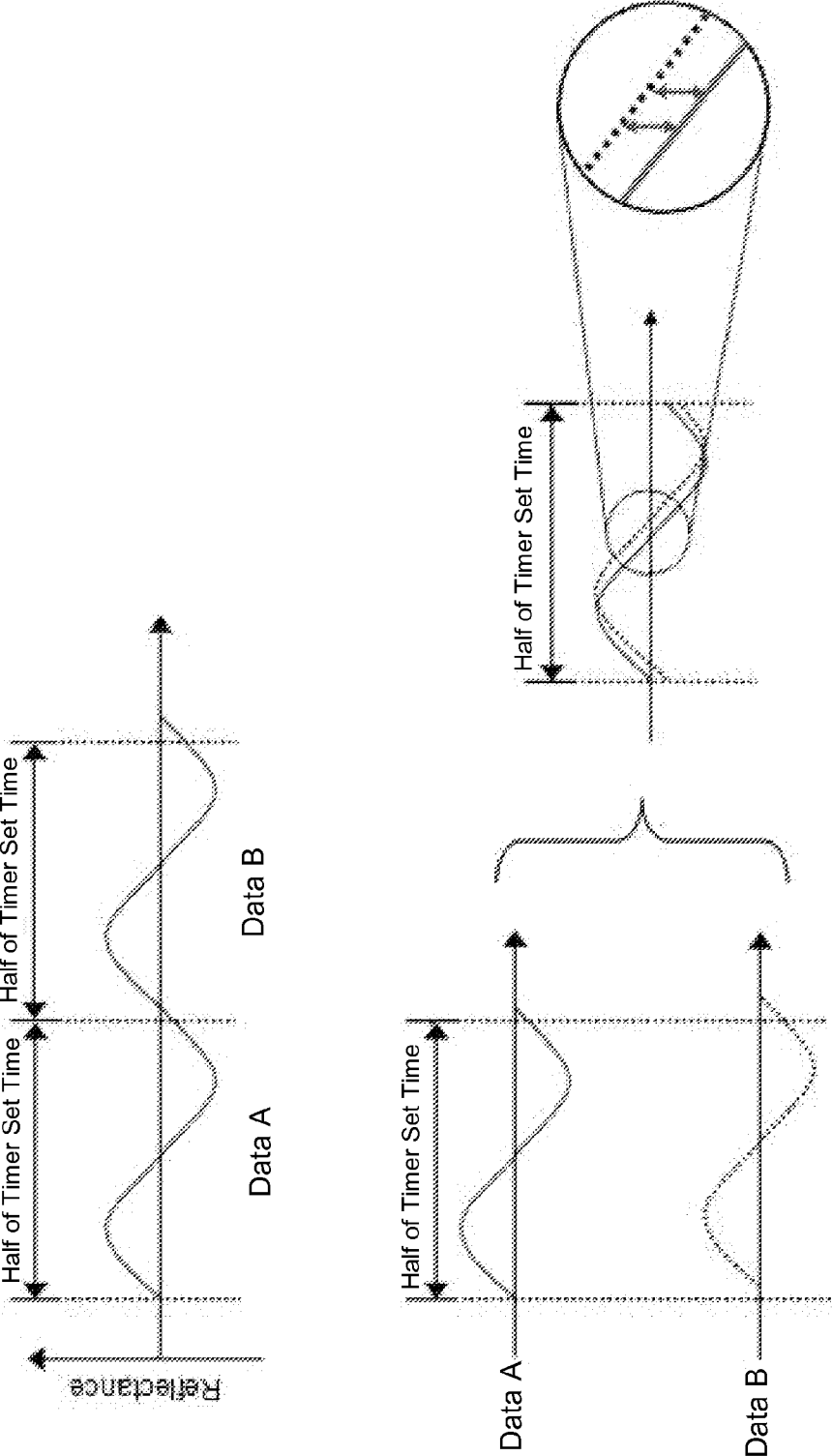
FIG. 5

Time Difference	$-3\triangle t$	$-2\triangle t$	$-\triangle t$	0	$\triangle t$	$2\triangle t$	$3\triangle t$
Average Value of Difference	Average Value 1	Average Value 2	Average Value 3	Average Value 4	Average Value 5	Average Value 6	Average value 7
Time For One Cycle	$Tb-3\triangle t$	$Tb-2\triangle t$	$Tb-\triangle t$	Tb	$Tb+\triangle t$	$Tb+2\triangle t$	$Tb+3\triangle t$

FIG. 6

Document Reading Unit — 12	Image Processing Unit — 11
Document Feeding Unit — 13	Operation Panel Unit — 16
Image Forming Unit — 20	Storage Unit — 19
Reflectance Sensor — 18	Timer Unit — 100
Conveying Unit — 42b. 44. 45	Network Transmission/Reception Unit — 15

Control Unit — 10

To External Network

1
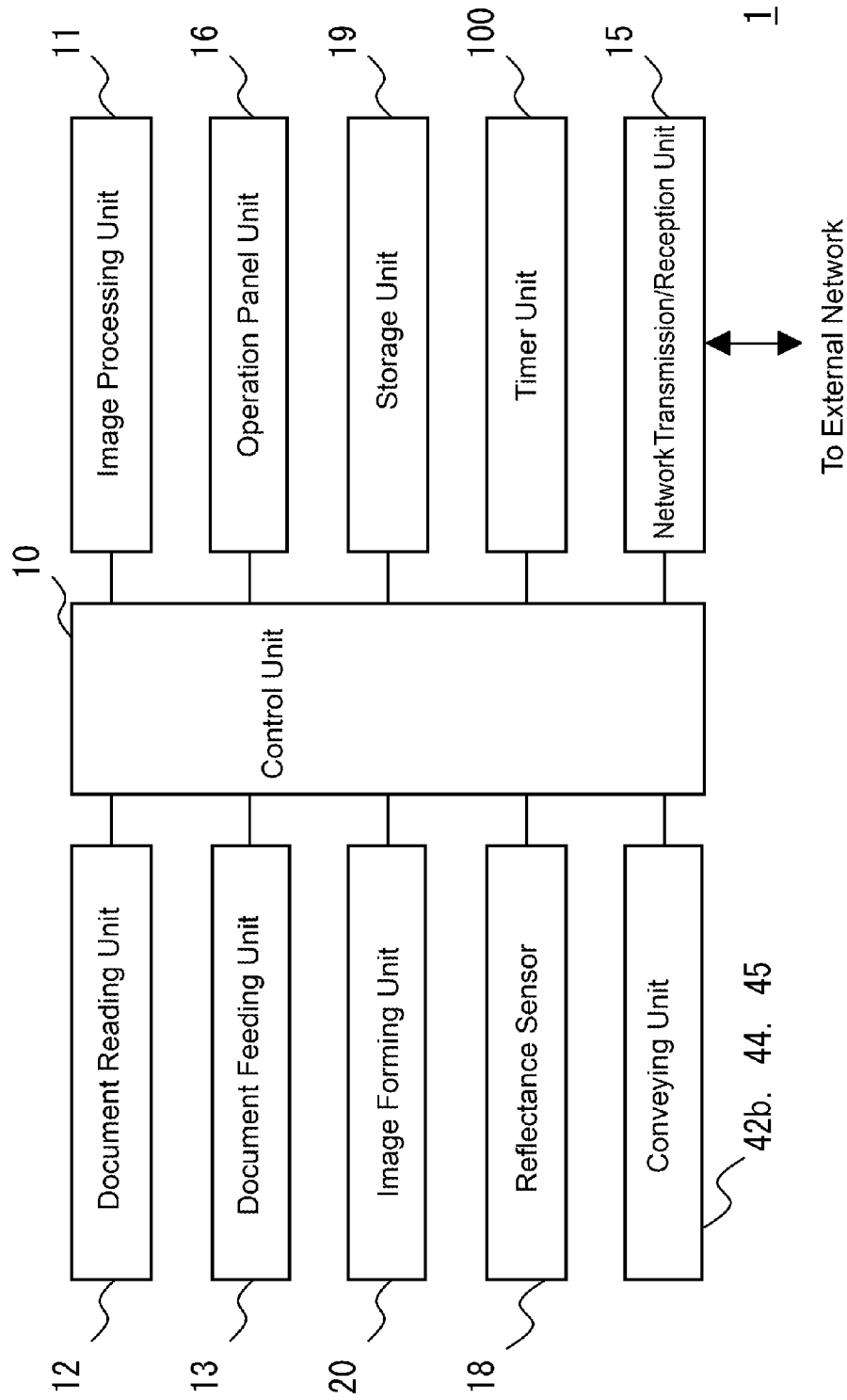
FIG. 7
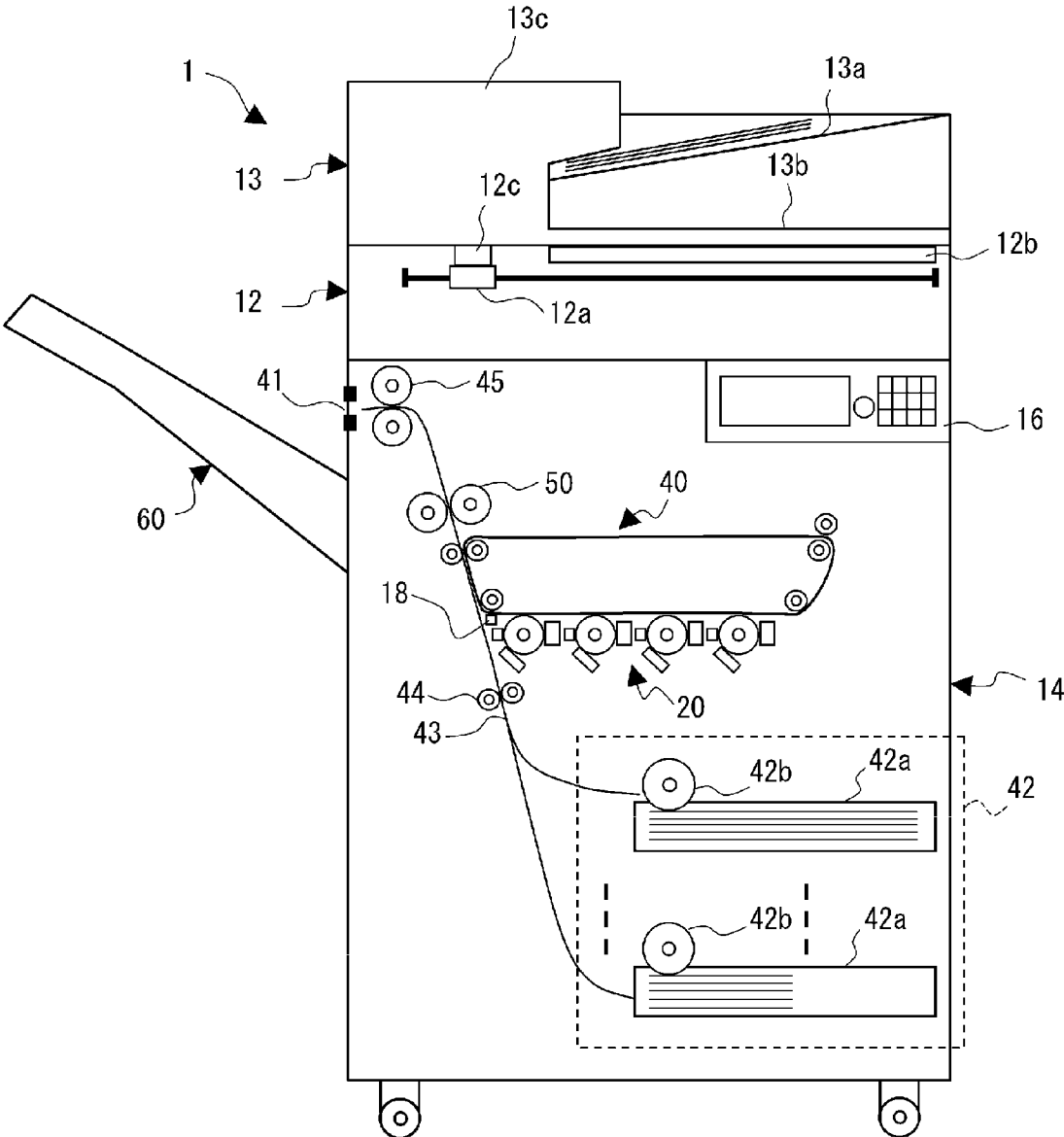
FIG. 8
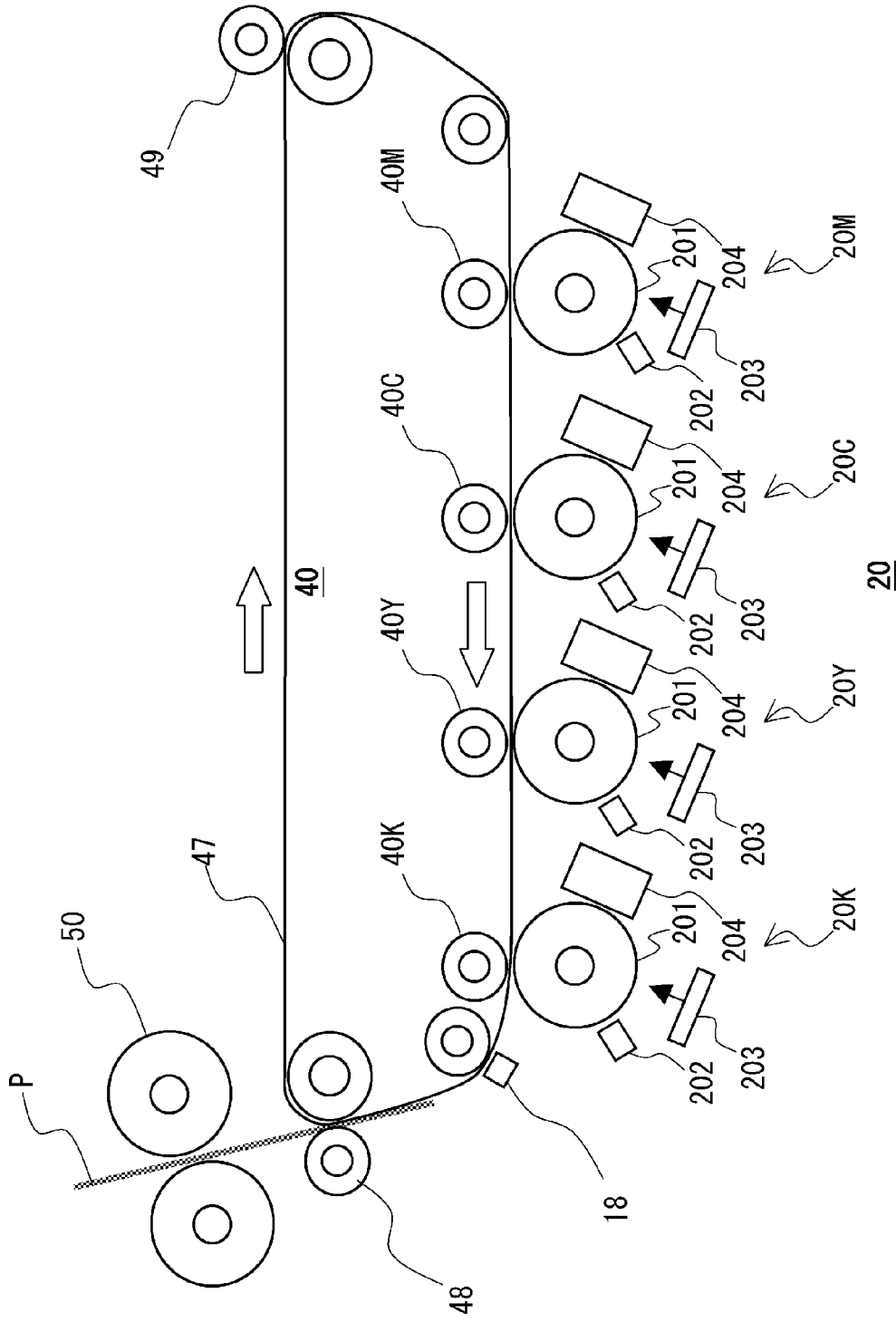
IMAGE FORMING APPARATUS ENSURING CALIBRATION OF TRANSFER UNIT

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon, and claims the benefit of priority from, corresponding Japanese Patent Application Nos. 2013-179376 filed on Aug. 30, 2013 and 2014-153953 filed on Jul. 29, 2014 in the Japan Patent Office on Aug. 30, 2013, the entire contents of which are incorporated herein by reference.

BACKGROUND

[0002] Unless otherwise indicated herein, the description in this section is not prior art to the claims in this application and is not admitted to be prior art by inclusion in this section.

[0003] Typically, there is known an image forming apparatus such as a multifunctional peripheral (MFP) that can print a document and an image. In particular, in an image forming apparatus for color printing, toner images in respective colors in which electrostatic latent images are exposed by a laser or similar method are developed are once superimposed on an intermediate transfer belt of a transfer unit and then transferred to a recording sheet at a time.

[0004] As a typical image forming apparatus using the transfer unit, there is a technique that performs correction using at least one or more reference position marks disposed at an intermediate transfer belt such that the transfer position of a toner image to a transfer material is not displaced from a predetermined transfer position even when the perimeter of the intermediate transfer belt changes with time or when there is an individual difference in perimeter of the intermediate transfer belt during production.

SUMMARY

[0005] An image forming apparatus of the disclosure includes a transfer unit, a reflectance sensor, a time-series data acquiring unit, and a transfer-unit rotation-time calculating unit. The transfer unit includes an image carrier to which a toner image formed by developing an exposure-formed electrostatic latent image is transferred. The reflectance sensor is configured to measure reflectance of a background portion of the image carrier. The time-series data acquiring unit is configured to acquire time-series data with respect to the image carrier background-portion reflectance, measured by the reflectance sensor, as reference data over a time period twice longer than a time period that by design the image carrier requires for one cycle, and as advance/delay data over a time period twice longer than a time period longer or shorter in multiples of a predetermined time interval than the by-design time period. The transfer-unit rotation-time calculating unit is configured to calculate a one-cycle-time calculation value that is the time actually required for one cycle of the image carrier, based on the reference data and the advance/delay data acquired by the time-series data acquiring unit.

[0006] An image forming method of the disclosure is an image forming method performed by an image forming apparatus with a transfer unit including an image carrier whereby a toner image formed by an exposure-formed electrostatic latent image being developed is transferred. The image forming method includes: acquiring time-series data with respect to reflectance of a background portion of the image carrier, as reference data over a time period twice longer than a time

period that by design the image carrier requires for one cycle, and as advance/delay data over a time period twice longer than a time period longer or shorter in multiples of a predetermined time interval than the by-design time period; and calculating a one-cycle-time calculation value that is the time actually required for one cycle of the image carrier, based on the acquired reference data and the acquired advance/delay data.

[0007] These as well as other aspects, advantages, and alternatives will become apparent to those of ordinary skill in the art by reading the following detailed description with reference where appropriate to the accompanying drawings. Further, it should be understood that the description provided in this summary section and elsewhere in this document is intended to illustrate the claimed subject matter by way of example and not by way of limitation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 illustrates a system configuration of an image forming apparatus according to an embodiment of the disclosure;

[0009] FIG. 2 illustrates a transfer-unit calibration process according to the embodiment;

[0010] FIGS. 3A to 3C illustrate a difference-average-value calculating process according to the embodiment;

[0011] FIGS. 4A and 4B illustrate a one-cycle-time calculating process according to the embodiment;

[0012] FIG. 5 illustrates a working example of the disclosure;

[0013] FIG. 6 illustrates the overall configuration of the image forming apparatus according to the embodiment;

[0014] FIG. 7 illustrates the image forming apparatus according to the embodiment; and

[0015] FIG. 8 illustrates an image forming unit of the image forming apparatus according to the embodiment.

DETAILED DESCRIPTION

[0016] Example apparatuses are described herein. Other example embodiments or features may further be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. In the following detailed description, reference is made to the accompanying drawings, which form a part thereof.

[0017] The example embodiments described herein are not meant to be limiting. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the drawings, can be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

Overall Configuration of Image Forming Apparatus 1 According to Embodiment

[0018] Firstly, a description will be given of the overall configuration of an image forming apparatus 1 with reference to FIG. 6.

[0019] In the image forming apparatus 1, a control unit 10 connects to an image processing unit 11, a document reading unit 12, a document feeding unit 13, a conveying unit (a paper feed roller 42b, a conveyance roller pair 44, and a discharge roller pair 45), a network transmission/reception unit 15, an operation panel unit 16, a reflectance sensor 18, a storage unit

19, an image forming unit **20**, and a timer unit **100**. The operations of the respective units are controlled by the control unit **10**.

[0020] The control unit **10** is an information processing unit such as a general purpose processor (GPP), a central processing unit (CPU), a micro processing unit (MPU), a digital signal processor (DSP), a graphics processing unit (GPU), and an application specific processor (ASIC). The control unit **10** reads a control program stored in a ROM or an HDD of the storage unit **19**, uncompresses this control program in the RAM, and executes this control program. This causes the control unit **10** to operate as each unit of function blocks described later. The control unit **10** performs the control of the entire image forming apparatus **1** corresponding to predetermined instruction information that is input from an external terminal (not illustrated) or the operation panel unit **16**.

[0021] The image processing unit **11** is an operation control unit such as a digital signal processor (DSP) and a graphics processing unit (GPU). The image processing unit **11** performs an image process on image data. For example, the image processing unit **11** performs image processes such as scaling, print density adjustment, gradation adjustment, and image improvement. The image processing unit **11** stores the image read by the document reading unit **12** as print data in the storage unit **19**. At this time, the image processing unit **11** can also convert the print data into a file unit in a format such as a PDF and a TIFF.

[0022] The document reading unit **12** reads (scans) a set original document. The document feeding unit **13** conveys the original document to be read by the document reading unit **12**. By an output command of a user, the image forming unit **20** performs image formation on a recording sheet based on the data that is stored in the storage unit **19**, read by the document reading unit **12** or acquired from an external terminal. The reflectance sensor **18** is an optical sensor for calibration of an intermediate transfer belt **47** (see FIG. **8**) of an intermediate transfer unit **40** in the image forming unit **20**. Here, the respective operations of the document reading unit **12**, the document feeding unit **13**, the image forming unit **20**, and the reflectance sensor **18** will be described later.

[0023] The network transmission/reception unit **15** is a network connection unit that includes a LAN board, a wireless transceiver, and similar unit for connecting to an external network such as a LAN, a wireless LAN, a WAN, and a mobile phone network. The network transmission/reception unit **15** transmits and receives data through a data communication line and transmits and receives a voice signal through a voice-grade telephone line.

[0024] The operation panel unit **16** includes a display unit such as an LCD and an input unit such as: a numeric keypad; a start key; a cancel key; a key for switching operation modes such as copy, FAX transmission, and scanner; a key for issuing an instruction for execution of a job related to printing, transmission, storage, recording, or similar operation of a selected document and a touch panel. The operation panel unit **16** acquires the instructions of various jobs of the image forming apparatus **1** from a user. Additionally, the control unit **10** can store device settings of the image forming apparatus **1** and/or information of each user in the storage unit **19** or can change the information stored in the storage unit **19** based on the instruction of the user acquired from the operation panel unit **16**.

[0025] The storage unit **19** is a storage unit that employs a semiconductor memory such as a read only memory (ROM)

and a random access memory (RAM), or a recording medium such as a hard disk drive (HDD). The ROM and the HDD in the storage unit **19** store control programs for performing the operation control of the image forming apparatus **1**. In addition, the storage unit **19** stores account setting of the user. The storage unit **19** may include a region for a storage folder for every user.

[0026] The timer unit **100** is, for example, a real-time clock with a battery backup function and/or a circuit that measures time by counting a clock of the control unit **10**. For example, the timer unit **100** can measure a time per several microseconds to one second based on the clock supplied from a crystal oscillator circuit or similar circuit (not illustrated) provided separately from the circuit for the control unit **10**. The timer unit **100** can be set as an interval timer that causes interruption or similar process at a predetermined interval of several microseconds to one second.

[0027] In the image forming apparatus **1**, the control unit **10** and the image processing unit **11** may be integrally formed like a GPU Built-in CPU or a chip-on-module package. The control unit **10** and the image processing unit **11** may each incorporate a RAM, a ROM, a flash memory, or similar member. The image forming apparatus **1** may include a FAX transmission/reception unit for transmission to and reception from a facsimile.

Operation of Image Forming Apparatus **1**

[0028] Next, a description will be given of the operation of the image forming apparatus **1** according to the embodiment of the disclosure with reference to FIG. **7**. The image forming apparatus **1** includes a main unit **14**, the document reading unit **12**, the document feeding unit **13**, and similar member. The document reading unit **12** is arranged above the main unit **14**. The document feeding unit **13** is arranged above the document reading unit **12**. A discharge port **41** is formed in the main unit **14**. At the discharge port **41** side of the main unit **14**, a stack tray **60** is arranged. The operation panel unit **16** is arranged at the front side of the main unit **14**.

[0029] The document reading unit **12** includes a scanner **12a**, a platen glass **12b**, and a document reading slit **12c**. The scanner **12a** includes an exposing lamp and an imaging sensor such as a charge coupled device (CCD) and a complementary metal oxide semiconductor (CMOS). The scanner **12a** can move in the conveyance direction of the original document by the document feeding unit **13**. The platen glass **12b** is a platen formed of a transparent member such as glass. The document reading slit **12c** has a slit formed in a direction perpendicular to the conveyance direction of the original document by the document feeding unit **13**.

[0030] To read the original document placed on the platen glass **12b**, the scanner **12a** is moved to the position facing the platen glass **12b**. Subsequently, the scanner **12a** acquires image data by reading the original document while scanning the original document placed on the platen glass **12b**. Subsequently, the scanner **12a** outputs the acquired image data to the control unit **10** (see FIG. **6**) provided in the main unit **14**. To read the original document conveyed by the document feeding unit **13**, the scanner **12a** is moved to the position facing the document reading slit **12c**. Subsequently, the scanner **12a** acquires image data through the document reading slit **12c** by reading the original document in synchronization with the conveying operation of the original document by the document feeding unit **13**. Subsequently, the scanner **12a** outputs the acquired image data to the control unit **10**.

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[0031] The document feeding unit **13** includes a document placement unit **13***a*, a document discharging unit **13***b*, and a document conveying mechanism **13***c*. The original document placed on the document placement unit **13***a* is sequentially fed one by one by the document conveying mechanism **13***c*, conveyed to the position facing the document reading slit **12***c*, and then discharged to the document discharging unit **13***b*. Here, the document feeding unit **13** can be lifted up around the rotation axis (not illustrated). Lifting up the document feeding unit **13** ensures opening the top surface of the platen glass **12***b*.

[0032] The main unit **14** includes the image forming unit **20**, the intermediate transfer unit **40**, and a fixing unit **50**, and also includes a paper sheet feeder **42**, a paper sheet conveyance passage **43**, the conveyance roller pair **44**, and the discharge roller pair **45**. The paper sheet feeder **42** includes a plurality of sheet feed cassettes **42***a* and a plurality of paper feed rollers **42***b*. The sheet feed cassettes **42***a* store respective recording sheets having different sizes or orientations. The paper feed roller **42***b* feeds the recording sheet one by one to the paper sheet conveyance passage **43** from the sheet feed cassette **42***a*. The paper feed roller **42***b*, the conveyance roller pair **44**, and the discharge roller pair **45** function as a conveying unit. The recording sheet is conveyed by this conveying unit. The recording sheet, which is fed to the paper sheet conveyance passage **43** by the paper feed roller **42***b*, is conveyed toward the intermediate transfer unit **40** by the conveyance roller pair **44**.

[0033] The image forming unit **20** performs, for example, image formation of color toner image on a recording sheet. The recording sheet after recording by the image forming unit **20** is discharged to the stack tray **60** by the discharge roller pair **45**.

[0034] With reference to FIG. **8**, the detailed configuration of the image forming unit **20** will be described. The image forming unit **20** includes an image forming unit **20M**, an image forming unit **20C**, an image forming unit **20Y**, and an image forming unit **20K** corresponding to respective four colors of magenta (M), cyan (C), yellow (Y), and black (K or B).

[0035] The respective configurations of the image forming unit **20M**, the image forming unit **20C**, the image forming unit **20Y**, and the image forming unit **20K** are the same. Therefore, only the image forming unit **20K** will be described. In the approximately center of the image forming unit **20K**, a photoreceptor drum **201** is arranged. In the peripheral area of the photoreceptor drum **201**, a charging unit **202**, an exposing unit **203**, a developing unit **204**, and a photoreceptor-drum cleaning unit (not illustrated) are arranged in this order along the rotation direction of the photoreceptor drum **201**. The charging unit **202** charges the circumference surface of the photoreceptor drum **201** at a predetermined electric potential. The exposing unit **203** performs scanning and exposure on the charged circumference surface of the photoreceptor drum **201** using a laser beam modulated based on the image data transmitted from the document reading unit **12** and similar unit so as to form an electrostatic latent image on the circumference surface of the photoreceptor drum **201**. The developing unit **204** develops the electrostatic latent image formed on the circumference surface of the photoreceptor drum **201** using toner so as to form a toner image on the circumference surface of the photoreceptor drum **201**. The photoreceptor-drum cleaning unit removes the toner remaining on the circumference surface of the photoreceptor drum **201** from the circumference surface of the photoreceptor drum **201** after a primary transfer described later.

[0036] The intermediate transfer unit **40** includes a primary transfer roller **40M**, a primary transfer roller **40C**, a primary transfer roller **40Y**, and a primary transfer roller **40K** that correspond to the respective image forming units. The intermediate transfer unit **40** further includes the intermediate transfer belt **47** (image carrier), a secondary transfer roller **48**, and a cleaner **49**. The primary transfer roller **40M**, the primary transfer roller **40C**, the primary transfer roller **40Y**, and the primary transfer roller **40K** perform primary transfer of the toner images in respective colors formed on the respective photoreceptor drums **201** corresponding to the image forming unit **20M**, the image forming unit **20C**, the image forming unit **20Y**, and the image forming unit **20K** such that the respective toner images are superimposed on one another on the intermediate transfer belt **47**. The secondary transfer roller **48** performs secondary transfer of the toner image transferred to the intermediate transfer belt **47** by the primary transfer on a recording sheet P. The cleaner **49** removes the toner attached onto the intermediate transfer belt **47** after the secondary transfer. The intermediate transfer belt **47** is driven by a roller to cause movement in the direction, for example, by an outlined arrow illustrated in the drawing.

[0037] The fixing unit **50** heats the recording sheet P on which the toner image is transferred by the intermediate transfer unit **40** so as to fix the toner image to the recording sheet.

[0038] The reflectance sensor **18** is an optical sensor for optically measuring the reflectance of the intermediate belt or similar member with infrared in the portion where the toner image is not transferred to the intermediate transfer belt **47** of the intermediate transfer unit **40**, that is, on a "background." Here, the reflectance sensor **18** may be used to measure the print density of the toner image transferred to the intermediate transfer belt **47** for correction of the image density. For example, the reflectance sensor **18** continuously measures the reflectance of the intermediate transfer belt **47** in actual time (real time). The reflectance sensor **18** may perform real-time measurement of the reflectances in a plurality of positions facing the driving direction of the intermediate transfer belt **47** so as to calculate the average value or similar parameter of the reflectances.

System Configuration of Image Forming Apparatus **1**

[0039] With reference to FIG. **1**, the system configuration of the image forming apparatus **1** will be described. The image forming apparatus **1** includes, as functions of the control unit **10**, a time-series data acquiring unit **110**, a transfer-unit rotation-time calculating unit **120**, and a patch-image generating unit **130**. The storage unit **19** stores a by-design one-cycle-time value **200** and a one-cycle-time calculation value **230**. Additionally, the storage unit **19** can store a time-series data group **210** and an average value **220**, and overwrite the stored contents. Further, the storage unit **19** can overwrite and store the one-cycle-time calculation value **230**.

[0040] The time-series data acquiring unit **110** performs an operation for acquiring the time-series data of the reflectance of the background portion of the intermediate transfer belt **47** measured by the reflectance sensor **18** over the by-design one-cycle-time value **200** twice in a row. Additionally, the time-series data acquiring unit **110** performs an operation for acquiring the time-series data of the reflectance of the background portion of the intermediate transfer belt **47** over a time

longer than the by-design one-cycle-time value **200** in multiples of the predetermined period twice in a row. Further, the time-series data acquiring unit **110** performs an operation for acquiring the time-series data of the reflectance of the background portion of the intermediate transfer belt **47** over a time shorter than the by-design one-cycle-time value **200** in multiples of the predetermined period twice in a row. Here, the time longer than the by-design one-cycle-time value **200** in multiples of the predetermined period means the by-design one-cycle-time value **200+Δt**, the by-design one-cycle-time value **200+2Δt**, the by-design one-cycle-time value **200+3Δt**, and similar time. The time shorter than the by-design one-cycle-time value **200** in multiples of the predetermined period means the by-design one-cycle-time value **200−Δt**, the by-design one-cycle-time value **200−2Δt**, the by-design one-cycle-time value **200−3Δt**, and similar time. Here, the time-series data of the reflectance of the background portion of the intermediate transfer belt **47** obtained by performing the operation for acquiring the time-series data of the reflectance over the by-design one-cycle-time value **200** twice in a row is referred to as reference data. The time-series data of the reflectance of the background portion of the intermediate transfer belt **47** obtained by measuring the time-series data of the reflectance over another time is referred to as advance/delay data. That is, the time-series data acquiring unit **110** acquires the time-series data group **210** that includes the reference data and the advance/delay data.

[0041] The transfer-unit rotation-time calculating unit **120** uses the time-series data group **210** acquired by the time-series data acquiring unit **110** to calculate the one-cycle-time calculation value **230**. Here, the reference data and the advance/delay data each include data A and data B. In the two measurements in a row, the data A is time-series data of the reflectance of the background portion of the intermediate transfer belt **47** obtained in the first measurement, and the data B is time-series data of the reflectance of the background portion of the intermediate transfer belt **47** obtained in the second measurement. For each of reference data **211** and respective pieces of advance/delay data **212**, the transfer-unit rotation-time calculating unit **120** calculates the difference between the data A (reflectance) and the data B (reflectance) using the time-series data obtained by the measurement performed twice in a row. Subsequently, the transfer-unit rotation-time calculating unit **120** calculates the average value **220** of the differences for each of the reference data **211** and the respective pieces of the advance/delay data **212**. Subsequently, the transfer-unit rotation-time calculating unit **120** calculates the time when the calculated average value **220** of the differences between the reflectances becomes minimum, for example, the by-design one-cycle-time value **200−2Δt** as the one-cycle-time calculation value **230**.

[0042] The patch-image generating unit **130** forms a patch image for image density calibration. The patch-image generating unit **130** adjusts the timing for forming the patch image based on the one-cycle-time calculation value **230** calculated by the transfer-unit rotation-time calculating unit **120** so as to accurately form a patch image for image density calibration in a desired position on the intermediate transfer belt **47**. This can accurately remove the influence of the reflectance (background optical density) of the background portion in the image density calibration. Here, the background optical density of the intermediate transfer belt **47** is different by position on the intermediate transfer belt **47**. Therefore, if the one-cycle-time calculation value **230** that is the time required for

one cycle of the intermediate transfer belt **47** (image carrier) is not accurately obtained, the patch image cannot be formed in an intended position on the intermediate transfer belt **47**. That is, the background optical density of the intermediate transfer belt **47** in the position where the patch image is to be formed cannot be accurately obtained. Thus, the image density calibration cannot be performed with high accuracy.

[0043] The by-design one-cycle-time value **200** corresponds to the by-design time period required for one cycle of the intermediate transfer belt **47**. The by-design one-cycle-time value **200** is calculated from the by-design perimeter and the by-design speed of the intermediate transfer belt **47**. The by-design one-cycle-time value **200** may be stored in the storage unit **19**, for example, at the time of factory shipment or replacement of the intermediate transfer unit **40**.

[0044] The time-series data group **210** is data obtained such that the measured reflectance by the reflectance sensor **18** in the background portion of the intermediate transfer belt **47** of the intermediate transfer unit **40** or similar parameter is acquired by the time-series data acquiring unit **110** at a predetermined interval during a predetermined period. The time-series data acquiring unit **110** may acquire, for example, data sampled at an interval of several msec to several tens msec as the time-series data group **210**.

[0045] The average value **220** is calculated regarding the reference data **211** and the respective pieces of the advance/delay data **212**, and is data of the average value of the differences among the reflectances at the respective sampling points of the time-series data (data A) obtained in the first measurement and the time-series data (data B) obtained in the second measurement. Here, the average value **220** is not a simple arithmetic average, and may be calculated as an average value of the absolute values of the differences, an average value of the squared differences, and a value related to a statistical average such as dispersion and median.

[0046] The one-cycle-time calculation value **230** is an actual time required for one cycle of the intermediate transfer belt **47** of the intermediate transfer unit **40** calculated by the transfer-unit rotation-time calculating unit **120**. The one-cycle-time calculation value **230** is the half time of the measurement time used for obtaining the reference data **211** or the advance/delay data **212** in which this average value **220** becomes minimum, for example, the by-design one-cycle-time value **200−2Δt**.

[0047] Here, the control unit **10** of the image forming apparatus **1** executes the control program stored in the storage unit **19** so as to function as the time-series data acquiring unit **110**, the transfer-unit rotation-time calculating unit **120**, and the patch-image generating unit **130**. The respective units of the above-described image forming apparatus **1** are hardware resources for performing an image forming method of the disclosure.

Transfer-Unit Calibration Process by Image Forming Apparatus **1**

[0048] The following describes a transfer-unit calibration process by the image forming apparatus **1** according to the embodiment of the disclosure with reference to FIG. **2** to FIGS. **4A** and **4B**. In the transfer-unit calibration process of this embodiment, the time-series data group **210** of the reflectance of the background of the intermediate transfer belt **47** of the intermediate transfer unit **40** is acquired while the time set in the timer unit **100** is shifted in multiples of a predetermined period. Then, the average value **220** of the differences is

calculated to calculate the time of the timer unit **100** when this average value **220** becomes minimum as the one-cycle-time calculation value **230** that is the time actually required for one cycle of the intermediate transfer belt **47** of the intermediate transfer unit **40**. The transfer-unit calibration process in this embodiment is executed such that the control unit **10** mainly executes the program stored in the storage unit **19** in collaboration with the respective units using the hardware resources. The following describes the detail of the transfer-unit calibration process for each step with reference to a flow chart in FIG. **2**.

Step S101

[0049] Firstly, the time-series data acquiring unit **110** in the control unit **10** performs a measurement starting process. The time-series data acquiring unit **110** initializes the respective units to start the driving of the intermediate transfer belt **47** of the intermediate transfer unit **40**, so as to ensure a state where the reflectance sensor **18** can measure the reflectance. Subsequently, the time-series data acquiring unit **110** waits for the rotation speed of the intermediate transfer belt **47** of the intermediate transfer unit **40** to reach a predetermined speed, and then causes the process to proceed to step S102.

Step S102

[0050] Subsequently, the time-series data acquiring unit **110** performs a timer setting process. The time-series data acquiring unit **110** sets the by-design one-cycle-time value **200** or the times longer or shorter than the by-design one-cycle-time value **200** by the predetermined period to the timer unit **100**. The time-series data acquiring unit **110** sets these times longer or shorter by the predetermined period corresponding to a predetermined number of changes described later. For example, the time-series data acquiring unit **110** changes the by-design one-cycle-time value **200** by $\pm n\Delta t$ time $(n=0, 1, 2, 3, \ldots, N)$ as these times longer or shorter by the predetermined period. This Δt time can be set in several msec to several tens msec. The maximum value N of n in the $\pm n\Delta t$ time is the maximum value for the number of changes of the Δt time. The maximum value N can be set to a predetermined number based on, for example, the dispersion of displacement of the length of the intermediate transfer belt **47** of the intermediate transfer unit **40** or similar parameter. The time-series data acquiring unit **110** may set the number of change of, for example, about $\pm \Delta t$. Here, the time when n=0 corresponds to the time of the by-design one-cycle-time value **200**. For example, when $n=\pm 2$, the time-series data acquiring unit **110** sets the time period twice longer than the time of the by-design one-cycle-time value **200+2Δt** to the timer unit **100**. This is because performing the measurement over the by-design one-cycle-time value **200+2Δt** twice in a row shows that when the time-series data of the reflectance of the background portion of the intermediate transfer belt **47** obtained in the first measurement coincides with the time-series data of the reflectance of the background portion of the intermediate transfer belt **47** obtained in the second measurement, the half time of the time of this measurement, for example, the by-design one-cycle-time value **200+2Δt** is the time actually required for one cycle of the intermediate transfer belt **47**.

Step S103

[0051] Subsequently, the time-series data acquiring unit **110** performs a time-series-data acquiring process. The time-series data acquiring unit **110** acquires the measurement data of the reflectance from the reflectance sensor **18** at a predetermined interval using the interval timer of the timer unit **100** or similar unit, and stores the acquired measurement data as the time-series data group **210** in the storage unit **19**.

Step S104

[0052] Subsequently, the time-series data acquiring unit **110** determines whether or not the time (for example, the time period twice longer than the time of the by-design one-cycle-time value **200+2Δt**) set in the timer unit **100** has passed. The time-series data acquiring unit **110** makes a determination of Yes when the time set in the timer unit **100** has passed and a predetermined number of samplings have been completed. Otherwise, the time-series data acquiring unit **110** makes a determination of No. In the case of Yes, the time-series data acquiring unit **110** causes the process to proceed to step S105. In the case of No, the time-series data acquiring unit **110** returns the process to step S103 and continues acquiring the time-series data group **210**.

Step S105

[0053] When the time set in the timer unit **100** has passed, the transfer-unit rotation-time calculating unit **120** in the control unit **10** determines whether or not the acquisition of all the time-series data has been completed. In the example described above, the transfer-unit rotation-time calculating unit **120** makes a determination of Yes when the reference data **211** and the advance/delay data **212** that is changed up to N as the maximum value for the number of changes of the Δt time are acquired. Otherwise, the transfer-unit rotation-time calculating unit **120** makes a determination of No. In the case of Yes, the transfer-unit rotation-time calculating unit **120** causes the process to proceed to step S106. In the case of No, the transfer-unit rotation-time calculating unit **120** returns the process to step S102. After the process returns to step S102, the time-series data acquiring unit **110** sets the time period twice longer than the time longer or shorter than the by-design one-cycle-time value **200** by the predetermined period to the timer unit **100**, and continues the acquisition of the time-series data that becomes the advance/delay data **212**. As the time with advance or delay by the predetermined period, for example, n in the $\pm n\Delta t$ time is increased.

Step S106

[0054] When the acquisition of all the time-series data has been completed, the transfer-unit rotation-time calculating unit **120** performs a difference-average-value calculating process. The transfer-unit rotation-time calculating unit **120** calculates the average value **220** of the differences between data (the reflectance of the background portion of the intermediate transfer belt **47**: the data A) of the sampling points obtained in the first measurement and data (the data B) of the sampling points obtained in the second measurement regarding the reference data **211** and the respective pieces of the advance/delay data **212**. By the description with reference to the example in FIGS. **3A** to **3C**, regarding the data A and the data B, the transfer-unit rotation-time calculating unit **120** calculates the differences of the data in the respective sampling points and then averages the differences. For example, the data in the respective sampling points of the data A is defined as $S1[i]$ $(i=1, 2, 3, \ldots, m)$. The data in the respective sampling points of the data B is defined as $S2[i]$ $(i=1, 2, 3, \ldots, m)$. Here,

m has the same value in the data A and the data B since the data is acquired at the same predetermined sampling interval during the same measurement time. In this case, an average value AVE of the differences between the data A and the data B is, for example, calculated with the following formula (1). Here, in the examples of FIGS. 3A to 3C and FIGS. 4A and 4B described later, the data A and the data B are described as sine waves. However, this should not be construed in a limiting sense. The data A and the data B each have a waveform containing a specific pattern and an error based on the configurations of the intermediate transfer belt 47 and similar member of the intermediate transfer unit 40.

Formula 1

$$AVE = \left(\sum_{i=1}^{m} S1[i] - S2[i] \right) \div m \qquad \text{Formula 1}$$

[0055] The transfer-unit rotation-time calculating unit 120 calculates the average value AVE of the time-series data regarding the reference data 211 and the respective pieces of the advance/delay data 212 at ±nΔt times with the above-described formula (1), and stores these values of the average value AVE as the respective average values 220 in the storage unit 19.

Step S107

[0056] Subsequently, the transfer-unit rotation-time calculating unit 120 performs a one-cycle-time calculating process. The transfer-unit rotation-time calculating unit 120 calculates the one-cycle-time calculation value 230 based on the respective average values 220 corresponding to the reference data 211 and the advance/delay data 212 acquired by the time-series data acquiring unit 110. By the description with reference to FIGS. 4A and 4B, in the example of FIG. 4A, if the half time of the time set to the timer unit 100 and the time actually required for one cycle of the intermediate transfer belt 47 coincide with each other, the cycle of the data A and the cycle of the data B are supposed to coincide with each other. However, as illustrated in the example of FIG. 4B, actually, since the intermediate transfer belt 47 expands due to the temperature and varies due to the variation in tolerance, these cycles rarely coincide with each other. Accordingly, the transfer-unit rotation-time calculating unit 120 calculates the time when the average value 220 of the difference between the data A and the data B calculated in the difference-average-value calculating process described above becomes minimum as the one-cycle-time calculation value 230, which is the time actually required for one cycle of the intermediate transfer belt 47. This one-cycle-time calculation value 230 is the time actually required for one cycle of the intermediate transfer belt 47.

Step S108

[0057] Subsequently, the patch-image generating unit 130 in the control unit performs a patch-image generating process. The patch-image generating unit 130 adjusts the timing such that a toner image is transferred in a predetermined position on the intermediate transfer belt 47 based on the one-cycle-time calculation value 230 calculated by the transfer-unit rotation-time calculating unit 120. Additionally, the

patch-image generating unit 130 forms a patch image for image density calibration, and transfers the patch image to the intermediate transfer belt 47. Accordingly, the patch image is formed always in the same portion on the intermediate transfer belt 47. Then, the transfer-unit calibration process according to the embodiment of the disclosure is terminated.

[0058] The above-described configuration can obtain the following effects. Typically, when the reference position marks are used in calibration for measuring the length of the intermediate transfer belt of the transfer unit, there is the need for the member to mark the reference position, thus costing money.

[0059] In contrast, the image forming apparatus 1 according to the embodiment of the disclosure includes the intermediate transfer unit 40 that includes the intermediate transfer belt 47 (image carrier) to which a toner image formed by developing an exposure-formed electrostatic latent image is transferred. The image forming apparatus 1 further includes the reflectance sensor 18, the time-series data acquiring unit 110, the transfer-unit rotation-time calculating unit 120, and the patch-image generating unit 130. The reflectance sensor 18 measures the reflectance of the background portion of the image carrier. The time-series data acquiring unit 110 acquires the time-series data group 210 of the reflectance of the background portion of the image carrier measured by the reflectance sensor 18 as the reference data 211 over the time period twice longer than the by-design time period (the by-design one-cycle-time value 200) required for one cycle of the image carrier and as the advance/delay data 212 over the time period twice longer than the time longer in multiples of the predetermined period or shorter in multiples of the predetermined period than the by-design time period. The transfer-unit rotation-time calculating unit 120 calculates the one-cycle-time calculation value 230, which is the time actually required for one cycle of the image carrier, based on the time-series data group 210 including the reference data 211 and the advance/delay data 212 acquired by the time-series data acquiring unit 110. The patch-image generating unit 130 performs the correction on the timing for forming a patch image based on the one-cycle-time calculation value 230, which is calculated by the transfer-unit rotation-time calculating unit 120. This configuration can perform the correction on the time without using a special member like the reference position mark, thus saving the cost. Additionally, the time actually required for one cycle of the intermediate transfer belt 47 of the intermediate transfer unit 40 can be accurately calculated without the reference mark. This causes an increase in accuracy of the calibration. Additionally, when the intermediate transfer unit 40 performs a meander correction control on the intermediate transfer belt 47, the elimination of the reference mark can prevent erroneous detection in a belt-end detecting unit (not illustrated) that determines a meandering state of the transfer belt.

[0060] The image forming apparatus 1 according to the embodiment of the disclosure calculates the differences of the respective reflectances regarding the data A and the data B. The data A is the time-series data obtained in the first measurement in the two measurements in a row. The data B is the time-series data obtained in the second measurement in the two measurements in the row. Then, the image forming apparatus 1 calculates the time actually required for one cycle of the intermediate transfer belt 47 based on the time when the average value 220 of the calculated differences of the reflectances becomes minimum. This configuration can accurately

calculate the time (the one-cycle-time calculation value **230**) actually required for one cycle of the intermediate transfer belt **47** of the intermediate transfer unit **40** even when the measured value of the reflectance by the reflectance sensor **18** contains noise, an error, or similar component.

[0061] Typically, when the by-design length for one cycle of the intermediate transfer belt is different from the actual length of the intermediate transfer belt, the position of the intermediate transfer belt on which the patch image for the image density calibration is formed is different from the desired position. Thus, typically, due to the difference in background optical density depending on the position on the intermediate transfer belt, a problem arises in that the calibration for image density considering background optical density cannot be accurately performed and an error occurs in the calibration for image density.

[0062] In contrast, the image forming apparatus **1** according to the embodiment of the disclosure can form the patch image for the image density calibration in the same portion where the background optical density is measured on the intermediate transfer belt **47**, using the one-cycle-time calculation value **230**, which is the time actually required for one cycle of the intermediate transfer belt **47**. This can improve the accuracy of the image density calibration.

Working Example

[0063] By referring to FIG. **5**, assuming that the intermediate transfer belt **47** of the intermediate transfer unit **40** has a perimeter of 936.2 mm, a product tolerance of ±1 mm, and a variation due to temperature of ±1 mm/10° C., and the speed of the intermediate transfer belt **47** is 266.7 [mm/s], the time for one cycle of the intermediate transfer belt **47** of the intermediate transfer unit **40** can be calculated as follows:

$$Tb=936.2 \text{ mm} \div 266.7 \text{ [mm/s]}=3.510 \text{ [s]}$$

[0064] Using this Tb as the by-design one-cycle-time value **200**, the time period twice longer than the by-design one-cycle-time value **200** is set in the timer unit **100**. The second measurement over the one-cycle-time calculation value **230** is performed in a row after the first measurement over the one-cycle-time calculation value **230**. Then, from the start of the first measurement of the intermediate transfer belt **47** of the intermediate transfer unit **40**, the reflectance of the background is acquired by the reflectance sensor **18** every 1.25 ms, so as to store the first data as the data A of the reference data **211** in the storage unit **19**. Afterward, similarly, the second data is stored as the data B of the reference data **211** in the storage unit **19**. Subsequently, as the ±nΔt time (n=1, . . . , 3), the setting of the timer unit **100** is changed from Tb−3Δt to Tb+3Δt and then the reflectance of the background is acquired (the data A and the data B of the advance/delay data **212** are acquired) every 1.25 ms. The data thus acquired is stored as the data A and the data B of the advance/delay data **212** in the storage unit **19**. The respective average values AVE of the differences between the data A and the data B included in the reference data **211** and the respective pieces of the advance/delay data **212** are calculated. The by-design one-cycle-time value **200** or the time ±nΔt with respect to the by-design one-cycle-time value **200** corresponding to the minimum average value among the calculated average values AVE is calculated as the one-cycle-time calculation value **230**. For example, like the table of FIG. **5**, as the result of acquiring the average values of AVE1 to AVE7, assuming that AVE3 is minimum, the one-cycle-time calculation value **230** is Tb−Δt.

[0065] The control unit **10** can use the time-series data group **210** of the reflectance sensor **18** to detect the value exceeding a predetermined threshold value or detect a specific pattern or similar parameter, so as to detect failure due to burnout or breakage of the intermediate transfer belt **47** of the intermediate transfer unit **40**. This ensures both the calibration and the failure detection, thus saving the maintenance cost of the image forming apparatus **1**.

[0066] While the above-described embodiment has been described such that the toner images are superimposed in a tandem manner on the intermediate transfer belt **47** of the intermediate transfer unit **40** as illustrated in FIG. **7** and FIG. **8**, it is possible to use an intermediate transfer belt in any structure or similar member. Alternatively, the configuration may employ a drum for intermediate transfer or similar member. Alternatively, the configuration may employ a developing unit with a rotary structure. The disclosure is applicable to the calibration of an image forming apparatus that does not form color images but includes the intermediate transfer unit **40** for performing intermediate transfer. While the above-described embodiment has been described such that the built-in reflectance sensor **18** is provided, a possible configuration is that a serviceman externally mounts the reflectance sensor **18** on the intermediate transfer unit **40** at the time of calibration.

[0067] The disclosure is applicable to an information processing apparatus other than the image forming apparatus except the multi-functional peripheral. That is, a single-function printer or similar printer may be used.

[0068] While various aspects and embodiments have been disclosed herein, other aspects and embodiments will be apparent to those skilled in the art. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

What is claimed is:

1. An image forming apparatus, comprising:

a transfer unit including an image carrier to which a toner image formed by developing an exposure-formed electrostatic latent image is transferred;

a reflectance sensor configured to measure reflectance of a background portion of the image carrier;

a time-series data acquiring unit configured to acquire time-series data with respect to the image carrier background-portion reflectance, measured by the reflectance sensor, as reference data over a time period twice longer than a time period that by design the image carrier requires for one cycle, and as advance/delay data over a time period twice longer than a time period longer or shorter in multiples of a predetermined time interval than the by-design time period; and

a transfer-unit rotation-time calculating unit configured to calculate a one-cycle-time calculation value that is the time actually required for one cycle of the image carrier, based on the reference data and the advance/delay data acquired by the time-series data acquiring unit.

2. The image forming apparatus according to claim **1**, wherein the transfer-unit rotation-time calculating unit is configured to:

calculate differences between respective reflectances included in data A and respective reflectances included in data B, the data A and the data B being included in each of the reference data and the advance/delay data,

the data A being time-series data obtained in first measurement, the data B being time-series data obtained in second measurement; and

select the reference data and each of the advance/delay data in which an average value of the calculated differences of the reflectances becomes minimum so as to calculate a half time of a time used for measuring the selected reference data or each of the selected advance/delay data as the one-cycle-time calculation value.

3. An image forming method performed by an image forming apparatus with a transfer unit including an image carrier to which a toner image formed by developing an exposure-formed electrostatic latent image is transferred, the image forming method comprising:

acquiring time-series data with respect to reflectance of a background portion of the image carrier, as reference data over a time period twice longer than a time period that by design the image carrier requires for one cycle, and as advance/delay data over a time period twice longer than a time period longer or shorter in multiples of a predetermined time interval than the by-design time period; and

calculating a one-cycle-time calculation value that is the time actually required for one cycle of the image carrier, based on the acquired reference data and the acquired advance/delay data.

4. A non-transitory computer-readable recording medium storing an image forming program executed by an image forming apparatus with a transfer unit including an image carrier to which a toner image formed by developing an exposure-formed electrostatic latent images is transferred, the image forming program causing the image forming apparatus to function as:

a time-series data acquiring unit configured to acquire time-series data with respect to reflectance of a background portion of the image carrier, as reference data over a time period twice longer than a time period that by design the image carrier requires for one cycle, and as advance/delay data over a time period twice longer than a time period longer or shorter in multiples of a predetermined time interval than the by-design time period; and

a transfer-unit rotation-time calculating unit configured to calculate a one-cycle-time calculation value that is the time actually required for one cycle of the image carrier, based on the acquired reference data and the acquired advance/delay data.

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